



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

---

**DOT HS 807 588  
Final Report**

**February 1990**

# **Exploration of Impact Measures of Safety Belt Use Laws Volume I: Final Report**

**The United States Government does not endorse products or manufactures Trade or manufacturer's names appear only because they are considered essential to the object of this report.**

1. Report No. DOT HS 807 588		2. Government Accession No.		3. Recipient's Catalog No.	
4. Title and Subtitle EXPLORATION OF IMPACT MEASURES OF SAFETY BELT USE LAWS. VOLUME I: FINAL REPORT				5. Report Date February 1990	
				6. Performing Organization Code	
7. Author(s) Thomas W. Planek, Alan F. Hoskin, Kevin T. Fearn, Terrence A. Miller, Kathryn E. H. Race, George S. Benjamin				8. Performing Organization Report No.	
9. Performing Organization Name and Address National Safety Council 444 North Michigan Avenue Chicago, Illinois 60611				10. Work Unit No. (TRAIS)	
				11. Contract or Grant No. DTNH22-88-Z-07391	
12. Sponsoring Agency Name and Address U. S. Department of Transportation National Highway Traffic Safety Administration Office of Driver and Pedestrian Research (NRD-41) Washington, DC 20590				13. Type of Report and Period Covered Final Report	
				14. Sponsoring Agency Code	
15. Supplementary Notes Volume II of this report, which is available from the sponsoring agency (box 12), contains (1) an annotated bibliography of literature reviewed, (2) expert team comments on potential indicators, and (3) a catalog of profiles of all potential indicators considered.					
16. Abstract <p>This project identified, evaluated, and recommended indicators of safety belt use law (SBUL) impact (other than fatality reduction and observed belt usage), as well as institutional sources that collect them. The project involved an extensive literature review, indicator assessment by an expert team, and a survey of data sources sponsored by the National Safety Council.</p> <p>Four indicators out of 52 candidates were judged to have the highest potential for assessing SBUL impacts: (1) the "KABC" injury scale used on police accident reports, (2) the Abbreviated Injury Scale used on medical records, and its derivative Injury Severity Score, (3) occupant ejections from vehicles, and (4) head and face injuries including cranium, brain, and concussive injuries but excluding ear and eye injuries.</p> <p>Two data sources out of 160 surveyed satisfied most of the 13 evaluation criteria. The Major Trauma Outcome Study appears useful for a multi-state, before-and-after study of SBUL impact. The National Electronic Injury Surveillance System could be adapted to gather national data to monitor future impacts of belt law revisions and other programmatic measures. The most promising long-term, state-level evaluation approach involves modifications of several data systems to link crash data in police accident reports with injury data in hospital medical records and trauma registries.</p> <p>Valid and reliable SBUL impact indicators are not immediately available from many existing sources and it is unlikely that they can be generated quickly. It is recommended that coordination and integration of data-gathering efforts at the national level should be given first priority.</p>					
17. Key Words safety belts safety belt use laws traffic laws evaluation impact assessment			18. Distribution Statement Document is available to the U. S. public through the National Technical Information Service, Springfield, Virginia 22161		
19. Security Classif. (of this report) Unclassified		20. Security Classif. (of this page) Unclassified		21. No. of Pages	22. Price

## Preface

This report presents a singular effort to discover new or uncommon criteria that can provide scientifically valid and politically useful measures of safety belt use law impact. The search for these "nontraditional indicators," as they are termed in the report, entailed a rapid and broad-based coverage of indicators and data sources as well as an equally expeditious convergence on the most promising found.

The two volumes of this report contain the results obtained at both levels of endeavor. This volume contains specific and final project findings and recommendations. The information upon which these findings are based is detailed in the second volume.

This project required the cooperation of scientists and professionals from a number of disciplines. The fact that so many volunteered their time to participate in it bespeaks both their genuine interest and generosity in the cause of highway safety. On behalf of the Project Staff, who gained immeasurably from the experts' contributions, I wish to express appreciation. In particular, I would like to thank the full-participation expert team including Brad Cushing, MD, Daniel Fife, MD, Sandra Johnson, Raymond Peck, David Sleet, PhD, and John States, MD, for the extra time and effort they devoted to the final project tasks.

Equally appreciated was the advice and meticulous project management work of the NHTSA's project technical representative, Doug Gurin. A special word of thanks is also due Jacqueline Waddell whose record-keeping, typing, and other administrative skills, supported the work of project staff on a day to day basis.

Finally, this report attempts to reflect fairly the sometimes divergent expert opinion and research results gathered during this project. In so doing, it becomes necessary to present a "consensus" of findings as well as to draw conclusions with which some of the project contributors may disagree. For both instances I take full responsibility.

Thomas W. Planek, PhD  
February 15, 1990

Table of Contents

<u>Chapter</u>		<u>Page</u>
	Executive Summary .....	ix
I.	Introduction .....	1
	A. Background .....	1
	B. Traditional indicators used to evaluate SBUL impact .....	3
	C. Statement of problem .....	4
	D. Project objectives .....	4
II.	Method .....	6
	A. Organization of expert team .....	6
	B. Selection of high-potential indicators .....	7
	1. Identification of candidate indicators ..	7
	2. Development of selection criteria .....	10
	3. Evaluation of candidate indicators .....	10
	C. Survey of information sources by National Safety Council .....	11
	1. Identification of candidate information sources .....	11
	2. Development of selection criteria .....	12
	3. Procedures for categorizing and con- tacting candidate information sources .....	13
	D. Evaluation of high-potential indicators and data systems .....	13
III.	Results and Discussion .....	15
	A. High-potential indicator candidates .....	15
	1. Summary of indicator profile data .....	15
	2. Experts' ranking of indicators .....	20
	3. Recommended high-potential indicators ...	22
	4. High-potential indicators not recommended	26
	5. Comments on other indicators .....	27
	6. Foreign experience .....	29
	B. Data system candidates .....	29
	1. Trauma registries .....	29
	2. Linked systems .....	32
	3. Other systems .....	33
	4. Promising data systems .....	34
	C. Methodological issues .....	36
	1. Impact of non-SBUL programs and other factors on high-potential indicators ..	36
	2. Retrospective vs. prospective study of SBUL impact .....	38
	3. Population based data sources, limitations of indicator data collection and coding .....	39
	4. Political utility of indicator data .....	41
IV.	Recommendations .....	44
	A. National coordination of indicator data collection .....	44
	B. High-potential indicator data collection .....	45
	C. Promising data systems .....	46

Table of Contents, Cont'd.

	<u>Page</u>
D. Retrospective study of high-potential indicators .....	46
E. Prospective study of high-potential indicators	47
F. High-potential indicator utility .....	49
V. References .....	51

List of Appendices

<u>Appendix</u>	<u>Page</u>
A Expert Team Members .....	A-1
B Results of Commercial Data Base Search .....	B-1
C Indicator Profile Form .....	C-1
D Expert Team Ratings of Candidate Indicators of Belt Use Law Impacts .....	D-1
E Ranked Listing of Candidate Indicators .....	E-1
F Governors' Highway Safety Representatives and American College of Surgeons Information Solicitation Letters .....	F-1
G Data System Profile Form .....	G-1
H Data System Profile Interview Form .....	H-1
I Data System Survey Summary and Data Systems Rejection Summary .....	I-1
J Indicator Profiles	
General Shifts in Frequency or Distribution by Severity: KABC Scale .....	J-1
General Shifts in Frequency or Distribution by Severity: Abbreviated Injury Scale (AIS)	J-3
General Shifts in Frequency or Distribution by Severity: Maximum AIS, Overall AIS .....	J-4
General Shifts in Frequency or Distribution by Severity: Injury Severity Score .....	J-5
Ejections .....	J-7
Head .....	J-10
Face .....	J-14
Eye .....	J-17
Spine .....	J-20
Upper Extremities .....	J-22
Lower Extremities .....	J-23
Index of Head Injuries to Whiplash .....	J-25
K Summary of Expert Team Rankings of High-potential Indicators .....	K-1
L Data System Profile Summaries	
Bay Area Trauma Registry [California] .....	L-1
Boston City Hospital Trauma Registry .....	L-2
Emergency Medical Services Major Trauma Records [San Diego County, CA] .....	L-3
Florida Trauma/Head/Spinal Cord Injury Registry .....	L-4

List of Appendices, Cont'd.

	<u>Page</u>
Injury Prevention and Analysis Group	
[Long Island, NY] .....	L-5
Iowa Safety Restraint Assessment .....	L-6
Major Trauma Outcome Study [multi-state] .....	L-7
Maryland Automated Accident Reporting System (MAARS) .....	L-8
Missouri Bureau of EMS Ambulance Reporting System .....	L-9
Missouri Head and Spinal Cord Injury Trauma Registry .....	L-10
National Electronic Injury Surveillance System (NEISS) .....	L-11
New York Department of Motor Vehicles Records .....	L-12
New York State Safety Belt Use Law Evaluation .....	L-13
Oregon Injury (Trauma) Registry .....	L-14
Sensitivity Index Project [Maine] .....	L-15
Spinal Cord and Head Trauma Center [Georgia] .	L-16
Spinal Cord Injury Early Notification System [Colorado] .....	L-17
University of Massachusetts Trauma Registry .....	L-18
University of New Mexico Hospital Trauma Registry .....	L-19
West Virginia Trauma Registry .....	L-20
M   Expert Team Comments on Methodological Issues .....	M-1

List of Tables

<u>Table</u>	<u>Page</u>
1. States with Safety Belt Use Laws .....	2
2. Frequency Distribution of Indicator Characteristics in Reviewed Literature .....	8
3. High-potential Indicators, Definitions, and Sources .....	16
4. Adjusted Rankings of High-potential Indicators .....	21
5. High-potential Data Systems, Institutions, and Descriptions .....	30

### List of Abbreviations

AIS	Abbreviated Injury Scale
EMS	emergency medical services
ER	emergency room
E-code	external cause of injury (part of the ICD)
ICD	<u>International Classification of Diseases</u> , a manual used to classify diseases, injuries and causes of death.
ISS	Injury Severity Score
KABC	an injury code used for police accident reports: K-killed, A-incapacitating injury, B-nonincapacitating evident injury, C-possible injury
MAIS	maximum AIS severity score
MV	motor vehicle
MVA	motor-vehicle accident
NHTSA	National Highway Traffic Safety Administration

## EXECUTIVE SUMMARY

### Introduction

Although a total of 33 states plus the District of Columbia have enacted safety belt use laws (SBULs), there is a continuing need to demonstrate their benefits to legislators and other officials. Traditional indicators of changes in seat belt usage such as fatality data, observed usage reports, and self-reported usage data have failed to eliminate controversy about SBULs. Indicators that can supplement findings based on traditional measures are needed.

This project focused on indicators that were robust enough to detect changes attributable to SBUL enactment, without knowledge about safety belt use by vehicle occupants, and that were available from existing rather than new data sources. Specifically, the objectives were to:

- \* Identify nontraditional indicators of safety belt use law impact and sources that collect them.
- \* Evaluate the suitability of identified indicators for future research.
- \* Recommend high-potential indicators and how their use should be implemented.

### Method

To attain these objectives, the National Safety Council project team, consisting of psychologists, statisticians, and a physician:

- \* Reviewed and cataloged more than 1,000 documents and abstracts from the research literature to uncover alternative indicators of SBUL impacts.
- \* Sponsored and conducted a nationwide survey of more than 160 organizations with an identifiable interest in safety belts or SBULs to find promising data sources.
- \* Developed evaluation criteria to assess the adequacy of these indicators and data sources.

The indicator evaluation and selection criteria were:

**Validity:** has a demonstrably causal association with SBULs.  
**Objectivity:** is founded on observable evidence.  
**Usefulness:** is of concern to society and public officials.  
**Sensitivity:** changes with variation in safety belt use.

**Generalizability:** can be logically applied to other situations and groups.

**Feasibility:** can be reliably recorded by data collectors.

The data system evaluation and selection criteria were:

**Representativeness:** is a census or statistical sample of a well-defined population.

**Timeliness:** insures data are collected promptly and made available for analysis quickly.

**Reliability/Quality:** insures data are coded and classified consistently over time; coding scheme is well defined.

**Flexibility:** can be modified easily/cheaply to collect additional data.

**Detail:** can distinguish motor-vehicle-related trauma; may record crash characteristics.

**Nature of the System:** insures continuing participation and support.

**Specificity:** defines variables as singular attributes.

**Accessibility:** is automated for computer analysis and currently available from an institutional source.

**Cost:** has reasonable user fees associated with obtaining a machine readable data set.

**Compatibility:** can be linked to other data bases and used nationally recognized coding standards.

**Disadvantages:** additional shortcomings not noted elsewhere.

**Other Advantages:** additional advantages not noted elsewhere.

**Future Plans:** planned changes that could affect its usefulness.

Thirty technical experts from fields such as emergency medicine, traffic safety research, and public health were invited to assess the potential of the indicators and data sources. Six experts participated in a meeting to discuss and evaluate interim findings. The project team then selected the most promising indicators and data systems based on the experts' feedback, the literature review and the data system survey results.

## Results

Indicators. Four indicators were selected by the project team as having the highest potential for assessing SBUL impact. In order of increasing specificity, they are:

- \* General injury severity as measured by the KABC scale.
- \* General injury severity as measured by the Abbreviated Injury Scale (AIS) and its derivative index, the Injury Severity Score (ISS).
- \* Ejections.
- \* Head and face injuries.

### General Injury Severity as Measured by the KABC Scale.

Police accident reports commonly use the KABC scale to record the presence of injuries where "K" means fatal injury, "A" means incapacitating injury, "B" means nonincapacitating evident injury, and "C" means possible injury.

The KABC scale is recommended particularly for retrospective examination of SBUL impact because of its widespread, long term use and computerized availability. Several states have used these records in evaluation studies.

Because KABC is used on the crash scene by police, it is applied to a broad spectrum of motor vehicle occupants. KABC may be more sensitive to SBUL impact than other severity measures insofar as it does a better job of recording the incidence of "no" and "low severity" injury cases. Life-threatening conditions, however, which may not be visible to police at the scene, such as internal injuries or shock, may be classified as "C" injuries rather than "A."

Consistency of crash reporting, data collection and data coding policies and procedures during the SBUL impact measurement period is critical to KABC's acceptability as a high-potential indicator.

### General Injury Severity as Measured by the Abbreviated Injury Scale and its derivative index, the Injury Severity Score.

The Abbreviated Injury Scale (AIS) is used to code the part of body, nature of injury, and threat to life for acute traumatic injuries. Each injury is assigned an AIS severity number, ranging from 1 for minor injury to 6 for maximum injury. The AIS is recommended because of its wide-spread use in emergency medical services, hospitals, and trauma registries<sup>1</sup> and because it can identify specific kinds of injuries involving specific parts of the body. If the medical records are complete, an investigator can track the incidence of precisely defined injuries among the covered population.

The Injury Severity Score (ISS) is derived from the individual AIS codes for all of a patient's injuries. The ISS is defined as the sum of the squares of the highest AIS severity code in each of the three most severely injured body regions: head or neck; face; chest; abdominal or pelvic contents; extremities or pelvic girdle; and external. The ISS is an attractive indicator because it assigns to each patient a single number which represents the overall severity (threat-to-life) of the patient's injuries. It may then be used in the computation of other statistics for groups of patients.

The AIS and ISS are applied only to those cases that enter the emergency medical care system. This restriction automatical-

---

<sup>1</sup>Trauma registries are specialized data bases that collect information, usually from hospital emergency room records, on the origin, severity, treatment, outcome, and other factors concerning traumatic injuries. Registries usually cover cases treated in a single hospital, a group of hospitals, or an entire state.

ly excludes persons who are uninjured, receive care from other sources, or die before entering the system--persons who likely would be accounted for on a police accident report and assigned a KABC code. Studies indicate that even though KABC and AIS measure different attributes, they correlate to a degree so that KABC may be considered a coarse measure of injury severity.

**Ejections.** Total ejection occurs when the entire body is thrown from the vehicle through a window, door, or other opening in the vehicle due to a crash. Partial ejection occurs when one or more parts of the body project from a window(s), door, or other openings in the vehicle during a crash.

Evidence gathered from the literature shows a correlation between belt use and reduced ejections that is strong and unequivocal. Ejection data are also widely available. All but four states include ejection on their police accident reports. It is also recorded on some emergency medical services reports, ambulance reports and trauma registries, though not to the same extent as on police records.

Four issues must be addressed, however, before ejection can be recommended unconditionally. The issues are: (a) Are high ejection-risk drivers less likely to be affected by SBULs than low risk drivers? (b) Can partial ejections be accurately reported? (c) Are the characteristics of ejection data sufficient to make them a more sensitive measure of SBUL laws than fatalities, which frequently result from ejection? (d) Can the overall reliability of ejection reporting be improved and standardized across jurisdictions?

**Head and Face Injuries.** This high-potential indicator includes all head and face injuries, excluding ear and eye, and is defined by the AIS (1985) to include cranial injuries, anatomic brain lesions, and non-anatomic (concussive) brain injuries. It is recorded in emergency medical services, hospital, and trauma registry records.

Head and face injuries, taken separately or together, probably have the highest potential for measuring SBUL impact. They constitute the most frequently occurring types of motor vehicle occupant injury. They have, in most studies, shown sizeable reductions, which can logically be tied to safety belt use and SBULs.

From the viewpoint of public appeal and impact on legislators, the likelihood of significant reductions in head and/or facial injuries constitutes an emotionally persuasive argument for enacting or strengthening SBULs. The potential reduction in the high cost of head injuries presents an important economic argument, too.

The feasibility of head and face injuries as SBUL impact indicators is subject to the following four qualifications: (a) The limited post-SBUL use of safety belts in the U.S. attenuates the size of head and face injury reduction that can be expected. (b) Belted drivers are more likely to suffer head injury (from the steering wheel) than belted front seat passengers (from the dashboard), so that occupant seating position is an important

analytic variable. (c) Crash type and speed can affect frequency and severity of head and face injuries and whenever possible, should be included in pre/post SBUL comparisons. (d) Head/face injury reductions can be masked in populations that do not include uninjured and fatally injured front seat occupants.

Data systems. One data system was selected by the project team as being a promising, multi-state system and one was selected that could be useful in the near future. A third kind of system has potential for single-state studies.

Major Trauma Outcome Study (MTOS). The MTOS is a standardized set of data contributed by approximately 90 trauma registries. The AIS, ISS, and head/face injury indicators are included. It is operated by the Washington Hospital Center, Trauma Research Center, Washington, D.C.

The MTOS enjoys broader geographical coverage than other systems but participation is voluntary so that its data are not necessarily nationally representative. The MTOS is the one data system identified in the Council's survey that is similar to the NHTSA's 19-city safety belt use observation study (i.e., broad geographical coverage from a single source) and available immediately without substantial modifications.

National Electronic Injury Surveillance System (NEISS). Operated by the U.S. Consumer Product Safety Commission, NEISS is a statistical, nationwide sample of 61 emergency rooms in 32 states (22 of which have SBULs) that report data on product-related injuries.

From 1978 to 1982, the National Electronic Injury Surveillance System (NEISS) collected data on motor-vehicle-related injuries for NHTSA under a cooperative agreement. Apparently the agreement was terminated when NHTSA brought on line the National Accident Sampling System. The NEISS still has the potential to provide nationally representative data from a single source if the agreement were renewed. It appears to be the only system currently in existence that can be modified relatively easily for such a purpose and is, therefore, worth consideration as a possible source of indicator data.

According to the Director of the CPSC's Division of Hazard and Injury Data Systems, it could take as little as two to three months to define data and reporting requirements and begin data collection. The cost of using NEISS depends on the level of detail desired. It could be as low as \$10 per case for routine surveillance data obtained from the emergency room records. Or, it could be as low as \$100 per case for in-depth data obtained through follow-up telephone contacts. The main disadvantage to using NEISS would be the lack of pre-SBUL data in SBUL states, and the limitation on the kinds of cases that are treated at hospital emergency rooms. The advantages would be that NEISS surveillance data can be AIS-coded and NHTSA could specify the data elements to be collected and the coding schemes to be used for follow-up interviews.

**Single-State Data Systems.** At the state level, trauma registries generally seem to be good sources of data for injury indicators (head, face, etc.). The injuries are usually coded using the AIS from which an ISS may be derived. Motor-vehicle-related injuries can usually be identified through an "external cause of injury code" assigned to each case. Specific kinds of injuries can be tracked as well as changes in injury distribution or overall severity. The disadvantage is the limitation on the kinds of cases that enter the trauma registries. The uninjured, some fatalities, and those who use other sources of care are not included.

To overcome this disadvantage, trauma registry records can be linked to other record systems such as police, emergency medical services, or medical examiner, by some common identifier. Linked records systems are the most promising approach to SBUL evaluation. Linked records allow the researcher to build corroborative evidence from multiple indicators, to examine the injury outcome for all vehicle occupants if police accident records are included, and to control for potential confounding factors. Police accident reports provide vital crash data that are not captured on medical records, and medical records provide more complete injury data. Record linkage has already been achieved in Maine, Missouri, New Jersey, and Pennsylvania.

### Recommendations

The primary objective of this project was to explore the feasibility of using data from existing sources to monitor safety belt use law (SBUL) impact. The findings of this investigation suggest that there is no clear-cut indicator or combination of indicators currently being collected by a data system or systems that can provide immediate and useful trend information on SBUL effectiveness. There are both indicators and data systems that appear to have future potential, but they cannot be termed "existing" and "ready to go" on a national scale as initially envisioned in this project.

Clearly, the potential of SBUL impact indicators recommended in this project depends directly on the adequacy of the data systems that collect them. If indicator data are not collected in a representative and reliable fashion, their credibility is lost no matter how valid or sensitive they are. The first priority for high-potential indicator development must be the advancement and fostering of comprehensive and reliable data collection systems. The following recommendations address this issue.

National Coordination of Indicator Data Collection. The foundation for achievement of this objective must be laid at the national level, through the following actions:

- \* Initiate institutional cooperation in the collection of SBUL impact data by the federal government and national

organizations. This effort should include NHTSA, the National Institute for Occupational Safety and Health, the Occupational Safety and Health Administration, the Centers for Disease Control, the Consumer Product Safety Commission, the Bureau of Labor Statistics, private organizations such as the National Safety Council, Traffic Safety Now, the Insurance Institute for Highway Safety, and other appropriate agencies and groups.

- \* Obtain input about data collection problems and plans to overcome them from state/local injury surveillance, law enforcement, research and other professionals similar to those who participated in this project.
- \* Develop and disseminate technical information to improve the overall adequacy of high-potential indicator data collection at the state and local levels.
- \* Establish a special "start-up" assistance program with some degree of preference for organizations willing to "institutionalize" indicator data collection.
- \* When appropriate, develop data sources and indicators that officials can also use to monitor impacts of other (non-SBUL) highway safety programs.

High-Potential Indicator Data Collection. Although no new SBUL impact indicators were found that can provide immediate and useful trend information to officials, some can be recommended for future study. These high-potential indicators are:

- \* General changes in injury severity as measured by the KABC scale.
- \* General changes in injury severity as measured by AIS, and its derivative index, ISS.
- \* Ejections.
- \* Head and face injuries as defined by AIS codes.

Because this selection was made on the basis of earlier research and expert opinion, the efficacy of these indicators remains to be demonstrated. It is necessary to verify that they possess the measurement characteristics necessary to assess SBUL impact. In particular, there is a need to:

- \* Determine the sensitivity of high-potential indicators to assess SBUL impact at less than the maximum safety belt usage levels.
- \* Determine the feasibility of indicator data collection given the questions concerning the reliability and

stability over time of police and medical reporting and record sources.

Promising Data Systems. The findings of this investigation suggest that there are no data systems that can be termed "existing" and "ready to go" in a manner analogous to NHTSA's "19 city" belt use survey. There are, however, two promising data systems that can be recommended as possible national or multi-state sources of indicator data and a third option has potential for single-state studies:

- \* The Major Trauma Outcome Study (MTOS) operated by the Washington Hospital Center for the American College of Surgeons Committee on Trauma. [See p. xv.]
- \* The National Electronic Injury Surveillance System (NEISS) operated by the U. S. Consumer Product Safety Commission. [See p. xv.]

The key concerns in the use of MTOS are attracting a more representative sample of trauma registries than currently exists and maintaining the participation of those that become involved.

The NEISS has collected motor vehicle injury data for NHTSA in the past and an interagency agreement could be reinstated. Costs and start-up time seem to be reasonable. The data collected can include some high-potential indicators. One limitation involves the nature of the sample, i.e., emergency room visits only.

Single-state systems. In addition to the multi-state systems, MTOS and NEISS, there are many state-wide trauma registries and state traffic records systems that can provide data immediately on some of the high-potential indicators, or could provide data with some modification.

Linkage between record keeping systems [see page xv], is highly desirable though not absolutely necessary for evaluation research. In spite of the many barriers to linkage, it has been achieved successfully in a few states.

Retrospective<sup>2</sup> Study of High-Potential Indicators. Retrospective impact studies are possible in states that have already enacted SBULs. KABC and/or ejection data probably are the most readily available indicators for this purpose.

Availability of indicator data from several states provides a unique opportunity for comparing the effects of state-to-state differences in SBUL content and enforcement practices. These data also can serve as baselines against which to measure the effects of repeal actions.

---

<sup>2</sup>Retrospective studies are those that analyze existing data on events that occurred in the past.

States with trauma registries should also be encouraged to provide retrospective data, if available. In particular, there is a need to correlate head/face injury data and AIS/ISS severity data with general background data from state traffic records.

Prospective<sup>3</sup> Study of High-Potential Indicators. Prospective study of SBUL impact should be considered for non-SBUL states that have data systems already in operation and are likely to enact SBULs, and for SBUL states to monitor and evaluate changes in enforcement or other belt-related programs or to improve the future quality of trend data. Specific recommendations for this type of research are as follows:

- \* Insure the scientific adequacy of evaluation design and data collection methods with built-in reliability checks.
- \* Use a sufficiently large population base (preferably statewide) to provide an adequate indicator sample size and enable appropriate generalization of results.
- \* Use police, emergency medical services and injury surveillance data systems whose records are linked to improve the comprehensiveness and accuracy of indicator data, or, if linking records systems is not possible, include the collection of crash information, such as occupant seating position, belt use, crash speed and collision type, to refine SBUL impact analysis.
- \* Include control groups to provide concurrent baseline and post-SBUL impact indicator data.

Due to the complex realities that are associated with SBUL impact assessment, these guidelines represent ideals that can only be approximated. It is recommended, however, that research sponsors give emphasis to the conduct of a few well-controlled, scientifically adequate investigations rather than many investigations where lack of sufficient resources could compromise research quality.

A number of general indicator data collection improvements related to state traffic record and injury surveillance systems can be recommended to support impact evaluation:

- \* Use of common identifiers on police accident reports, emergency medical service and emergency room records, trauma registries and other systems to promote linkage of records.

---

<sup>3</sup>Prospective studies collect and analyze data on events as they occur using existing or specially created record keeping systems.

- \* Modify traffic records systems to record partial ejection on police accident reports.
- \* Promote the use of AIS codes in autopsy records and coroner/medical examiner reports to facilitate inclusion of fatality data in SBUL evaluations.
- \* Promote the uniform use of International Classification of Diseases external cause (E-code) coding of injuries in emergency room and hospital admission records.
- \* Develop a medically more meaningful injury classification than KABC, that can be used by police.
- \* Develop a more direct measure of disability than incapacity or threat to life.
- \* Develop a realistic and acceptable injury cost model that can be used to describe SBUL benefits as measured by the recommended indicator variables.

High-Potential Indicator Utility. The utility of the recommended indicators should be explored with a view to positioning them in the future politics of SBUL passage, amendment and repeal decisions. Two issues appear to be critical: (a) the difference between safety belt effectiveness and safety belt use law impact as it affects legislative and public debate; and (b) the role of the high-potential indicators in influencing SBUL passage and/or repeal. Two activities are recommended in priority order:

- \* Review the philosophical issues raised in the SBUL debates and redefine research and related problems in the context of these issues.
- \* Obtain the reaction of legislators and other decision makers to the high-potential indicators in view of the defined problems and issues.

It is imperative to answer the indicator utility questions prior to expending resources in high-potential indicator data collection. It is unclear as to what those answers will be. In addition, these findings clearly portray the lack of usable indicator data for highway safety generally. For this reason, the general recommendations about coordination of data gathering efforts at the national level should be given first order priority.

Conclusion. The results of this study suggest that valid, reliable and comparable SBUL impact indicators from multiple states are not immediately available from many existing sources. Overall assessments of SBUL impacts by national safety

organizations would take at least two years because of the need to alter ongoing data collection systems and gather sufficient data. In the short term, existing single- and multi-state data bases that have begun to link crash data in police accident reports with injury data in hospital medical records or trauma registries may be used for impact analyses. The most promising long-term evaluation approaches would involve linking the existing separate data systems in states, first within each of the remaining SBUL states and then in states that may enact SBULs in the future, and taking steps to improve data definition and data system management to foster indicator analyses among the states.

In addition, these findings clearly portray the lack of usable indicator data for highway safety in general. This revelation is not new but simply reflects what has been a chronic problem for decades. For this reason, the general recommendations about coordination of data gathering efforts at the national level should be given first order priority.

## I. INTRODUCTION

Since the passage of the first safety belt use law (SBUL) in New York in 1984, a total of 33 states plus the District of Columbia have enacted similar legislation (see Table 1). Reported usage rates in states with belt laws currently cluster around 50%, with usage in some states reaching as high as 70% (Campbell and Campbell, 1986). In addition, pre-law usage rates in states that have recently passed belt laws appear to be increasing over time, perhaps reflecting a positive benefit from heightened public awareness concerning safety belts due to publicity campaigns and/or the previous passage of SBULs in other states.

### A. Background

The reasons for the widespread adoption of SBULs in the U.S. were many. First, the New York passage acted as a legislative ice breaker, triggering debate in a number of states (Leichter, 1986). About one month after the New York law was passed, the 1984 U. S. Department of Transportation automatic restraint rule was published by Secretary Dole requiring installation of air bags or automatic restraints in all new passenger automobiles sold in the U. S. by 1990. The rule also had an automatic revocation clause, which took effect if two thirds of the public were covered by specific seat belt use laws by April 1989. This move accelerated safety belt policy and legislative initiatives so that action on SBULs was occurring in almost all states by 1986.

Other factors have contributed to the successful passage of SBULs. These include (1) apparent public approval of child restraint laws in all 50 states, which opened the door for acceptance of adult laws; (2) the increase in usage rates and casualty reductions observed in Great Britain, whose law went into effect in July 1981, and other foreign countries, which enacted belt laws as early as 1970; (3) a change from the adversarial, "either/or" nature of the safety belt vs. air bag debate to consideration of them as complementary systems; and (4) the multi-media lobbying efforts of public and private traffic safety, health care, and education groups as well as automobile manufacturers and insurers.

All of these influences were necessary to counter the often vehement opposition to mandated usage. The majority of those in opposition perceived SBULs as a violation of individual rights and a governmental invasion of privacy. Many legislators also expressed concerns about the matter of SBUL enforceability. Still others expressed a belief in the survival value of ejection during a crash and/or fears of being trapped in a burning or submersed vehicle.

**Table 1**  
**States with Safety Belt Use Laws**

<u>State</u>	<u>Effective Date</u>
New York	12/1/84
New Jersey	3/1/85
Illinois	7/1/85
Michigan	7/1/85
Texas	9/1/85
Nebraska	9/6/85*
Missouri	9/28/85
North Carolina	10/1/85
District of Columbia	12/12/85
Hawaii	12/16/85
California	1/1/86
Connecticut	1/1/86
Massachusetts	1/1/86**
New Mexico	1/1/86
Tennessee	4/21/86
Utah	4/28/86
Ohio	5/6/86
Washington	6/11/86
Florida	7/1/86
Idaho	7/1/86
Iowa	7/1/86
Kansas	7/1/86
Louisiana	7/1/86
Maryland	7/1/86
Minnesota	8/1/86
Oklahoma	2/1/87
Indiana	7/1/87
Colorado	7/1/87
Nevada	7/1/87
Oregon	9/27/87***
Montana	10/1/87
Pennsylvania	11/23/87
Wisconsin	12/1/87
Virginia	1/1/88
Georgia	9/1/88
Wyoming	6/8/89
North Dakota	7/13/89

Notes: \* Nebraska repealed law 11/30/86.  
 \*\* Massachusetts repealed law 12/4/86.  
 \*\*\* Oregon repealed law 11/88; never enforced.

Even today, after the passage of belt laws in a majority of states, opposition to them has remained strong in many quarters, stalling legislative drives in states without laws and fostering repeal movements in states with laws. In this regard, SBUL laws have been repealed in Massachusetts and Nebraska and repeal bills have been introduced in at least seven other states (Barancik et al., 1988).

Clearly, there is a continuing need for persuasive arguments to convince legislators that the benefits of SBULs outweigh the concerns of those opposed to them. Before the passage of the first belt law, these arguments were based on projections of potential or estimated increases in belt use and reductions in casualties derived mainly from the post-SBUL experience of foreign countries. The enactment of state laws, however, has enabled SBUL evaluations to occur in the U. S.

#### B. Traditional Indicators used to Evaluate SBUL Impact

Traditional indicators of changes in seat belt usage, either in the U. S. as a whole or on a statewide level, have typically involved fatality data, observed usage reports, and self-reported usage data. Selection of these measures has been dictated mainly by their availability and/or ease of collection.

Fatalities are the most readily collected and reliable crash data that logically can be linked to changes in seat belt use. Partyka (1988) used FARS data to estimate that between 1983 and 1987, safety belts saved the lives of 10,938 travelers over four years old in the front seats of passenger vehicles. Of these, 6,907 or 63 percent, were saved by increasing belt use over pre-law levels. States with belt laws were found to experience, on average, 7 percent fewer fatalities than would have been expected without laws.

Measurement of belt usage by observational surveys is also common, whether in small scale studies or on a national basis. Most notable of the national surveys is the 19-city observation administered by NHTSA. This continual survey shows that belt usage in the cities surveyed has risen from 11 percent in 1982 to 45 percent in 1988 (NHTSA, 1989). In 1988, among the six survey cities without belt laws, usage was 34 percent (up from 30 percent in 1987) as compared with 50 percent (no change from 1987) among the 13 survey cities with belt laws.

In addition to observation-based surveys, self-reports or opinions about belt-wearing have been compiled. Many states have used surveys of this type to gather information about shifts in public opinion during implementation of SBULs. Rood and Kraichy (1985) found that public support for New York's SBUL remained constant at 65 percent both before and after implementation.

National surveys have also been conducted. The 1985 National Health Interview Survey conducted by the National Center for Health Statistics reported that 35 percent of respondents wore their belts all or most of the time, 18 percent wore them

some of the time, 14 percent wore them once in awhile, and 32 percent never wore them.

### C. Statement of Problem

The search for existing indicator data was prompted by the need to obtain a picture of SBUL impact on injuries, monitor post-enactment trends, and evaluate effects of program changes such as enforcement practices, grace periods, fines, etc.

Of the three traditional measures used to evaluate SBULs, none has proved fully satisfactory. Fatality reductions have been smaller in most states than expected (O'Neill, 1988). Belt use patterns vary considerably both among and within states so that the 19-city sample does not provide a representative nationwide picture of safety belt use. There have been several studies in which state-recorded data have been used to estimate belt use by injured occupants but the inadequacies of these data are also well recognized. For example, Hunter, Reinfurt, and Hirsch (1988) conclude their study of state accident data by observing that accident belt usage data fail to answer how a state law affects safety belt use. Finally, the worth of self-reported information, which usually results in inflated belt use figures, has always been questioned by researchers. Self-reported usage in New York rose from 45 percent before to 84 percent after the law (Rood and Kraichy, 1985). In contrast, observed use rose from 16 percent before to 57 percent after the law (Rood, Kraichy, & Carubia, 1985).

Use of alternative indicators to supplement findings based on traditional measures might help to overcome these problems. In this regard, the project focus was on indicators that were sufficiently robust to produce observable changes after SBUL enactment, apart from knowledge about safety belt use by vehicle occupants. The availability of data before SBUL enactment was considered to be critical to an indicator's capacity to demonstrate these changes.

Dependence on existing rather than newly developed data sources also recognizes the importance of obtaining SBUL impact data before changes in the U. S. motor vehicle fleet, such as the introduction of air bags, add further dimensions to an already complex evaluation process. In view of this consideration and the fact that new data system institution may take several years, it is questionable whether resources to support such an endeavor would be forthcoming.

The underlying rationale for this project also can be viewed in the broader context of avoidable cost issues; that is, finding improved ways to show how much the cost to society can be reduced by minimizing motor vehicle crash occupant injuries.

### D. Project Objectives

This project explored the conceptual feasibility of using data from a variety of existing sources for better monitoring of

the impacts of state safety belt use laws by national and state officials. Specifically, the objectives of this project were to:

- \* Identify indicators of safety belt use law impact and sources that collect them.
- \* Evaluate the suitability of identified indicators for future research.
- \* Recommend high-potential indicators and how their use should be implemented.

Clearly, fulfillment of these objectives called for a comprehensive search of available literature and existing data sources. The emphasis on "nontraditional" indicators, however, required a somewhat broader base of inquiry than is implied by a literature review.

The strategy adopted for project completion involved the blending of the talents of the project team with those of experts knowledgeable in safety belt research and related fields. It was felt that the experts would:

- \* Augment the indicator identification process.
- \* Critique the indicator data collection, screening, and evaluation process.
- \* Participate in indicator evaluation and priority selection.
- \* Recommend how working relationships with indicator sources and databases can be achieved.
- \* Offer resolutions to practical, technical and theoretical problems associated with indicator data collections and interpretation.

As will be described in the Method section, the organization and composition of the expert team was established with these objectives in mind.

## II. Method

The project's objective was to generate recommendations about high-potential indicators of safety belt use law (SBUL) impact based on existing information. The types and sources of this information were broadly defined to include data, theories, and judgments drawn from all those interested in safety belt use and laws that affect it, including researchers, practitioners, officials, and legislators.

To achieve the breadth of coverage implied by the project objective, a group of experts was invited to provide guidance and feedback. Also, a large body of research literature, primarily in the medical and traffic safety evaluation areas, was reviewed and catalogued by the project team. Finally, the National Safety Council conducted a nationwide survey of organizations with an identifiable interest in safety belts or SBULs to locate potential data sources.

### A. Organization of Expert Team

The expert team functioned in an advisory capacity throughout the project. Invitations to participate were made to those knowledgeable about safety belt laws, use, and related issues and experienced in the following fields:

- \* Trauma/Emergency Room treatment
- \* Health care/rehabilitation records
- \* Emergency medical services (EMS)
- \* Epidemiology
- \* Injury specialties (e.g.; facial, spinal cord, brain)
- \* Highway safety program evaluation
- \* Legislative/advocacy matters
- \* Law enforcement
- \* Insurance/workers compensation

Experts were asked to participate on a full or supplemental basis. Full participation included response to mailings and other ad hoc requests as well as meeting attendance during the project's final phase. Supplemental participation involved only response to mailings. Appendix A contains a listing of experts who participated during the project.

Project implementation required the integration of project team efforts with those of the experts to identify, screen, and select indicators with the potential of measuring SBUL impact. This objective was achieved by three mailings to the experts sent at the beginning, middle and toward the end of the project.

The first two mailings requested recommendations about the indicators and data systems that should be included in the project as well as comments about the instruments being developed for their assessment.

The third mailing focused on the selection of high-potential indicators and asked for commentary about major methodological issues likely to affect SBUL impact evaluation. A meeting with the full participation experts was convened at the time of the third mailing to consider these matters as well as the adequacy of promising data systems that the Council survey uncovered.

## B. Selection of High-Potential Indicators

Selection of high-potential indicators involved the tasks of identifying, screening, and evaluating indicators. As will be seen, all facets of the selection process were accomplished in an iterative fashion with ample opportunities for both project and expert team input and refinements to be incorporated into the final recommendations.

1. Identification of candidate indicators. Candidate indicators were obtained from four sources: (a) literature review, (b) NHTSA staff, (c) the project team, and (d) the expert team. Indicator recommendations were accepted uncritically in an effort to amass the most comprehensive listing possible.

The literature review served two purposes. First, it was used to find supporting evidence for candidate indicators identified by the other three sources. Second, it was used to discover additional indicators and support for them. In fact, the project team identified the majority of SBUL impact indicators through the review of safety belt research literature.

Several sources were used to obtain relevant literature including the National Safety Council's library and nine commercial data bases. (See Appendix B.) These retrievals were supplemented with documents and abstracts provided or identified by the COTR and the expert team.

Upon receipt, citation abstracts were examined by reviewers from the project team and indicator information was recorded. For those citations where more information was desired, the original document was obtained.

More than 1,000 documents or abstracts were screened. Of these, 128 articles were determined to be relevant to this project. These were catalogued and reviewed by the project team. General identifying information for these articles was recorded and selected details about the candidate indicator were noted along with descriptions of the indicator and the results of the research (see Volume II, Part A).

To facilitate the review process, a standardized abstract form was developed. It consisted of eight variables that described the most important characteristics of the indicator(s) mentioned in each article.

All document descriptors were entered into a computerized data base using Nutshell Plus software (Nashoba, 1987) so that articles could be easily sorted or listed according to any of the key words on the abstract form, e. g., spinal cord injuries. As Table 2 shows, most of the literature focused on injuries and

**Table 2**  
**Frequency Distribution of Indicator Characteristics**  
**in Reviewed Literature**

<u>What was Counted</u>	<u>N*</u>		
Injuries .....	74	Neck/Throat .....	34
Hospital stays .....	19	Neck .....	32
Admissions .....	19	Throat .....	2
Bed-days .....	3	Spine .....	31
Discharges .....	0	Cervical .....	9
Emergency room visits .....	18	Thoracic .....	7
Persons injured .....	15	Lumbar .....	6
Costs .....	8	Extremities/Pelvis .....	31
Injury episodes .....	6	Lower extremities .....	19
Accidents .....	6	Upper extremities .....	17
Insurance claims .....	4	Pelvis .....	12
Persons involved .....	4	External .....	2
Clinic visits .....	3	Skin .....	0
Medical procedures .....	2		
Ambulance runs .....	2	<u>Severity measure</u>	<u>N</u>
Disability days .....	2	Abbreviated Injury Scale ..	41
Doctor visits .....	1	Injury Severity Score .....	9
Drivers involved .....	1	Maximum AIS .....	7
Consumption of medical		KABC .....	6
supplies .....	0	Int'l. Classif. of Diseases	2
Memberships in disabled		Probability of Death Score	0
advocacy groups .....	0		
Sales of medical appliances	0	<u>Safety belt use law link</u>	<u>N</u>
Law suits .....	0	No .....	65
Accident-involved vehicles	0	Yes .....	44
		Unspecified .....	8
<u>Part of Body</u>	<u>N</u>		
Head .....	46	<u>How it was Reported</u>	<u>N</u>
Cranium .....	4	Number (frequency) .....	68
Brain .....	3	Per cent distribution .....	50
Thorax .....	46	Rates .....	15
Heart .....	9	Averages .....	3
Sternum .....	9	Scores .....	3
Ribs .....	7		
Chest wall .....	4		
Abdomen/Pelvic contents ...	39		
Face .....	35		
Face .....	35		
Eye .....	11		
Mouth .....	3		
Ear .....	0		

\* N is the number of articles reviewed that mentioned each characteristic.

**Table 2 (cont'd.)**  
**Frequency Distribution of Indicator Characteristics**  
**in Reviewed Literature**

<u>How it was used</u>	<u>N*</u>	<u>Misc. associated variables</u>	<u>N</u>
Safety belt effectiveness evaluation .....	46	Safety belt use .....	71
Safety belt use law evaluation .....	37	Seating position .....	36
Case reports .....	17	Crash configuration .....	33
Epidemiological studies ...	12	Vehicle parts .....	18
Other evaluation .....	8	Ejection .....	16
		Belt-induced injury .....	11
		Speed .....	10
		Injury type .....	8
<u>Source records</u>	<u>N</u>	Age .....	6
Hospital records .....	59	Alcohol .....	4
Emerg. room records	21	Type of vehicle .....	4
Inpatient records	21	Accident type .....	2
Outpatient records	0	Occupant-occupant contact .	2
Accident records .....	39		
Corporate records .....	8		
Insurance records .....	4		
EMS records .....	2		
Other medical records .....	0		
Employer	0		
Physician	0		
Association records .....	0		
Legal records .....	0		

\* N is the number of articles reviewed that mentioned each characteristic.

reported results in terms of frequencies and per cent distributions. Hospital records were the most common data source. The head and thorax were the parts of body most often discussed. When injury severity was a factor, AIS was used almost exclusively. About one third of the studies linked their results to safety belt use laws. Almost two thirds of the studies used safety belt use as a factor in the analyses and almost one third used seating position or crash configuration as a factor.

2. Development of selection criteria. Features named in the Statement of Work were used as criteria to select the most promising indicators. Additional criteria were suggested by the project team and by the expert team in both the first and second mailings. Indicator features were refined based on expert input and are as follows:

Validity:	has a demonstrably causal association with SBULs.
Objectivity:	is founded on observable evidence.
Usefulness:	is of concern to society and public officials.
Sensitivity:	changes with variation in safety belt use.
Generalizability:	can be logically applied to other situations and groups.
Feasibility:	can be reliably recorded by data collectors.

These features were elaborated by one or more descriptive questions as part of an indicator profile form developed to document, describe and evaluate each candidate indicator (see Appendix C). The profile also requested an overall rating of high, medium or low to assess the extent to which an indicator satisfied each feature's requirements.

3. Evaluation of candidate indicators. A list of candidate indicators was sent to the expert team for their preliminary evaluation. They were asked to categorize each indicator as having "promising," "unknown," or "little" potential. The results of this rating are shown in Appendix D and expert team comments on the indicators are included in Volume II, Part B.

The project team completed profile forms for each indicator, which were entered into a Nutshell Plus data base (see Volume II, Part C) together with the expert team's preliminary ratings. This information was used by the project team to assign an overall high/medium/low rating to each candidate indicator. Based on the overall rating, a ranked list of indicators was produced (see

Appendix E). This list was sent as part of the second mailing to the expert team, who were asked to assess it and if not in agreement, to rebut the overall rating assigned by the project team.

Based on the expert team's assessments of the overall ratings, the project team selected 12 high-potential indicator candidates for final evaluation. A literature review was completed for each of these indicators to assist the project team with their input into the evaluation task. In this review, emphasis was given to studies that used indicators to evaluate a safety belt use law, although studies that used indicators to compare the experience of belted versus unbelted occupants in crashes were also included.

### C. Survey of Information Sources by National Safety Council

To complement the indicator selection process, the National Safety Council sponsored and conducted its own survey of non-traditional data resources using its professional and organization-based affiliations. Because the Council is a broad-based membership organization and publisher of safety and health information, these relationships provided access to the requisite variety of traffic, health, medical, and other institutional resources. Candidate data systems that had indicator data for periods before and after SBUL enactment were of particular interest, as were data systems whose target population was widespread, preferably statewide or multistate in scope.

The purposes of this survey were to identify organizations that were not recognized sources of SBUL-related information, such as professional societies and trauma registries, and to find out if they could become indicator data sources. Accordingly, traditional sources known to have this information, such as state-level police accident report data bases, safety belt use observation studies, and attitude/opinion surveys were specifically excluded from the survey, but not from consideration as potential data sources.

The final results of the survey and the data system profiles were made available to NHTSA and used at the expert team meeting.

1. Identification of candidate information sources. An initial list of information sources was developed through a search of the Encyclopedia of Associations (Burek, Koek & Novallo, 1989). Sources were screened based on their description in the Encyclopedia. An organization was excluded from this survey if it clearly did not keep any kind of data. If any information collection or dissemination activity was indicated, the organization was put on the contact list. Additionally, information sources were suggested by the COTR and the expert team.

Specific mailings were prepared to solicit information source recommendations from the governors' highway safety representatives and from the chairmen of the state and regional

trauma committees of the American College of Surgeons. (See Appendix F.) These two groups were thought to be most knowledgeable about data collection activities in their geographical areas and fields of expertise (highway safety and trauma care, respectively).

2. Development of selection criteria. The features contained in the data system profile were developed in the same way as those in the indicator profile. They were refined based on expert input and are as follows:

<b>Representativeness:</b>	is a census or statistical sample of a well-defined population.
<b>Timeliness:</b>	insures data are collected promptly and made available for analysis quickly.
<b>Reliability/Quality:</b>	insures data are coded and classified consistently over time; coding scheme is well defined.
<b>Flexibility:</b>	can be modified easily/cheaply to collect additional data.
<b>Detail:</b>	can distinguish motor-vehicle-related trauma; may record crash characteristics.
<b>Nature of the System:</b>	insures continuing participation and support.
<b>Specificity:</b>	defines variables as singular attributes.
<b>Accessibility:</b>	is automated for computer analysis and currently available from an institutional source.
<b>Cost:</b>	has reasonable user fees associated with obtaining a machine readable data set.
<b>Compatibility:</b>	can be linked to other data bases and used nationally recognized coding standards.
<b>Disadvantages:</b>	additional shortcomings not noted elsewhere.
<b>Other Advantages:</b>	additional advantages not noted elsewhere.



The expert team comments and rankings were used by the project team to assist them in making the final report recommendations.

During the expert team meeting, participants were asked to indicate the data systems they thought would not be promising for the future pilot evaluation study of high-potential SBUL indicators. The experts recommended two additional selection criteria which were accepted by the project team and the list of high-potential data systems was further shortened to 15.

The final selection of indicators and data systems was the responsibility of the project team, taking into account the advice and recommendations of the experts. The project team used the rankings and comments provided by the experts together with the in-depth literature reviews and data system profiles to arrive at its final conclusions.

### III. RESULTS AND DISCUSSION

Table 3 lists and defines the 12 indicators selected by the project team as having the highest potential for assessing SBUL impact. The first four are general injury severity indices that can be expected to change in pattern and level following the introduction of a SBUL. The next variable, ejection, is an event that safety belt use is directly intended to prevent. The proposed part of body indicators (head, face, eye, etc.) and the head injury to whiplash ratio have been found in a variety of research studies to be affected by safety belt use and use laws.

#### A. High-potential Indicator Candidates

In general, the high-potential candidate indicators selected by the project team were obtained from the literature review. Past use of an indicator to evaluate safety belts or belt laws provided the most solid evidence of its future utility as a SBUL impact indicator. It also afforded a reasonable expectation that the indicator would be available in existing data systems or could feasibly be collected. The profiles in Appendix J discuss each of these indicators on the basis of the literature review and input from the expert team. The relative importance of the high-potential indicators was established through the following analysis of the characteristics of the indicators with respect to the evaluation features and the expert team's rankings.

1. Summary of indicator profile data. Final selection of high-potential indicators was based on the body of information compiled during the project as it applied to the six indicator profile features.

Validity. Although all the top indicators are associated with consequences of crashes, some appear to have a more direct connection than others, namely, head and/or face injuries, whiplash, and ejections. They portray relatively specific circumstances that safety belt use and, by inference, SBULs should affect. The other injury types and the general injury indices are likely to be influenced by a number of variables not associated with belt use. These confounding variables are not easily identified and therefore difficult to eliminate or control. The validity of the Maximum AIS (MAIS) index is open to question for another reason, as well. MAIS may not be a valid indicator of severity itself because it focuses on the single most serious injury and may not represent the overall threat to life that occurs among victims with multiple low severity injuries. Also, relative measures such as the ratio of head to whiplash injuries possess statistical ambiguity, that is, a change in the ratio does not necessarily mean that the injury of interest is actually affected.

**Table 3**  
**High-potential Indicators, Definitions, and Sources**

General Shifts in Frequency or Distribution by Severity: KABC

The KABC scale is a system for recording the presence and severity of injuries whereby "K"=fatal injury, "A"=incapacitating injury, "B"=nonincapacitating evident injury, and "C"=possible injury. Complete definitions are in sections 2.3.2 through 2.3.5 of the Manual on Classification of Motor Vehicle Traffic Accidents, ANSI D16.1-1983.

Sources: Police accident reports.

General Shifts in Frequency or Distribution by Severity:  
Abbreviated Injury Scale

The Abbreviated Injury Scale (AIS) is used to code the part of body, nature of injury, and threat to life for acute traumatic injuries. Each injury is assigned a six digit numerical code that identifies (1) the general body region, (2) the organ or specific area, (3) the severity level assigned in succession within each organ or body part entry, and (4) the AIS severity code number, ranging from 1=minor injury to 6=maximum-virtually unsurvivable injury and 9=unknown.

Sources: Emergency medical services, hospital, and trauma registry data.

General Shifts in Frequency or Distribution by Severity: Maximum AIS and Overall AIS

The Maximum AIS (MAIS) and Overall AIS (OAIS) are derived from the single digit AIS severity code number and are defined as the highest severity code assigned to any of a patient's injuries. The severity codes for MAIS/OAIS are identical to those for AIS. However, while the AIS severity code is assigned to an injury, the MAIS/OAIS codes are assigned to a patient.

Sources: Derived from AIS severity codes in emergency medical services, hospital, and trauma registry data.

General Shifts in Frequency or Distribution by Severity: Injury Severity Score

The Injury Severity Score (ISS) is derived from the individual AIS codes for all of a patient's injuries. It is defined as the sum of the squares of the highest AIS severity codes in each of the three most severely injured body regions. The body regions differ from those for AIS and are (1) head or neck, (2) face, (3) chest, (4) abdominal or pelvic contents, (5) extremities or pelvic girdle, and (6) external.

Sources: Derived from AIS severity codes in emergency medical services, hospital, and trauma registry data.

Table 3, Cont'd.  
High-potential Indicators, Definitions, and Sources

Ejections

Total ejection occurs when the entire body is thrown from the vehicle through a window, door, or other opening in the vehicle due to a crash. Partial ejection occurs when one or more parts of the body project from a window(s), door, or other openings in the vehicle during a crash.

Sources: Police reports, ambulance run reports, emergency medical services data.

Head Injuries

All head injuries, excluding ear, eye and face, and defined by AIS (1985) to include cranium injuries, anatomic lesions, and non-anatomic (concussive) injuries.

Sources: Emergency medical services, hospital, and trauma registry data.

Facial Injuries

All facial injuries except for the eye.

Sources: Emergency medical services, hospital, and trauma registry data.

Eye Injuries

Eye injuries which carry significant risk of permanent visual impairment (AIS>1).

Sources: Emergency medical services, hospital, and trauma registry data; National Eye Trauma Registry.

Spinal Cord Injuries

Transient or paraplegic injury to the lumbar, thoracic, or cervical spine of AIS>1.

Sources: Emergency medical services, hospital, and trauma registry data; National Spinal Cord Injury Database.

Upper Extremity Injuries

Upper extremity injuries as defined by AIS (1985) to include the shoulder girdle and joints and all structures of the arm, elbow, forearm, wrist, hands and fingers.

Sources: Emergency medical services, hospital, and trauma registry data.

Lower Extremity Injuries

Lower extremity injuries as defined by AIS (1985) to include all structures of the thigh, knee, leg, ankle, foot and toes.

Sources: Emergency medical services, hospital, and trauma registry data.

Table 3, Cont'd.  
High-potential Indicators, Definitions, and Sources

Ratio of Head Injuries to Whiplash Injuries

This indicator is an index equal to the ratio of head injuries to cervical sprain or whiplash injuries.

Sources: Derived from emergency medical services, hospital, and trauma registry data.

[Note: See Appendix J for a complete discussion and review of the literature on each indicator.]

**Usefulness.** The information gathered in this project provided only cursory guidance with regard to the political utility of the indicators. Indicators that are readily understandable and whose consequences are evident appear most likely to appeal to legislators and the general public. Such injuries as head, face, spinal cord, eye, and ejection fit this description well, whereas coded indices, which are somewhat difficult to comprehend, and injuries that are usually non-life threatening, are intuitively not as provocative. Nevertheless, the actual costs implied in some of the "less attractive" indicators may be quite a bit larger than is immediately apparent. For example, the national cost of lower extremity injury as a major cause of disability and lost work is significant, according to the expert team.

**Objectivity.** All the medical indicators are defined by AIS codes and based on observed diagnostic data gathered by trained coders. Even so, some injuries such as whiplash are more dependent upon subjective report than others. KABC also is based on defined physical evidence of a type that law enforcement personnel are trained to perceive or secure from interviews. Similarly, full ejection should be readily observable, although partial ejection, as was indicated in Appendix J, may be less susceptible to direct detection.

**Sensitivity.** Sensitivity relates to the capacity of an indicator to detect a change produced by SBUL enactment. The importance of this feature is magnified by the fact that post-SBUL usage rates in the U.S. are usually well below those reported in the foreign countries whose research has been reviewed for this project.

In general, indicators that can be expected to show the largest differences between belted vs. unbelted occupants and that occur most frequently, are likely to be the best measures of SBUL impact. With these thoughts in mind, the sensitivity of indicators such as eye and spinal cord injuries, which do not show large post-SBUL reductions and occur infrequently, must be termed suspect. In contrast, injuries to the head and face, which occur with relative frequency and show consistently large safety belt use effects, appear to have great potential for SBUL impact measurement. Occupant ejections, which are known to be reduced significantly by belt use, have the potential to be a highly sensitive measure, although frequency of reported occurrence may be a problem. Shifts in overall severity as measured by AIS and KABC also appear to have potential for reflecting SBUL impact, but, as generic indicators, they may be more susceptible to the effects of confounding variables than specific injury events.

**Feasibility.** Indicators were ranked as highly feasible if they could be defined for reliable data collection. Due to the nature of training required for AIS users, its reliability as a coding system should be quite high, probably higher than the KABC system which entails much less precision. That is, fatalities and incapacitating injuries appear to be consistently and

accurately detected by both systems while the match between KABC and AIS coding for less serious injuries, including the non-incapacitating variety, is not good. One reason for this discrepancy is that many KABC coded occupants who are only slightly injured may never seek medical treatment at an emergency room. Also, KABC and its variations appear to be more subject to local investigation and administrative policies and conditions than is the AIS process. Likewise, the reporting of ejection appears to be influenced by local investigative practices.

**Generalizability.** All indicators are based on commonly accepted definitions and are inherently generalizable within the limitations of the representativeness of the sample(s) included in the data collection process. Unlike medical and treatment costs and related variables, which are likely to be influenced by local social and administrative conditions, these indicators have wide applicability to the general driving population.

2. Experts' ranking of indicators. In an effort to obtain some consensus of opinion from expert team members about the candidate indicators, a ranking task was used. Its objective was to produce an ordering of the indicators based on their general potential and usefulness for measuring SBUL impact. As part of the procedure, experts were invited to add other indicators to the list and offer comments to enhance an indicators's future usefulness.

A number of respondents did not complete the ranking as instructed. As a result, it was difficult to determine the level of inter-rater agreement on the relative potential of the indicators.

To enable analysis of the original ranking data shown in Appendix K, the following method of standardization was employed. Indicators not ranked by an expert were assumed to be tied for the remaining ranks. Other indicators suggested by the experts were deleted from the rankings and the ranks of the remaining indicators were adjusted accordingly. This procedure produced Table 4 in which every indicator was ranked from 1 to 12 by each expert with no missing ranks and no extra indicators.

To determine the degree of overall agreement among the experts, the standardized rankings were analyzed using Kendall's coefficient of concordance,  $W$ , which is a measure of correlation (Siegel, 1956). After adjusting for ties,  $W$  was found to equal 0.268, which is statistically significant ( $X^2=61.95$ , d.f.=11,  $p<.001$ ), indicating a modicum of agreement among the experts. That is, there was some commonality among the criteria used by the experts in making their judgments about indicator potential.

Given the finding of a statistically significant  $W$ , the order of the sums of ranks (the  $R_j$ 's in Table 4) may be considered the best estimate of the "true" ranking of the indicators. Thus, head injuries and ejections were judged to be the two most promising indicators followed by face injuries, general shifts in the ISS, and general shifts in AIS.

Table 4  
Adjusted Rankings of High-potential Indicators

Indicator	Expert																				R <sub>j</sub>	Order of R <sub>j</sub> 's	
	#2	#5	#7	#9	#12	#14	#16	#17	#19	#26	#27	#29	#31	#37	#38	#8	#13	#18	#28	#32			#33
KABC	5	1	11	9	2	12	9.5	12	11	6	10	2	11	7	12	6	11.5	4.5	2	6	9	159.5	7
ALS	3	2	8	3	8	10	9.5	5	10	3	7	3	9	4	4	8	6	4.5	3.5	2	11	123.5	5
MAIS	8	3.5	12	9	10	11	9.5	2	9	5	9	10	10	3	3	12	6	4.5	8.5	5	12	162	8
ISS	1	3.5	7	9	9	9	9.5	8	8	4	4	11	8	2	2	2	6	4.5	1	4	10	122.5	4
Ejections	2	8.5	6	2	1	3	1	4	1	12	1	1	7	1	1	5	3	8	3.5	1	2	74	2
Head	6	8.5	3	1	3	2	3	1	2	1	6	4	1.5	5	5	1	2	1	5	3	1	65	1
Face	12	8.5	2	9	4	1	5.5	6	4	2	3	5	1.5	8	6	3	1	2	6.5	7	5	102	3
Eye	7	8.5	1	9	12	5	5.5	11	5	8	5	6	3	12	9	7	9	10	6.5	9	8	156.5	6
Spinal Cord	11	8.5	9	9	5	8	3	3	12	11	2	8	4	6	7	9	9	11	10	12	7	164.5	10
Upper Extr.	9	8.5	4	5	6	7	9.5	10	6	9	11	12	6	11	8	11	9	12	8.5	10	6	178.5	12
Lower Extr.	10	8.5	10	4	7	6	9.5	9	7	10	8	4	5	10	11	4	11.5	7	11	8	4	167.5	11
Head/Whip	4	8.5	5	9	11	4	3	7	3	7	12	9	12	9	10	10	4	9	12	11	3	162.5	9

Kendall's coefficient of concordance,  $W = 0.268$ , ( $X^2=61.95$ , d.f.=11,  $p<.001$ ).

Note: R<sub>j</sub> is the sum of the adjusted rankings for each row of the table.

The indicator ranking results must be interpreted in light of the nature of the task. Its objective was to judge indicator potential at the most general level, that is, without regard for the multiplicity of specific data sources, research questions, and analytic techniques that could influence the outcome of the ranking process. These factors together with the varying backgrounds of the experts, which can be assumed to influence their perspective, obviously contributed to the response variability shown in the rankings. Nevertheless, the array in Table 4, particularly at the high and low ends of the ranking, corresponds well with the expert team comments received during the project and at the final meeting.

3. Recommended high-potential indicators. On the basis of expert in-put, literature review and data system survey results, the project team judged four indicators to be the most promising. In order of increasing specificity, they are:

- \* General injury severity as measured by the KABC scale.
- \* General injury severity as measured by AIS and its derivative index, ISS.
- \* Ejections.
- \* Head & face injuries.

General injury severity as measured by the KABC scale. The KABC system is recommended because of its widespread use and the likely availability and computerization of its records, particularly for retrospective examination of SBUL impact. Several studies have already used these records in time series analyses in the states of North Carolina (Reinfurt, et al., 1988), and Michigan (Wagenaar, Streff, & Liu, 1988). Other studies indicate that KABC and its variants correlate to a degree with AIS codes and as such, are at least coarse measures of injury severity.

Because it is used on the crash scene by police, KABC is applied to a broader spectrum of motor vehicle occupants than is AIS, which describes only medically evaluated crash victims. Available evidence seems to indicate that injury reduction following SBUL impact is likely to be greater for minor and moderate injuries than for more severe injury categories. If this is true, it may be that KABC has the potential of being a more sensitive indicator of SBUL impact than AIS insofar as it does a better job of recording the incidence of "no" and "low severity" injury cases. On the other hand, the relationship between KABC assessment and hospital admission/outcome of a case deteriorates as injury severity is reduced. In a study currently being conducted in Maine, only about one third of nonincapacitating injuries can be matched to a final disposition. Clearly, the use of KABC data appears appropriate as a first cut in a two tiered study or as part of a linked data collection effort. If severity classification system definitions other than KABC's are being used by police, their objectivity must be considered,

together with the manner of their use in MV crash investigation. In particular, the need to use consistent reporting policies, procedures and practices as well as coding and recording during the SBUL impact measurement period is critical to KABC's acceptability as a high-potential indicator.

General injury severity as measured by the Abbreviated Injury Scale and its derivative index, the Injury Severity Score. The Abbreviated Injury Scale (AIS) is recommended because it is widely used by emergency departments and trauma registries. [Trauma registries are specialized data bases containing information about the characteristics, treatment, and outcome of injuries.] EMS or ambulance records also use AIS although the Glasgow Coma Scale and Champion's trauma score are more common.

The AIS has the advantage of being able to identify specific kinds of injuries involving specific parts of the body. If the records are complete, an investigator can track the incidence of precisely defined injuries.

The Injury Severity Score (ISS) is derived from the individual AIS codes for all of a patient's injuries. The ISS is an attractive indicator because it assigns to each patient a single number which represents the overall severity of the patient's injuries and which may then be used in the computation of other statistics for groups of patients.

One obstacle to widespread use of the ISS is that there is no commonly accepted interpretation of the scores into descriptive terms such as minor, moderate, severe, etc. Although an ISS greater than 10 is usually considered "severe," authors have used 9 or 12 as the separation point.

Proper use of the ISS also requires complete AIS coding of all of the patient's injuries. If a data system severely restricts the number of injuries that may be coded, then the computed ISS may not be valid.

Application of both the AIS and ISS is limited to those cases that enter the emergency medical care system. This automatically excludes persons who are uninjured, receive care from other sources, or die before entering the system.

Ejections. Of all the indicators under discussion in this project, ejection is the only one linked to an event that safety belts are specifically intended to prevent. It is not surprising, then, that the evidence gathered from the literature shows a correlation between belt use and reduced ejections that is strong and unequivocal.

That a reduction in ejections will reduce deaths and injuries is well documented. Evans (1989) estimated fatality reduction for unrestrained car occupants at 18% if ejections alone could be eliminated. Other studies estimating the effect of reduced ejections on decreasing nonfatal injuries have previously been cited. For these reasons, ejections are a strong candidate as an indicator of SBUL effects.

Measurement of ejection is not without problems, however. Ideally, data should be collected on both total and partial ejections, and although total ejections seem to be well reported,

most studies have suggested that the reporting of partial ejection is unreliable. This may be because there is little emphasis on collecting data about partial ejections, or because injured persons are moved before accurate data can be collected. This latter event could affect determination of total ejection as well.

Aside from reliability considerations, the only serious question about the use of ejection as an indicator involves belt usage among "high-risk" drivers who are likely to be involved in violent crashes with ejection situations. Specifically, is this group affected less by SBULs than others in the population? Clark & Sursi (1989) posed this problem based on their review of FARS data. No direct empirical evidence has been found in the literature to resolve it. In a recent study, Hunter et al. (1988) found that although belt non-users had significantly more single vehicle and rollover accidents than users, crash severity, vehicle deformation and accident speed did not vary significantly by belt use. Unfortunately, this study did not look at ejection differences. Even if SBULs affected belt-wearing for the ejected population as a whole less than others in the population, strong ejection reduction effects may still be found among certain population sub-groups whose belt wearing is affected by SBULs.

Ejection occurs relatively infrequently and produces serious injuries and deaths. Accordingly, its capacity as a SBUL impact indicator may not differ from that of fatalities alone. The similarity between ejections and fatalities as impact measures is both a plus and a minus. On the positive side, the ability to eliminate particularly severe injuries, which can result from ejection, has great legislative appeal. Even though fatality data are readily available to legislators, corollary information about ejections may be very beneficial. On the negative side, fatality data have not been found to be a particularly sensitive indicator of SBUL effects, and ejections may prove to be no better. Even so, the incidence of non-fatal ejections increases the sensitivity of ejection as an indicator at least numerically speaking, and makes its further investigation worthwhile.

Apart from the question of SBUL impact, it seems certain that the importance of ejection data will increase for other reasons. The introduction of air bags may give those who doubt the worth of safety belts or question the need for SBULs ammunition to begin repeal efforts. Indeed, the groundwork for an "either-or" misconception about air bags and safety belts was laid in the late 60s and early 70s and reinforced by the revocation clause in DOT's 1984 automatic restraint rule. Prevention of ejection by safety belt use will no doubt be a major argument of those in the traffic safety field who want to counter SBUL repeal efforts and to emphasize the continued need to wear belts. Also, ejection is likely to be the primary indicator used by researchers to measure the life-saving benefits of SBULs when both safety belts and air bags are employed in crashes. Since air bags are likely to affect ejections less than other high-potential indicators, the methodological problems of

competing causal influences may be diminished by using ejections as an indicator.

Ejection data are also widely available. All but four states include ejection on their police accident reports. It is also recorded on some EMS or ambulance run reports and by some trauma registries, though not nearly to the same extent as on police records. Nevertheless, the reliability of ejection reporting is open to question. Whether the source is police or EMS personnel, reporting is influenced by local administrative policies and practices. This problem must be confronted if ejection data are to be useful.

**Head and face injuries.** Head and face injuries, taken separately or together, probably have the highest potential for measuring the effects of SBUL impact. Relatively speaking, they constitute the most frequently occurring types of motor vehicle occupant injury. They have, in most studies, shown sizeable reductions in passenger injuries of all severities and minor driver head injuries, which can logically be tied to safety belt use and SBULs.

This effect has been reported both under circumstances where the nature and severity of injury has been specific and well defined through the use of AIS code designations as recommended in this project, and in cases where injury site and severity have been stated only generally.

From the viewpoint of public appeal and impact on legislators, the likelihood of significant reductions in head and/or facial injuries constitutes both an economic and emotionally persuasive argument for enacting or strengthening SBULs. Visualization of the potential for death, long-term brain damage, and disfigurement from such injuries requires little stretch of the imagination. Further, the opportunity for human interest publicity focusing on the tragic effects of these injuries is readily evident both to dramatize the meaning of statistical findings and to marshal "grass roots" support for SBULs.

Although both of these indicators appear to be robust based on this project's findings, there are several factors that can impede their feasibility as SBUL impact indicators. These include level of post-SBUL safety belt use, vehicle occupant seating position, and type and speed of crash as well as nature of the injured occupant sample itself.

The non-U.S. studies, which support these indicators all report high levels of usage--in excess of 90% post-SBUL. This is far greater than the 40% post-SBUL usage typically reported in this country. The size of SBUL effects on these indicators cannot be expected to be as great with lower post-SBUL usage.

The driver is more liable to incur head and face injury than the front-seat passenger because of the steering wheel. This vulnerability rises with increased speed and crash severity. As a result, post-SBUL impact may be most readily demonstrable among front-seat passengers or when driver head/face injury is studied under conditions where crash speed and severity is considered in the results analysis. Also, as air bags become prevalent in the

vehicle fleet and play their obvious role in protecting the driver, they complicate attempts to isolate SBUL impact on driver head and face injuries.

As is the case for all medically collected injuries, the pre/post SBUL sample consists only of those whose injuries are included in the recording process and not all MV occupants exposed to the crash situation. That is, those who are saved from injury because of the SBUL and often, those who receive immediately fatal head/face injuries are excluded from the sample. Autopsy records of fatalities can be incorporated into the collection process but determination of the exposed but uninjured occupants is not possible within the medical record system. Inability to gain access to these figures may result in a failure to detect on a statistical basis, actual reductions in head/face injuries.

**Conclusion.** If the high-potential indicators recommended here prove to be valid, reliable and sensitive in pilot evaluations, then state officials may have access to several immediately useful SBUL impact measures unavailable nationally. Almost all states have police accident report systems that record ejections and 40 states record injury data using the KABC scale or equivalent. Many states also have trauma registries that could provide AIS-coded injury data for the medical indicators. Linked or unlinked, these two sources can provide data for evaluation studies of SBUL impact in states that have laws and baseline data for future impact studies in states without laws.

4. High-potential indicators not recommended. Several of the high-potential indicators listed in Table 3 were, for various reasons, not recommended.

**Maximum AIS (MAIS).** According to Rutherford (no date), the MAIS is too rough a measure of overall severity for patients with multiple injuries. Multiple injuries at a lower severity grade may be a greater threat to life than a single injury at a higher severity. The Injury Severity Score (ISS) appears to be a better measure of overall threat of multiple injuries.

**Eye injuries.** Eye injuries that result in visual impairment appear to be a poor indicator because of their low frequency of occurrence. Huelke, O'Day and Barhydt (1982) estimated an incidence of 17-26 permanent eye-impairment cases per 100,000 occupants. Furthermore, while the experience with eye injury reduction in foreign countries has been positive, the U.S. experience may not be comparable because of the significant differences in vehicle windshields. U.S.-manufactured cars use a High Penetration Resistance (HPR) windshield while many of the cars in Europe, England, Australia and Asian countries, where the evaluation studies were performed, have tempered windshields. Although tempered glass breaks into small pieces when impacted, the jagged glass retained in the lower windshield frame frequently causes ocular perforations.

**Spinal cord injuries.** Spinal cord injuries are also rare events. The National Spinal Cord Injury Data Research Center

reported an estimated incident rate of 30 to 50 spinal cord injuries per million population with approximately 50% of these cases resulting from motor-vehicle crash induced trauma (Stover & Fine, 1986). Research studies evaluating the effectiveness of safety belts or belt-use laws support the rarity of this injury. Consequently, the numbers reported in these studies are often too few to be statistically meaningful.

Regardless of the small numbers of cases, the care of individuals with spinal cord injuries ranges far beyond initial medical treatment and rehabilitation, permeating all aspects of an individual's lifestyle from simple activities of daily living to career and family. The broad physical consequences to the individual and the high societal costs of such injuries seem to suggest that, while not useful as an indicator, preventing even a small number of these injuries through SBULs could have a large effect on the public's positive perceptions of safety belt use.

Upper and lower extremity injuries. Injuries to the upper and lower extremities are clearly reduced by safety belt use according to a number of foreign studies. Lower extremity injuries tend to be much more disabling and costly (to individuals and society) than upper extremity injuries. Both upper and lower extremity injuries, however, are usually minor and rarely life-threatening. For this reason, it may be difficult to position this reduction in such a way that the public or legislators will recognize it as a meaningful benefit of safety belt-use. While useful as research tools, these indicators lack the utility to be recommended for general use.

Head injury to whiplash ratio. This ratio is, technically, a good candidate indicator. Several studies have shown a reciprocal relationship between the incidence of head injuries and cervical neck sprains -- as one increases the other generally decreases. Nevertheless, whiplash can be difficult to diagnose, so that measuring frequency of cases is not always reliable. Thus, legislators may be somewhat skeptical of an indicator which relies on it, and may be reluctant to use a "negative" indicator (one which shows undesirable effects) of safety belt use laws. It is also possible that the ratio could show a decrease, implying a positive effect of the law, even if neck injuries increased while head injuries remained the same.

5. Comments on other indicators. Absent from the indicators selected by the project team for final evaluation were criteria such as lost years, permanent impairment, or disability indices. Although these were recognized as critical from the viewpoint of both the direct and long term benefits of SBULs, they were judged to be beyond the scope of this project.

Information about the cost of motor vehicle injury and related indices was not found to exist in any usable fashion nor were insurance data determined to be useful for SBUL evaluation. With regard to the latter, Adrian Lund of the Insurance Institute for Highway Safety (personal communication, July 28, 1989) made the following observation in response to this project's inquiry:

Information from insurance injury claims is limited and cannot provide a very sensitive assessment of the effectiveness of belt use laws.

The reasons for these limitations, according to Lund, are the "self-report" nature of insurance data obtained from involved motorists; the lack of medical detail beyond actual costs, making injury coding difficult; the lack of computerized information other than financial regarding premium income and loss; and the few available mechanisms for pooling existing insurance information.

The Highway Loss Data Institute (HLDI) does collect limited information from participating insurance companies on insured vehicles and loss payments for personal injury protection and collision coverages. It has reported the results of loss experience based on these data for eight belt use law states with personal injury protection coverage, i.e., no-fault states. (Highway Loss Data Institute, 1988.) Although the effect of belt use laws on injury claim rates was found to be inconsistent, the report discusses a variety of reasons for this finding, chief among which, as Lund states "...is the fact that medically minor injuries (for example, whiplash) often have financially significant claims and tend to dominate the insurance claims." He sums up the HLDI findings by saying:

The effect of belt use laws on injury claims estimated in the report is probably not a good measure of the effect of such laws on the public health. Given current limitations on the kinds of data available from insurance companies, it is not possible to improve on the HLDI analysis at this time.

A variety of unusual candidate indicators such as dental records, organ donations, and windshield repair data, which were hypothesized to have some relationship to SBUL enactment, were also examined during the project. Without exception, these data were not collected in a way that would make them suitable SBUL impact indicators. This situation was not surprising but, as was the case with insurance data, reflects the chronic difficulty of finding data collected for administrative or other general purposes that are also suitable for impact evaluation research.

Finally, as shown in Appendix E, numerous other indicators were reviewed during this project and found to be unacceptable. In particular, attempts to find previously untested indicators being compiled by new data sources were unsuccessful. No doubt some of the indicators eliminated during this project, might be useful in providing SBUL impact evidence on a case history or other anecdotal basis. But, for the purpose of future research,

the most promising indicators appear to be among those listed in Table 3.

6. Foreign experience. The U. S. evaluation of SBULs has relied mainly on the traditional indicators of fatalities and observed safety belt use. Therefore, the literature review phase of this project depended heavily on foreign research to identify alternative indicators. Australia, Sweden, West Germany, the United Kingdom, and other countries have had SBULs much longer than the U. S. and have used a wider variety of indicators for evaluation.

The project team found that some foreign studies of safety belt effectiveness and SBUL effectiveness used the traditional indicators but most used medical indicators such as the nature of injury or part of body injured or injury severity codes such as the AIS and ISS. The data for these studies came primarily from hospital records (either single hospitals or multi-hospital consortia) but some used police accident reports or EMS records.

The findings of these foreign studies are presented in Appendix J where the high-potential indicators are profiled.

## B. Data System Candidates

Profiles for 19 data systems selected in the Council's survey were created for the expert team meeting. At the COTR's suggestion, a profile of a twentieth data system, the National Electronic Injury Surveillance System (NEISS), was prepared following this meeting. (See Appendix L.)

The experts and the project team agreed on two additional selection criteria: (a) no single-hospital trauma registries because of the limited and sometimes changing catchment area, and (b) no one-time studies because of the lack of continuing data collection. The first criterion eliminated two systems and the second criterion eliminated three more systems.

The remaining 15 systems, listed in Table 5, were considered to be the kinds of data sources that could be involved in the future pilot testing of high-potential impact indicators, although not all were equally appropriate for specific research projects. A variety of systems were represented: single- and multi-county trauma registries; state-wide trauma registries; head or spinal cord injury registries; and systems that linked records from some combination of ambulance or EMS run reports, police accident reports, emergency room records, hospital in-patient records, death certificates, etc. Each general type of system had pros and cons which depend on the indicator and the research methodology to be employed.

1. Trauma registries. Trauma registries generally had limits on either the kinds of cases included or the area covered. Some of the registries investigated by the Council had rather complete coverage of a limited part of the state. For example, the Emergency Medical Services Major Trauma Records system covers

**Table 5**  
**High-potential Data Systems, Institutions and Descriptions**

Bay Area Trauma Registry

California Emergency Medical Services Authority  
Trauma registry including eight participating trauma centers in four counties of the San Francisco Bay area. Covers Fresno north to Oregon border.

Emergency Medical Services Major Trauma Records

San Diego County Emergency Medical Services  
Comprehensive trauma registry incorporating pre-hospital, inpatient and coroner's records.

Florida Trauma/Head Injury/SCI Registry

Florida office of Emergency Medical Services  
Trauma registry covering all injuries in hospitals >300 beds and head/SCI from those >100 beds.

Major Trauma Outcome Study (MTOS)

Washington Hospital Center, Trauma Research Center  
Standardized set of data contributed by approximately 90 trauma registries.

Maryland Automated Accident Reporting System (MAARS)

Maryland Institute for Emergency Medical Services Systems  
Statewide police accident report data base used for routine analyses and linked to various medical records for special studies.

Missouri Bureau of EMS, Ambulance Reporting System

Missouri Department of Health, Bureau of EMS  
Mandatory ambulance run reporting system used for administrative purposes, resource allocation, service evaluation and injury control programming.

Missouri Head and SCI Trauma Registry

Missouri Dept. of Health, Division of Health Resources  
Head and SCI trauma registry.

National Electronic Injury Surveillance System (NEISS)

U. S. Consumer Product Safety Commission  
Statistical, nationwide sample of 61 emergency rooms which report data on product-related injuries.

New York Department of Motor Vehicles Records

Institute for Traffic Safety Management and Research  
A series of studies of the NY safety belt law using police accident reports together with attitudinal measures (telephone surveys), observational data, and data on convictions and citations for nonuse.

**Table 5, Cont'd.**  
**High-potential Data Systems, Institutions and Descriptions**

**Oregon Injury (Trauma) Registry**

Oregon Department of Human Resources, Health Division  
Trauma registry including (1) all deaths due to injury, (2) hospital admissions for injury and poisoning, (3) hospital admissions for any external cause except E870-E879, and (4) re-admissions within 6 months after original discharge for treatment of injury.

**Sensitivity Index Project**

Maine Health Information Center  
A long-term special study to evaluate the effectiveness of EMS using linked police crash reports, ambulance run reports, hospital discharge diagnosis data, death certificates, and census data.

**Spinal Cord and Head Trauma Center**

Roosevelt Warm Springs Institute for Rehabilitation  
Statewide registry of SCI and disease resulting in neurological deficit; head injury resulting in temporary or permanent decrease in cognitive, behavioral, social, or physical functioning.

**Spinal Cord Injury Early Notification System**

Colorado Dept. of Health, Division of Prevention Programs  
Registry of SCIs involving (1) traumatic origin, (2) neurological deficit, (3) residents of Colorado or Wyoming at time of injury, (4) injured after 1/1/86, and (5) reported to the ENS surveillance system.

**University of New Mexico Hospital Trauma Registry**

University of New Mexico Hospital  
Statewide coverage. Includes patients admitted due to fall, mva, motorcycle, gunshot, stabbing, pedestrian, blunt assault, bicycle, blunt trauma, and other trauma. Excludes burns, poisonings, hangings, drownings, electrical shock, DOA, and treated & released in ER.

**West Virginia Trauma Registry**

West Virginia Department of Health, Office of EMS  
Relatively new general trauma registry.

[Note: See Appendix L for a full description of each system.]

only San Diego County, the Bay Area Trauma Registry includes eight participating trauma centers in four counties of the San Francisco area, and the Oregon Injury Registry covers only six counties. The limited geographical coverage of these systems generally means that a high percentage of trauma cases within the area are captured in the system because virtually all trauma cases are referred to these facilities. This is an advantage if one is using an indicator such as facial injury that tends to have low severity (e.g., AIS  $\leq 2$ ) but high frequency.

Some systems had more complete geographical coverage, usually statewide, but collected data from a limited number of facilities. The Florida Trauma Registry, New Mexico, and West Virginia systems were of this type. These systems would be more likely than the limited-coverage group to capture high-severity, low-frequency injuries, such as head or spinal cord injuries of AIS  $\geq 3$ .

All of the trauma registries were able to identify motor-vehicle-related injuries through either the ICD external cause of injury code (E-code) or a special variable used to record the most common injury causes.

Both the local and statewide trauma registries were generally able to provide data on any of the part-of-body indicators because almost all of them used the AIS to code injuries. Use of the AIS also means that the ISS may be computed and the corresponding "general shifts" indicators may also be used for analysis. Sometimes, though not often, the ICD was used to code injuries. In these cases it is necessary to use the ICD-to-AIS translation algorithm to describe part-of-body injuries. Other trauma registries specialized in certain kinds of high-severity cases, usually head or spinal cord injuries (SCI). The Florida Head Injury/SCI Registry, Missouri Head and SCI Trauma Registry, Spinal Cord and Head Trauma Center (Roosevelt Warm Springs Institute); and the Spinal Cord Injury Early Notification System (Colorado) were typical examples. These systems generally had very detailed medical information about the injury including diagnosis, treatment, and rehabilitation.

The amount of information about the etiology of the injury varied from system to system. Some used only an ICD E-code to indicate the manner of injury. Others included some crash factors such as seating position, safety belt use, type of vehicle, etc.

The general disadvantage of these systems was the small number of cases available for statistical analysis.

2.. Linked systems. Linked-record systems seem to hold the greatest promise for research purposes but pose some of the most difficult practical problems. The Maryland Institute for Emergency Medical Services Systems, for special purpose studies, links police accident reports from the Maryland Automated Accident Reporting System to EMS, hospital, and medical examiner records. The Sensitivity Index Project (Maine) links police, ambulance, hospital, and death certificate records. The advan-

tage of such systems is that they can provide the broadest range of indicators for analysis. They contain a great deal of detailed information about the crash, the injured who enter the medical system, the uninjured occupants, and those who die before entering the medical system, depending on how many record keeping systems are linked together. The principal disadvantage is the difficulty in making the necessary linkages. Unless provision is made in advance for some common identifier, it can be extraordinarily difficult to match records from two systems. If more than two systems are involved, such as linking police accident reports to ambulance/EMS run reports to emergency department records to inpatient records, then the number of unmatched records grows quickly which reduces the number of cases available for analysis and introduces questions about potential systematic biases in the cases studied.

3. Other systems. The Institute for Traffic Safety Management and Research (New York DMV Records) was included because it examined attitudinal measures, observational data, and conviction and citation records as well as police accident reports. While not a linked-records system, it does represent an attempt to use multiple data sources. Ejection and a derived-KABC scale were the only high-potential indicators available through this system.

The Missouri Bureau of EMS Ambulance Reporting System is an example of a system based solely on ambulance run reports. It has complete statewide coverage, but uses Champion's trauma score and the Glasgow coma scale rather than the AIS to assess severity. Attempts are being made to link the ambulance run reports to police accident reports and hospital records.

The Major Trauma Outcome Study (MTOS) is unique in that it was the only system uncovered that combined data from more than one state. That makes it attractive from the point of view of obtaining multi-state data from a single source. However, the contributing trauma registries participate voluntarily and tend to come and go. Of the approximately 90 systems currently participating, 15-20 have been involved for the full seven years of the project.

The MTOS records AIS codes for up to 25 injuries and uses the ICD E-code to record the manner of injury. This means that part-of-body indicators as well as general shifts in AIS or ISS may be used for analysis.

From 1978 to 1982, the National Electronic Injury Surveillance System (NEISS) collected data on motor-vehicle-related injuries for NHTSA under a cooperative agreement. Apparently the agreement was terminated when NHTSA brought on line the National Accident Sampling System (NASS). NASS gives NHTSA a statistically representative sample of crashes and the persons injured in them with more detail on crash factors than NEISS could provide. The NEISS still has the potential to provide nationally representative data from a single source. It appears to be the only system currently in existence that can be modified

relatively easily for such a purpose and is, therefore, worth consideration as a possible source of indicator data. Clearly, however, the NEISS cannot be used retrospectively to evaluate SBUL impacts in states that already have laws because crash data and motor vehicle injuries are not available for the period immediately before or after the law.

NEISS now has 61 data collection sites in 32 states and Puerto Rico. Twenty two of the 32 states (69%) have SBULs, and 48 of the 61 sites (79%) are in SBUL states. The CPSC plans to add 10 more sites, of which seven are in SBUL states.

On the other hand, NHTSA's Emergency Medical Services Division used the NEISS data to determine a "nationally representative estimate" of the fraction of highway-related injuries that were admitted to hospitals or arrived at the hospitals via ambulance. NHTSA learned that state EMS directors reject such "nationally representative estimates" as a basis for comparing or evaluating their programs. They consider that evaluation of their highway safety programs should be based on data which is representative of conditions in their particular states. This is not to say, however, that such estimates would not be useful at the national level.

4. Promising data systems. None of the data systems satisfied all of the evaluation criteria. All suffered disadvantages such as imprecisely defined indicators or limited geographical coverage. There was, however, one existing system that appeared promising as a "ready-to-go, multi-state" system and one that could be useful in the future. A third option has potential for single-state studies.

Multi-state systems. The Major Trauma Outcome Study (MTOS) has the advantage of broader geographical coverage than other systems because it includes data from about 90 registries, but voluntary participation in the system means that the data are not necessarily nationally representative. Injuries are coded using both AIS and the International Classification of Diseases (ICD) and the manner of injury is identified using ICD external cause of injury codes (E-codes), including the place of occurrence. Since January 1989, safety belt use can be recorded if known. If hospital and patient identifiers are stripped from the records, then the data could be made available for research. The MTOS is the one data system identified in the survey that is similar to the NHTSA's 19-city safety belt use observation study (i.e., broad geographical coverage from a single source) and available immediately without substantial modifications.

The National Electronic Injury Surveillance System (NEISS) currently could collect data on motor-vehicle-related injuries if the inter-agency agreement mentioned above were renewed. Then a nationally representative sample of hospital emergency room treated injuries would be available. According to the Director of the CPSC's Division of Hazard and Injury Data Systems, it could take as little as two to three months to define data and reporting requirements and begin data collection. The cost of

using NEISS depends on the level of detail desired. It could be as low as \$10 per case for routine surveillance data obtained from the emergency room records. Or, it could be as low as \$100 per case for in-depth data obtained through follow-up telephone contacts. The main disadvantage to using NEISS would be the lack of pre-SBUL data in SBUL states, and the limitation on the kinds of cases that are treated at hospital emergency rooms. The advantages would be that NEISS surveillance data can be AIS-coded and NHTSA could specify the data elements to be collected and the coding schemes to be used for follow-up interviews.

**Single-state systems.** Trauma registries, in general, seem to be good sources of data for the injury indicators (head, face, etc.). The injuries are usually coded using the AIS and an ISS can then be derived. Specific kinds of injuries can be tracked as well as changes in overall severity. The disadvantage is the limitation on the kinds of cases that enter the trauma registries. The uninjured and some fatalities are not included.

Systems that can be linked together through some common identifier seem to have the greatest potential, but also the greatest problems. A broader spectrum of cases can be examined by linking police accident reports to emergency department or trauma registry records and death certificates. The difficulty lies in making the necessary linkages. Existing records systems seldom contain the necessary common identifiers.

**Modifications or combinations.** There are several options available to improve the usefulness of data systems for state level SBUL evaluations. Some are more practical than others. Some can be done retrospectively while others must be planned for the future.

Medical records systems, which include ambulance or EMS reports, ER records, trauma registries, and inpatient records, can be modified to include full AIS coding of all injuries. These data would maximize the usefulness of the systems for all research and evaluation purposes (not just SBUL evaluation). If coroner/medical examiner reports of traumatic deaths also included AIS coding of injuries, then it would be possible to incorporate fatality data into analyses of changes in injury severity.

In view of the importance of ejection as a high-potential indicator, police accident reports that do not include information on ejection should be modified to collect such data, and those states that do not record partial ejection should be encouraged to do so.

Linked records systems have been identified as the most promising approach to SBUL evaluation. Linked records allow the researcher to build corroborative evidence from multiple indicators and, if police accident reports are included, to examine the injury outcome for all vehicle occupants. Furthermore, linked systems provide more data on potential confounding factors than single systems, which permits investigators to control for them. Police accident reports provide vital crash data that are not captured on medical records, and medical

records provide more complete injury data.

As mentioned before, however, linked records systems, such as those in Maine, Missouri, New Jersey, and Pennsylvania, are difficult to create. There are numerous barriers to linking systems. The most sensitive is privacy protection of the injured individual, a concern that creates resistance to use of common identifiers that are needed to link data bases. Other barriers include costs, cost sharing, workload burdens, timing, language or coding mismatches, and nonautomated records.

Except in prospective studies, where the investigator has greater control over the data to be collected, the kind of data system available to the investigator determines the indicators that can be used in a SBUL evaluation. Some researchers have only police accident report data with which to work. For them, the best indicators are ejections and severity changes as measured by the KABC scale. If, however, any of the medical record systems are available and the AIS is used to code injuries, then the part-of-body indicators may be used along with the general shifts in severity indicators.

### C. Methodological Issues

A primary goal of this project was to recommend indicators that were timely, reasonable, and immediately available. It was recognized that the indicators selected, whatever they were, would be influenced by methodological, practical, and political issues. The following discussion focuses on four of the issues that received the majority of comments by the experts (see Appendix M).

1. Impact of non-SBUL programs and other factors on high-potential indicators. To evaluate belt use law effectiveness, high-potential indicators must be compared under conditions of law present versus law absent. The simplest method of accomplishing this task is to observe the indicator data gathered from a target population over two study periods, one before and one after SBUL onset.

A major difficulty associated with simple before/after SBUL observation studies is the possibility that changes in variables other than the SBUL may occur during the investigation and that these changes may be wholly or partially responsible for any observed differences. In this regard, it is conceivable that these confounding variables may even produce "negative" findings in the form of no change or increases in indicators that are expected to decrease as a result of SBULs. Examples of such variables include speed limit increases, increased vehicle mileage, changes in vehicle equipment/construction, increased DWI enforcement, improved economic conditions, changes in medical care, or changes in other highway traffic safety programs.

To establish a causal relationship between the enactment of the law and changes in the high-potential indicators, the effects of these confounding variables must be eliminated or controlled

so that SBUL impact can be isolated and observed. Some level of control can be established statistically but it is usually accomplished by the use of control or comparison groups.

One of the more popular statistical techniques being used to assess SBUL impact is time series analysis. This approach requires numerous reliable data points (50-100). In most studies these data have been obtained from police records. The method requires that SBUL impact be strong enough statistically to produce changes in the indicator(s) being studied over and above those produced by historical variations. This analytic strategy as described by Wagenaar, Streff, and Liu (1988) in their study of Michigan's SBUL, "involves explaining as much of the variance in each (indicator) variable as possible on the basis of its past history before attributing any of the variance (impact) to another variable, such as passage of a law making restraint use compulsory."

Another option, in the absence of control groups, is to study post law usage rates to see if the effect size in the indicator(s) being examined is proportional to the change in the use rate. This corroborative analysis does not benefit from the increased control offered by historical variance estimates. It affords correlational rather than causal inferences but may be useful to add weight to the presentation of "positive" post-SBUL changes. A problem with this approach is that data on use rates in the after-law period beyond the initial data point may be unreliable or unavailable. Also, unless it can be shown that belt use declines or remains constant immediately post-law, which is highly unlikely, this method is of little use in interpreting cases where apparently "negative" indicator effects are observed.

The use of research designs that employ comparison groups is strongly recommended to provide the most acceptable presentation of impact results. Two approaches have been commonly employed.

One approach is to compare the experience of those targeted by the law with a group or groups not targeted by the law but exposed to similar highway/traffic conditions during the same period in the same state. The non-targeted populations might include bicyclists, motorcyclists or pedestrians, or possibly all three as a sort of macro control group. This type of design was employed by States et al. (1986), where bicyclists, motorcyclists, and pedestrians were identified for comparison with targeted occupants as to the frequency and change in severity of injuries sustained. The rear seat occupants of targeted vehicles have also been used as a non-targeted control group for comparison with targeted occupants on a similar basis (Rutherford et al., no date).

The logic of using a non-targeted population as a control group rests on the assumption that all other factors are affecting the safety of targeted and non-targeted populations equally, with the only difference between them being that belts are unavailable or unused in the non-targeted population. Some critics have suggested that the causal factors involved in the non-targeted classes of motor vehicle accidents may be suffi-

ciently different from those in the targeted group so as to bring into question the validity of this assumption. For example, some researchers maintain that the injury risk at different seating positions is quite variable, making the use of rear seat occupants as a comparison group of limited usefulness.

Another approach involves comparing indicator data in SBUL and non-SBUL states. Extreme care must be taken in choosing a comparison state as initial differences in driving conditions/terrain, vehicle mix, exposure (vehicle miles), mean driving speeds, and other factors may exist between states and affect SBUL impact indicator results, clouding their interpretation. Also, similarity between states in indicator data collection must be assured or if differences exist, their effects on results must be known. Another potential problem with this design rests in the uncertainty associated with changes in the SBUL status in the chosen study states, which disrupt continuity and affect results interpretation. For example, the state with the law may decide to repeal or strengthen it or the comparison state may enact an SBUL within the study period.

Despite the potential difficulties mentioned above, these two approaches have been employed with some success in evaluation belt law effectiveness. Campbell and Campbell (1986) utilized both approaches in a comparison model and observed that the largest decline in fatalities occurred in the targeted group and that four out of the eight belt law states achieved significant declines in fatalities relative to states without laws.

## 2. Retrospective vs. prospective study of SBUL impact.

Studies that analyze existing data on events that have already occurred are referred to as retrospective studies. On the other hand, studies that use existing or specially created record keeping systems to collect data on events as they occur and then analyze these data are called prospective studies.

Both retrospective and prospective investigations of SBUL impact are appropriate. Even so, prospectively gathered data are preferable to historical records data primarily because there is an opportunity to plan all aspects of the data collection process. This includes definition of the indicator(s) to be collected and establishment of the mechanisms by which reporting and recording will take place. The investigation by Rutherford et al. (no date), cited several times in this report, probably best exemplifies the potential of this approach, at least with reference to injury-based indicators. In this study, the data collection form, items, and recording procedures were piloted, monitored, and checked by in-person visits to the hospitals participating in the study.

Unfortunately, the option for conducting prospective studies rarely exists because the majority of belt laws do not include a data collection provision. Also, because SBUL enactment is so unpredictable and fraught with political entanglement, it has been difficult to attract before-the-fact support and institutional cooperation for prospective studies. This problem is

demonstrated by the general lack of promising data systems in non-SBUL states, as reflected in the results of the Council's survey.

Retrospective studies, although usually much cheaper and less time consuming than prospective studies, may be hampered by data that are deficient in detail and/or subject to unknown reporting biases. This situation is likely to be present in studies that are limited to police report data in computerized state records.

These data problems can be overcome to some degree, if data collection, coding and sampling procedures are highly controlled. For example, Barancik et al. (1988) used an epidemiologic study design to examine retrospectively emergency department records in Suffolk County, New York, during the first and second quarters of 1984 (pre-SBUL) and 1985 (post-SBUL). Injury data from records sampled for pre and post periods were compared with similarly retrieved injury data from the same periods from emergency departments in Rhode Island, a non-SBUL state. During this project, costly and painstaking examination of case records according to a strict sampling procedure was employed to obtain high quality data.

Clearly, retrospective studies are the only option available to those states that already have belt use laws. Dependent upon the resources available, these studies can focus on police recorded data, which is computerized and readily accessible or on hospital record data, which must be collected through a laborious and relatively costly process. On the other hand, prospective studies started after the SBUL effective date can be used to monitor and evaluate changes in enforcement or other belt-related programs or to improve the future quality of trend data.

3. Population-based data sources, limitations of indicator data collection and coding. Population-based data sources are needed to compute incidence rates (e.g., cases per thousand population or cases per hundred occupants). Precise population definition in terms of size and characteristics is essential to the interpretation of rates and to the generalization of results. In particular, ignorance about changes in an exposed population over time can undermine even the most meticulous data collection effort.

Ideally, the exposed population for SBUL impact encompasses all crash-involved front seat motor vehicle occupants covered by the SBUL. This covers both the uninjured and the injured at all severity levels including fatalities. It involves all property-damage-only crashes as well as injury crashes.

Unfortunately, data on the exposed SBUL population are rarely, if ever, available from state motor vehicle or medical records. Each of these sources has inherent deficiencies that prevent access to the entire motor vehicle crash victim spectrum.

All states have minimum motor-vehicle damage report levels, which are raised from time to time, so that only a portion of all accidents are recorded. For example, a 1984 study of state motor

vehicle records produced by the All-Industry Research Advisory Council, a council formed by the property-casualty insurance industry, described the overall conditions of motor vehicle accident recording by states as follows:

State limitations on reporting and recording of traffic accidents make state motor vehicle records incomplete as a source of information on driver performance. Only 47% of the 27,402 accidents known to insurers were found to be listed on the publicly available records of the 37 states included in this study. Even when the analysis was confined to accidents involving vehicle damage of \$500 or more, only 55% of these relatively serious accidents showed up on the MVRs. (p. 1)

Obviously, injury surveillance sources are more selective in their coverage than are police. Only victims with injuries sufficiently severe to require treatment enter the system. Also, injured victims who die immediately are not likely to be included in the case records. Those fatality records that are included frequently lack autopsy data, which could tie the death to injury types associated with safety belt non-use. It was estimated by one member of the expert team that autopsies were performed on only about 15% of motor vehicle fatalities.

Graitcer (1987) describes the general problems with medical indicator data collection as follows:

Most injury surveillance systems are based on data that have been collected for other purposes. Consequently, the data fail to include critical facts, are imprecise, and are often not timely, which limits their value for epidemiologic surveillance. (p. 193)

Certainly, linking trauma registries and other injury surveillance systems with police records constitutes an important and positive step toward developing a more complete picture of SBUL impact than is currently available. Even so, the data collection problems inherent in these sources when viewed separately will not be resolved by combining systems. For example, simple lack of motivation or training on the part of data collectors, which results in incomplete or erroneous reporting must be confronted and resolved. Also, within the states where the linking of data systems is occurring such as Maine, Maryland, and New York, the expeditious matching of records continues to present difficulties.

In summary, comprehensive population-based SBUL impact indicator data are not being collected by any source.

4. Political utility of indicator data. One of the primary objectives of this project was to recommend nontraditional indicators with high potential for political influence. This implies indicators that are substantive and valid, quickly and reliably gathered and presentable in a fashion that can withstand public scrutiny. All the indicators selected for the final evaluation have these characteristics, at least to a degree. Their political viability has yet to be demonstrated, however. This must be done with a recognition of the political climate as it exists for SBULs.

In examining the political ramifications of indicator data use, the ideological issues of the safety belt debate must not be overlooked. They involve the perceived lessening of individual responsibility and freedom as well as the government's role in promoting the common good by protecting the motorist and general public (Leichter, 1986).

Before a law is passed supporters tend to focus their arguments on the demonstrated effectiveness of safety belts in reducing deaths and injuries and the obligation of the government to see to it that these benefits are realized. The assumption is that a SBUL will cause an increase in belt use that is sufficient to produce these reductions. Opponents, though not necessarily disagreeing about the effectiveness of safety belts, question the wisdom of going to the extreme of passing a law to produce the projected benefits. This reluctance relates directly to a broader fear about the gradual erosion of personal freedom and responsibility through government intervention. SBULs are then seen as another case of the state imposing its judgment on that of the individual.

SBUL enactment does not resolve this controversy but rather places the burden of demonstrating the law's benefits directly on its supporters. Once a law is passed, if the anticipated reductions in fatalities and injuries cannot be shown to the expected degree, then the worth of the law becomes the issue, quite apart from the effectiveness of safety belts themselves. This situation is likely to arise when supporters have based their benefit estimates on the maximum reductions associated with unrealistically high post-law usage levels. The failure to show a sufficient benefit to offset the perceived loss of personal freedom implied by the existence of the SBUL not only works in favor of the opposition but can lessen the conviction of original SBUL supporters.

In a Massachusetts SBUL repeal study, Hingson et al. (1988) conducted a post-repeal survey that found a relatively strong interaction between judgments about the SBUL's effectiveness and its infringement upon personal liberty. Among respondents who switched allegiance from support to opposition, many who cited increased invasion of personal freedom as their reason, also perceived the SBUL to be less effective in reducing injury and death than they had earlier in the year.

Empirical evidence scientifically gathered and understandably presented offers the strongest foundation for

supporting safety belt use laws. Use of unreliable or invalid data as "evidence" to demonstrate SBUL impact is unacceptable and self-defeating. It is unacceptable because it demeans the intelligence of legislators and other decision makers whose support is needed to enact and/or retain SBULs. It is self-defeating because it provides leverage for SBUL critics and can damage the credibility of a pro-SBUL position on a long-term basis.

The matter of communicator credibility is also particularly important in light of the inherent complexity of the SBUL impact evaluation problem. Results of even well-designed and executed investigations are likely to yield varying and sometimes controversial findings. When claims are made based on inadequate studies or ill-founded conclusions, communicator competence as perceived by the target audience is jeopardized. If this situation is publicized, it can produce an atmosphere of public mistrust so that even valid findings have little persuasive value.

Hingson et al. noted that the radio talk host who was one of the prime spokespersons for repeal in Massachusetts did not challenge the validity of official safety belt effectiveness data. He did maintain, however, "that the government reports on the law's effects were constantly changing and inconsistent." This problem applies logically to attempts to introduce non-traditional indicators into the SBUL support picture. Care must be taken to insure that the body of data is not only authoritative but that the problem of inconsistency is eliminated or handled in an acceptable fashion.

Given the political and philosophical nature of the SBUL debate, it is not certain that the indicators recommended in this project will portray SBUL impact in a way that can influence legislators and the public, to a greater degree than has been done by traditional indicators. In pilot-testing the utility of the recommended indicators, however, the pitfalls of inadequate study design and overstatement of results must be avoided.

Notwithstanding the need for scientific excellence in the study of recommended indicators, it is clear that public opinion and legislation can be influenced by case history or correlation-based evidence. This notion is particularly relevant given the aforementioned indicator data limitations and the fact that in many instances the resources and institutional cooperation are simply not available to conduct SBUL research that will stand up under close scientific scrutiny.

Spinal cord and brain injuries, for example, convey inherent emotional appeal both among legislators and the general public and deserve comment. From a scientific or research perspective, the low incidence of these injuries may reduce their usefulness as indicators of SBUL effectiveness. That is, the overall number of these cases may be too small to permit comparisons that are statistically meaningful.

Nevertheless, the consequences of severe brain and spinal cord injuries can be devastating. Many of the injured are young

and will require long term treatment, rehabilitation, and training. Such far-reaching physical effects plus the high societal costs associated with these injuries may, on a case-study basis, be persuasive to legislators or to the public at large. Such injury cases could well be used by safety belt coalitions and other citizen advocacy groups to help increase public understanding or interest in the benefits of safety belt use laws.

Similarly, testimonials given by individuals and provided by various "saved by the belt" groups may be of value in reaching certain segments of the target population. In this way, everyone who has a motor vehicle accident and attributes his or her survival to the safety belt is a potential champion for belts and belt laws. This type of appeal may be just what it takes to reach certain segments of the targeted population, such as younger, 8-15 year old occupants. Care must be taken to make sure that the claims being made are reasonable and do not appear to be exaggerated or overly preachy.

Finally, with the current public concern over rising medical and insurance costs, translation of indicator data into cost units could have a substantial impact in legislatures that are pondering the passage of a seat belt law. Some possible sources for cost data are the health services cost review commissions or similar agencies, which may be found in approximately twenty states. Most of these maintain a minimum of information as defined by either the Uniform Hospital Discharge Data Set or the Uniform Billing Data Set, which share many of the same elements. In addition, some of the commissions or agencies use ICD external cause of injury codes (E-codes) and linkages may be possible to police reports, making them particularly useful in assessing the impact of belt laws. Despite the pitfalls experienced in some cost studies, this measure of injury impact on society may be quite cogent.

Regardless of the political utility problems potentially associated with SBUL impact indicators, the importance of linking SBULs to their injury reduction benefits is too great to forestall continued study of the recommended indicators. The indicators identified on page 22 can provide objective information not only to measure general belt usage changes, but also to monitor the impact of various facets of SBULs, such as fines, enforcement efforts and public information and education campaigns. The next chapter presents the project team's recommendations for developing the high-potential indicators into useful measures of SBUL impacts.

#### IV. RECOMMENDATIONS

The primary objective of this project was to explore the feasibility of using data from existing sources to monitor safety belt use law (SBUL) impact. The findings of this investigation suggest that there is no clear-cut indicator or combination of indicators currently being collected by a data system or systems that can provide immediate and useful trend information on SBUL effectiveness. There are both indicators and data systems that appear to have future potential, but they cannot be termed "existing" and "ready to go" on a national scale as initially envisioned in this project.

Use of existing rather than newly designed data systems to assess SBUL impact presents critical problems which cannot be overlooked and are not easily resolved. Data collected for administrative or other general uses rarely provide the kind and quality of information that meets research needs as they relate to political or program analysis.

Clearly, the potential of SBUL impact indicators recommended in this project depends directly on the adequacy of the data systems that collect them. If indicator data are not collected in a representative and reliable fashion, their credibility is lessened no matter how valid or sensitive they are. The first priority for high-potential indicator development must be the advancement and fostering of comprehensive and reliable data collection systems.

##### A. National Coordination of Indicator Data Collection

At the national level, the following actions are recommended to lay the foundation for achievement of this objective:

- \* Initiate institutional cooperation in the collection of SBUL impact data by the federal government and national organizations. This effort should include NHTSA, the National Institute for Occupational Safety and Health, the Occupational Safety and Health Administration, the Centers for Disease Control, the Consumer Product Safety Commission, the Bureau of Labor Statistics, private organizations such as the National Safety Council, Traffic Safety Now, the Insurance Institute for Highway Safety, and other appropriate agencies and groups.
- \* Obtain input about data collection problems and plans to overcome them from state/local injury surveillance, law enforcement, research and other professionals similar to those who participated in this project.

- \* Develop and disseminate technical information to improve the overall adequacy of high-potential indicator data collection at the state and local levels.
- \* Establish a special "start-up" assistance program with some degree of preference for organizations willing to "institutionalize" indicator data collection.
- \* When appropriate, develop data sources and indicators that can also monitor the impact of other (non-SBUL) highway safety programs.

It should be noted that NHTSA has established a cooperative agreement with the National Association of Governors' Highway Safety Representatives to foster the development of uniform statewide highway injury data bases.

#### B. High-potential Indicator Data Collection

Although no new SBUL impact indicators were found that can provide immediate and useful trend information to officials, some can be recommended for future study. These high-potential indicators are:

- \* General changes in injury severity as measured by the KABC scale.
- \* General changes in injury severity as measured by AIS, and its derivative index, ISS.
- \* Ejections.
- \* Head and face injuries as defined by AIS codes.

Because this selection was made on the basis of earlier research and expert opinion, the efficacy of the recommended indicators remains to be demonstrated. Specifically, it is necessary to verify that these indicators possess the measurement characteristics necessary to assess SBUL impact. In particular, research should be undertaken to:

- \* Determine the sensitivity of high-potential indicators to assess SBUL impact at less than the maximum expected safety belt usage levels.
- \* Determine the feasibility of indicator data collection given the questions concerning the reliability and consistency over time of police and medical reporting and record sources.

Conduct of this research can be initiated on a single-state or multi-state basis depending on the indicator(s) being ex-

amined. Also, although prospective investigation of SBUL impact is preferable, the pressure for "immediate" results and the fact that the majority of states have already enacted SBULs make retrospective studies attractive.

### C. Promising Data Systems

The findings of this investigation suggest that there are no data systems that can be termed "existing" and "ready to go" in a manner analogous to NHTSA's "19 city" belt use information. There are however, two promising data systems that can be recommended as possible national or multi-state sources of indicator data:

- \* The Major Trauma Outcome Study (MTOS) operated by the Washington Hospital Center for the American College of Surgeons Committee on Trauma.
- \* The National Electronic Injury Surveillance System (NEISS) operated by the U. S. Consumer Product Safety Commission.

The key concerns in the use of MTOS are attracting a more representative sample than currently exists and maintaining the participation of registries that become involved. To achieve this objective, the purpose of MTOS would probably have to be expanded beyond simply the evaluation of trauma care systems, which tends to invite short-term participation.

NEISS has collected motor vehicle injury data for NHTSA in the past and an interagency agreement could be reinstated. Costs and start-up time seem to be reasonable. The data that can be obtained include some high-potential indicators. One limitation involves the nature of the sample, i.e., emergency room visits.

In addition to the multi-state systems, MTOS and NEISS, there are many state-wide trauma registries and state traffic records systems that can provide data immediately on some of the high-potential indicators, or could provide data with some modification.

Linkage between record keeping systems, as discussed on page 35, is highly desirable though not absolutely necessary for evaluation research. In spite of the many barriers to linkage, it has been achieved successfully in a few states.

### D. Retrospective Study of High-potential Indicators

Only retrospective impact studies are possible in states that have already enacted SBULs. In this regard, KABC and/or ejection data probably constitute the most readily available indicator information. States that have this information should be asked to participate in these studies. Accumulation of indicator data sets from several states will allow comparisons of

impact results among states with differing SBULs and will enable the examination of the effects of such SBUL variables as strength of enforcement, inclusion of impact evaluation requirements, sunset clauses, and number and type of belt use exemptions. Other effects of SBULs such as changes in estimated belt use, public perceptions about enforcement levels and impact differences among demographic groups also can be studied. These data can also serve as baselines against which to measure the effects of changes in belt use programs and legislative threats, whether or not they are successful.

Along with the conduct of discriminative evaluations based on SBUL and other variables, availability of indicator data from a number of states provides a unique opportunity for comparing the power of different statistical methods. Exploration of new statistical techniques to refine detection of differences appears to be a necessary step toward SBUL impact analysis.

States with trauma registries should also be encouraged to provide retrospective data, if available. In particular there is a need to correlate head/face injury data and AIS/ISS severity data with general background data and the KABC data from state traffic record systems.

#### E. Prospective Study of High-Potential Indicators

The focus of prospective research recommendations is guided by the need to assess SBUL impact and to describe the benefits of highway safety programs in general. As regards the former, it is clear that prospective research potential is dependent on the existence of SBULs in states. In the general context of program evaluation, however, the shoring up of data collection to improve its reliability and usefulness can be undertaken in all states.

Prospective study of SBUL impact should be considered for non-SBUL states that have data systems already in operation and are likely to enact SBULs. In this project, non-SBUL states of Alaska, Arizona, Mississippi, South Carolina, Vermont, and West Virginia have trauma registries that hold promise for future study. Other non-SBUL states may also have suitable data systems that were not identified in this project. Another non-SBUL state, Maine, is already in the process of laying the groundwork for prospective research by evaluating a system that links police crash reports to ambulance run reports, hospital discharge data, and death certificates.

The passage of SBUL legislation in these non-SBUL states cannot be predicted with certainty. Even so, if indicator data are gathered in a limited number (3 or 4) of states where the most positive SBUL activity is occurring, then the passage of laws in one or more of these states would permit before/after evaluation. States that failed to pass SBULs could provide comparison data. Whatever the combination of passage decisions, so long as at least one state enacts a SBUL, the groundwork for a prospective study has been laid.

Specific recommendations for this type of research are as follows:

- \* Insure the scientific adequacy of evaluation design and data collection methods with built-in reliability checks.
- \* Use a sufficiently large population base (preferably statewide) to provide an adequate indicator sample size and enable appropriate generalization of results.
- \* Use police, EMS, and injury surveillance data systems whose records are linked to improve the comprehensiveness and accuracy of indicator data, or, if linking records systems is not possible, include the collection of crash information, such as occupant seating position, belt use, crash speed and collision type, to refine SBUL impact analysis.
- \* Include controls which can provide concurrent baseline and post-SBUL impact indicator data.

Due to the complex realities that are associated with SBUL impact assessment, these guidelines represent ideals that can only be approximated. It is recommended, however, that emphasis be given to the conduct of a few well-controlled investigations rather than many studies where, for lack of sufficient resources, research quality must be compromised.

Prospective studies can also be useful in states with SBULs to examine the long-term impact of the laws; to evaluate the effect of changes in enforcement, public information and education campaigns, or amendments to the law; or to provide base-line data to estimate the effect on safety belt use of other traffic safety measures.

There are a number of general indicator data collection improvements that can be recommended to support impact evaluation. These relate both to state traffic record and injury surveillance systems and are as follows:

- \* Use common identifiers on police accident reports, EMS and emergency room records, trauma registries and other systems to promote linkage of records.
- \* Modify traffic records systems to record partial ejection on police accident reports.
- \* Promote the use of AIS codes in autopsy records and coroner/medical examiner reports to facilitate inclusion of fatality data in SBUL evaluations.
- \* Promote the uniform use of ICD external cause (E-code)

coding of injuries in emergency room and hospital admission records.

- \* Develop a medically more meaningful injury classification than KABC, that can be used by police.
- \* Develop a more direct measure of disability than incapacity or threat to life.
- \* Develop a realistic and acceptable injury cost model that can be used to describe SBUL benefits as measured by the recommended indicator variables.

#### F. High-potential Indicator Utility

The utility of the recommended indicators should be explored with a view to positioning them in the future politics of SBUL passage, strengthening, and repeal decisions. Two issues appear to be critical: First, the difference between safety belt effectiveness and safety belt use law impact as it affects legislative and public debate; second, the role of the high-potential indicators in influencing SBUL passage and/or repeal.

Fatality and injury reductions attributed to safety belts have generally been less in SBUL states than was expected from the results of basic safety belt effectiveness research and less than was demonstrated in other countries. A variety of factors account for this situation, such as: relatively low belt use levels; nonaggressive enforcement, determined by SBUL provisions (e.g., secondary rather than primary enforcement) or administrative policy; the introduction of other confounding highway safety program changes (e.g., higher speed limits); incompleteness and unreliability of motor vehicle crash and injury data collection; the lack of auxiliary crash information to enable refined statistical analysis, and the lack of appropriate evaluation methods to enable interpretation of results that are detected.

These factors tend to lower apparent SBUL benefits, whatever measure is used. They also can be brought forward in adversarial discussions to cast doubt on the acceptability of impact findings, whether or not these findings support SBULs.

Given these seemingly inherent data collection and interpretation problems, the political importance of SBUL impact data should be reexamined. Two activities are recommended in priority order:

- \* Review the philosophical issues raised in the SBUL debates and redefine research and related problems in the context of these issues.
- \* Obtain the reaction of legislators and other decision makers to the high-potential indicators in view of the defined problems and issues.

It is imperative to answer the indicator utility questions prior to expending resources in high-potential indicator data collection. It is unclear at this time as to what those answers will be. In addition, these findings clearly portray the lack of usable indicator data for highway safety generally. This revelation is not new but simply reflects what has been a chronic problem for decades. For this reason, the general recommendations about coordination of data gathering efforts at the national level should be given first order priority.

In conclusion, the results of this study suggest that valid, reliable, and comparable SBUL impact indicators from multiple states are not immediately available from existing sources and the likelihood is low that they can be generated quickly. Overall assessments of SBUL impacts by national safety organizations would take at least two years because of the need to alter ongoing data collection systems and gather sufficient data. In the short term, existing single- and multi-state data bases that have begun to link crash data in police accident reports with injury data in hospital medical records or trauma registries may be used for impact analyses. The most promising long-term evaluation approaches would involve linking the existing separate data systems in states, first within each of the remaining SBUL states and then in states that may enact SBULs in the future, and taking steps to improve data definition and data system management to foster indicator analyses among the states.

## V. REFERENCES

- All Industry Research Advisory Council. (1984). Evaluation of motor vehicle records as a source of information on driver accidents and convictions. Oak Brook, Ill.: Author.
- American Association for Automotive Medicine. (1985). The abbreviated injury scale. Arlington Hts.: Author.
- Andreasson, R., & Roos, K. (1977). Effects of Sweden's belt use law. Proceedings of the 6th International Conference of the International Association of Accidents and Traffic Medicine.
- Ashton, S. J., MacKay, G. M., & Gloyns, P. F. (1973, June). International Conference on Biokinetics of Impacts. Amsterdam.
- Backaitis, S. H., & Dalmotas, D. (1985). Injury patterns and injury sources of unrestrained and three point belt restrained car occupants in injury producing frontal collisions. AAAM Proceedings, 29, 65-91.
- Barancik, J. I., Kramer, C. F., Thode, H. C., & Harris, D. (1988). Efficacy of the New York state seat belt law: Preliminary assessment of occurrence and severity. Bulletin of the New York Academy of Medicine, 64(7), 742-749.
- Briner, A. M. (1976). Penetrating eye injuries associated with motor vehicle accidents. Medical Journal of Australia, 1, 912-914.
- Burek, D. M., Koek, K. E., & Novallo, A. (Eds.) (1989). Encyclopedia of Associations. Detroit: Gale Research Inc.
- Burke, D. C. (1973). Spinal cord injuries and seat belts. Medical Journal of Australia, 2, 801-806.
- Cameron, M. H., & Nelson, P. G. (1977). Injury patterns with and without seat belts. Proceedings of the 6th International Conference of the International Association of Accidents and Traffic Medicine, 1977.
- Campbell, B. J., & Campbell, F. A. (1986). Early results of seat belt legislation in the United States of America. Proceedings of the IRCOBI Conference, 1986.
- Carlsson, G. (1983). Ejection--a hazard in traffic accidents. International Journal of Vehicle Design, 4(2), 122-125.

- Christian, M. S. (1984). Morbidity and mortality of car occupants: Comparative survey over 24 months. British Medical Journal, 289, 1525-1526.
- Clark, C., & Sursi, P. (1984). The ejection reduction possibilities of glass-plastic glazing. SAE Technical Paper 840390.
- Clark, C., & Sursi, P. (1985). Car crash tests of ejection reduction by glass-plastic side glazing. SAE Technical Paper 851203.
- Clark, C., & Sursi, P. (1989). Rollover crash and laboratory tests of ejection reduction by glass-plastic side windows and windshields. Society of Automotive Engineers (SAE) Technical Paper 890218, presented at the 1989 SAE International Conference and Exposition, Detroit, February 27, 1989.
- Cole, M. D., Clearkin, L., Dabbs, T., & Smerdon, D. (1987). The seat belt law and after. British Journal of Ophthalmology, 71(6), 436-440.
- Colorado Department of Health. (1987). Annual report of the Early Notification System (ENS). Denver: Division of Prevention Programs.
- Deans, G. T., Magalliard, J. N., Kerr, M., & Rutherford, W. H. (1987). Neck sprains--a major cause of disability following car accidents. Injury, 18(1), 10-12.
- Einar-Nilsson, L. (1976). Restraint system effectiveness. Statement to the National Motor Vehicle Safety Advisory Council, July 13, 1976.
- Evans, L. F. (1988). Restraint effectiveness, occupant ejection from cars, and fatality reductions (GMR-6398). Warren, Mich.: General Motors Research Laboratories.
- Evans, L. F., & Frick, M. C. (1989). Potential fatality reductions through eliminating occupant ejection from cars. Accident Analysis and Prevention, 21(2), 169-182.
- Freedman, L. S. (1984). Initial assessment of the effect of the compulsory use of seat belts on car occupants' injuries, and the trauma department work-load. Injury, 16(1), 60-62.
- Friedel, B., & Marburger, E. A. (1986, October). Belt usage rates in the Federal Republic of Germany and their medical consequences. 30th Annual Proceedings of the American Association for Automotive Medicine. Montreal, Quebec.

- Graitcer, P. L. (1987). The development of state and local injury surveillance systems. Journal of Safety Research, 18(4), 191-198.
- Grime, G. (1979). A review of research on the protection afforded to occupants of cars by seat belts which provide upper torso restraint. Accident Analysis and Prevention, 11, 293-306.
- Hartemann, F., Henry, C., Faverjon, G., Tarriere, C., Got, C., & Patel, A. (1984). Ten years of safety due to the three-point seat belt. Advances in Belt Restraint Systems: Design, Performance, and Usage, Society of Automotive Engineers.
- Highway Loss Data Institute. (1988). Insurance injury loss experience in eight states with seat belt laws, 1983-1986 models. Washington, D.C.: Author.
- Hingson, R., Levenson, S. M., Heeren, T., Mangione, T., Rodgers, C., Schiavonne, T., & Hertz, R. P. (1988). Repeal of the Massachusetts seat belt law. American Journal of Public Health, 78(5), 548-552.
- Hobbs, C. A. (1980). Car occupant injury patterns and mechanisms. Eighth International Conference on Experimental Safety Vehicles.
- Huelke, D. F. (1981). Effectiveness of occupant restraints in reducing serious injuries and fatalities. Proceedings of the International Symposium on Occupant Restraints, Toronto, June, 1981, American Association for Automotive Medicine.
- Huelke, D. F., & Compton, C. P. (1983). Facial injuries in automobile crashes. Journal of Oral and Maxillofacial Surgery, 41, 241-244.
- Huelke, D. F., Grabb, W. C., & Dingman, R. O. (1964, October). Facial injuries in automobile accidents. Proceedings of the American Association for Automotive Medicine. Louisville, KY.
- Huelke, D. F., Grabb, W. C., & Dingman, R. O. (1966). Facial injuries due to windshield impacts in automobile accidents. Journal of Plastic Reconstructive Surgery, 37, 324-333.
- Huelke, D. F., Grabb, W. C., & Dingman, R. O. (1967). Automobile occupant injuries from striking the windshield. (HSRI Report No. Bio-5). Ann Arbor: University of Michigan, Highway Safety Research Institute.

- Huelke, D. F., Grabb, W. C., & Dingman, R. O. (1968). The new automobile windshield and its effectiveness in reducing facial lacerations. Journal of Plastic Reconstructive Surgery, 41, 554-559.
- Huelke, D. F., Grabb, W. C., & Gikas, P. W. (1966). Injuries and deaths from windshield and instrument panel impacts. Proceedings Eighth Stapp Car Crash Conference. Detroit, MI.
- Huelke, D. F., Lawson, T. E., Scott, R., & Marsh, J. C. (1977). The effectiveness of belt systems in frontal and roll-over crashes. Proceedings of the 6th International Conference of the International Association of Accidents and Traffic Medicine.
- Huelke, D. F., O'Day, J. O., & Barhydt, W. H. (1982). Ocular injuries in automobile crashes. Journal of Trauma, 22(1), 50-52.
- Huelke, D. F., O'Day, J. O., & Mendelsohn, R. A. (1981). Cervical injuries suffered in automobile crashes. Journal of Neurosurgery, 54, 316-322.
- Huelke, D. F., & Sherman, H. W. (1975). Automobile accident studies of maxillofacial injuries. Clinical Plastic Surgery, 2, 53.
- Hunter, W. W., Reinfurt, D. W., & Hirsch, M. G. (1988). Analysis of occupant restraint issues from state accident data (NHTSA Project DTNH22-87-C-07103). Chapel Hill: University of North Carolina Highway Safety Research Center.
- Johnston, P. B., & Armstrong, M. F. (1986). Eye injuries in Northern Ireland two years after seat belt legislation. British Journal of Ophthalmology, 70(6), 460-462.
- Kahnberg, K. E., & Gothberg, K. A. (1987). Le Fort fractures (I). International Journal of Oral and Maxillofacial Surgery (Denmark), 154.
- Larder, D. R., Twiss, M. K., & MacKay, G. M. (1985). Neck injury to car occupants using seat belts. 29th Annual Proceedings of the American Association for Automotive Medicine.
- Leichter, H. (1986). Saving lives and protecting liberty: A comparative study of the seat-belt debate. Journal of Health Politics, Policy and Law. 11(2), 323-344.
- MacKay, G. M. (1978, February). Injuries for windscreens: A review of some recent literature. A Report to the Commission of the E.E.C.

- Marburger, E. A., & Friedel, E. A. (1987). Seat belt legislation and seat belt effectiveness in the Federal Republic of Germany. Journal of Trauma, 27(7), 703-705.
- Mills, P. J., & Hobbs, C. A. (1984, November). The probability of injury to car occupants in frontal and side impacts. SAE Technical Paper Series, 223-235.
- National Highway Traffic Safety Administration (NHTSA). (1989). Occupant protection facts, June 1989. Washington, D.C.: Author.
- Nashoba Systems Inc. (1987). Nutshell Plus: The relational file manager. Concord, Mass.: Author.
- National Safety Council. (1984). Manual on classification of motor vehicle traffic accidents. (Fourth edition). ANSI D16.1-1983. Chicago: Author.
- Newman, R. J., & Jones, I. S. (1984). A prospective study of 413 consecutive car occupants with chest injuries. Journal of Trauma, 24(2), 129-135.
- Nordentoft, E. L., Nielsen, H. V., Eriksen, E., & Weeth, R. (1977). Effect of mandatory seat belt legislation in Denmark, with special regard to minor and moderate injury. Proceedings of the 6th International Conference of the International Association of Accidents and Traffic Medicine.
- Norin, N., Carlsson, G., & Korner, J. (1984). Seat belt usage in Sweden and its injury reducing effect. Warrendale, Pa.: Society of Automotive Engineers Technical Paper 840194.
- Nygren, A. (no date). Injuries to car occupants: Some aspects of the interior safety of cars. Acta Oto-Laryngologica: Supplement 395.
- O'Day, J., & Scott, R. E. (1984a). Safety belt use, ejection and entrapment. Health Education Quarterly, 11 (2), 141-146.
- O'Day, J., & Scott, R. E. (1984b). Myths and realities of seat belt use. UMTRI Research Review, 14 (5), 1-5.
- Olney, D. B. & Marsden, A. K. (1986). The effect of head restraints and seat belts on the incidence of neck injury in car accidents. Injury, 17(6), 365-367.
- O'Neill, B. (1988). Seat belt use laws in the United States: Trends and prospects. Proceedings of the Symposium on Motor

Vehicle Injuries, December 7-8, 1987, New York, N.Y., pp. 729-741.

Partyka, S. (1988). Lives saved by seat belts from 1983 through 1987. (DOT HS 807 324). Washington, D.C.: National Highway Traffic Safety Administration.

Peterson, T. (1988). Iowa safety restraint assessment. Des Moines: Iowa Methodist Medical Center.

Pietrafesa, C. A., & Hoffman J. R. (1983). Traumatic dislocation of the hip. Journal of the American Medical Association, 249(24), 3342-3346.

Prentice, H. A. J. (1979, November). Seat belt effectiveness: Possible benefits and advertising. 1979 International Symposium on Seat Belts in Tokyo. Tokyo, Japan.

Pye, G., & Waters, E. A. (1986). Effect of seat belt legislation on injuries in road traffic accidents in Nottingham. British Medical Journal, 288, 756-757.

Reath, D. B., Kirby, J., Lynch, M., & Maull, K. I. (1989). Patterns of maxillofacial injuries in restrained and unrestrained motor vehicle crash victims. Journal of Trauma, 29(6), 806-810.

Reinfurt, D. W., Campbell, B. J., Stewart, J. R., & Stutts, J. C. (1988). North Carolina's occupant restraint law: A three year evaluation (HSRC-PR158). Chapel Hill: University of North Carolina Highway Safety Research Center.

Rood, D. H., & Kraichy, P. P. (1985). Evaluation of New York's mandatory occupant restraint law. Volume II: Attitudinal surveys of licensed drivers in New York state. Albany, N.Y.: Institute for Traffic Safety Management & Research.

Rood, D. H., Kraichy, P. P., & Carubia, J. (1985). Evaluation of New York's mandatory occupant restraint law. Observational survey of restraint use in New York state: April 1985. Albany, N.Y.: Institute for Traffic Safety Management & Research.

Rutherford, W. H., Greenfield, T., Hayes, H. R. M., & Nelson, J. K. (No date). The medical effects of seat belt legislation in the United Kingdom. London: Her Majesty's Stationery Office.

Sabey, B. E., Grant, B. E., & Hobbs, C, A. (1977). Alleviation of injuries by use of seat belts. Proceedings of the 6th International Conference of the International Association for Accident and Traffic Medicine.

- Sato, T. B. (1987). Effects of seat belts and injuries resulting from improper use. Journal of Trauma, 27(7), 754-758.
- Sherman, H. W., Murphy, M. J., & Huelke, D. F. (1976). A reappraisal of the use of police injury codes in accident data analysis. Proceedings of the American Association for Automotive Medicine, 128-138.
- Siegel, S. (1956). Nonparametric statistics for the behavioral sciences. New York: McGraw-Hill Book Company.
- States, J. D., Ingersoll, G. L., Annechiarico, R. P., Carleen, E. D., Good, R. G., Lieou, J., et al. (1986). The effect of the New York State safety belt law on hospital admissions in Monroe County (Rochester) New York. In 30th Annual Proceedings of the American Association for Automotive Medicine.
- Stover, S. L., & Fine, P. R. (1986). Spinal cord injury: The facts and figures. Birmingham: University of Alabama.
- Thomas, C., Faverjon, G., Henry, C., Tarriere, C., Got, C., & Patel, A. (1980). Comparative study of 1,624 belted and 3,242 nonbelted occupants: results on the effectiveness of seat belts. Proceedings of the 24th Conference of the American Association for Automotive Medicine.
- Trinca, G. W., & Dooley, B. J. (1977). Effects of seat belt legislation on road traffic injuries. Australian N 2 Journal of Surgery, 47, 675-678.
- Turnbridge, R. J., Everest, J. T., Wild, B. R., & Johnstone, R. A. (1988). An in-depth study of road accident casualties and their injury patterns. United Kingdom: Department of Transport, Transport and Road Research Laboratory.
- Vallet, G., Ramet, M., Debiez, G., Dedoyan, A., & Durand, F. (1986). Seat belt efficiency: Paired case study with unbelted and belted occupants. Proceedings of the IRCOBI Conference, 1986.
- Vernon, S. A., & Yorston, D. B. (1983). Incidence of ocular injuries from road traffic accidents after introduction of seat belt legislation. Journal of the Royal Society of Medicine, 77, 198-200.
- Wagenaar, A. C., Streff, F. M., & Liu, W. W. (1988, May). Injury reductions and social cost savings associated with mandatory restraint laws in Michigan. Ann Arbor: The University of Michigan Transportation Research Institute.

**APPENDIX A**

**EXPERT TEAM MEMBERS**

[\*Indicates those who participated in the expert team meeting.]

**APPENDIX B**  
**RESULTS OF COMMERCIAL DATA BASE SEARCH**

EXPERT TEAM MEMBERS

Phyllis F. Agran, MD  
University of California,  
Irvine

Jerome Barancik, DSci  
State University of New York,  
Stony Brook

Jeremy Broughton, PhD  
Transport and Road Research  
Laboratory, United Kingdom

B. J. Campbell, PhD  
University of North Carolina

Thomas Christoffel, JD  
University of Illinois at  
Chicago

Judith M. Conn, MS, MBA  
Centers for Disease Control

Brad Cushing, MD\*  
Maryland Institute for Emergen-  
cy Medical Services

Theodore Doege, MD  
American Medical Association

Leonard Evans, DPhil  
General Motors Research Labs

Daniel Fife, MD\*  
Princeton, NJ

Willis Goldbeck  
Washington Business Group on  
Health

Donald Huelke, PhD  
University of Michigan

Sandra Johnson\*  
Maine Health Information Center

Brian Jonah  
Transport Canada

John R. Lumpkin, MD, MPH  
Illinois Department of Public  
Health

Adrian Lund  
Insurance Institute for  
Highway Safety

Murray MacKay  
University of Birmingham,  
United Kingdom

Kimball I. Maull, MD  
University of Tennessee  
Medical Center

Rudolf G. Mortimer, PhD  
University of Illinois at  
Urbana

Raymond C. Peck\*  
California Department of Motor  
Vehicles

Tim Peterson, MD  
Iowa Methodist Hospital

Elaine Petrucelli  
Association for the Advance-  
ment of Automotive Medicine

Debra Rood  
Institute for Traffic Safety  
Management and Research

William Rutherford  
Belfast, N. Ireland

David A. Sleet, PhD\*  
San Diego State Universtiy

John D. States, MD\*  
Rochester General Hospital

Judith Stone  
National Safety Council

Claes Tingvall  
Folksam Traffic Safety Group,  
Sweden

David C. Viano, PhD  
General Motors Research Labs

Frank J. Vilaro, DPH  
Indiana University

## Literature Searches

The National Safety Council's holdings were searched using the term "seat belts" in combination with each of the following terms: (a) laws traffic, (b) evaluation, (c) legislation, (d) effectiveness, (e) regulations, (f) usage, (g) insurance, (h) trauma, and (i) injuries. Several hundred citations resulted from these searches.

Table B-1 shows the results of literature searches of the commercial data bases listed below. Also listed are the search strategies (key words) used, and any subsequent action after the initial screening.

**MEDLINE** -- general medical literature including trauma

**EMBASE** -- medical literature with special areas on public health and traffic accidents

**TRIS** -- all areas of transportation research

**ABI** -- business publications

**DISSERTATION ABSTRACTS** -- unpublished graduate dissertations

**PAIS** -- public affairs and public policy related to social, economic, and political issues

**LEGAL RESOURCES INDEX** -- legal literature

**NIOSH** -- occupational safety and health literature

**Table B-1  
Results of Commercial Data Base Search**

Search Strategies (key words) and Subsequent Actions	Number of Citations Found by Data Base							
	Medline #154	Embase #72	TRIS	ABI	Diss. Absts.	PAIS	Legal Res.	NIOSH
1. (occupant restraints or seat belts or safety belts) and (effectiveness or evaluation) <u>Subsequent Action:</u> This search was considered too general. It was decided that Search #2 would give better results.	48	13	821	7	4	4	8	11
2. (occupant restraints or seat belts or safety belts) and (effectiveness or evaluation) and laws or legislation <u>Subsequent Action:</u> Printed citations were obtained for all hits.	13	4	216	3	1	0	2	0
3. (occupant restraints or safety belts or seat belts) and (laws or legislation) <u>Subsequent Action:</u> The search was considered too general. It was decided that Search #4 would give better results.	131	37	681	25	2	15	29	5
4. (occupant restraints or seat belts or seat belts) and (laws or legislation) and impact <u>Subsequent Action:</u> Printed citations were obtained for all hits.	6	5	70	1	0	0	1	0
5. (occupant restraints or seat belts or safety belts) and (injuries or fatalities or trauma) <u>Subsequent Action:</u> Printed citations were requested from Medline, Embase, and TRIS.	293	105	1157	20	1	3	14	29
6. (occupant restraints or seat belts or safety belts) and (emergency or paramedic or ambulance) <u>Subsequent Action:</u> Printed citations were obtained for all hits.	19	10	129	3	1	1	-	5
7. (occupant restraints or seat belts or safety belts) and (defense or legalities) <u>Subsequent Action:</u> Printed citations were obtained for all hits.	0	0	18	4	0	1	29	0
8. (occupant restraints or seat belts or safety belts) and insurance and (costs or claims) and laws <u>Subsequent Action:</u> Printed citations were obtained for all hits.	0	0	3	4	0	0	0	0

**APPENDIX C**  
**INDICATOR PROFILE FORM**



INDICATOR PROFILE

Indicator: \_\_\_\_\_

Description/definition: \_\_\_\_\_

Completed by: \_\_\_\_\_ Date: \_\_\_\_\_

INSTRUCTIONS: Evaluate the indicator on each of the following features by (1) answering as many of the questions for which information is available and (2) rating the indicator high, medium, or low with respect to each feature. "High" means that the indicator exhibits the desirable aspect of the characteristic to a great degree. "Low" means that the indicator exhibits the desirable aspect of the feature to a low degree.

**Validity** [ high / medium / low ]

Is it logically associated with consequences of crashes and occupant belt use?

\_\_\_\_\_

Can it be causally linked to SBULs?

\_\_\_\_\_

Can it be temporally linked to SBULs? (I.e., is it available both before and after the SBUL was passed? took effect? was enforced?)

\_\_\_\_\_

Is it related to or influenced by factors other than belt use?

\_\_\_\_\_

If so, what other factors?

\_\_\_\_\_

How is it influenced by them?

\_\_\_\_\_

How can their influence be compensated for?

**Objectivity** [ high / medium / low ]

Is it based on observable physical evidence?

---

**Usefulness** [ high / medium / low ]

Is it oriented to the concerns of safety officials and legislators?

---

Does it measure a positive, desirable effect?

---

Does it measure a negative, undesirable effect?

---

Are the data already tabulated or analyzed periodically in useful ways?

---

**Sensitivity** [ high / medium / low ]

How much change in belt use is needed to produce a significant change in the indicator?

---

**Generalizability** [ high / medium / low ]

Can the indicator be used to make valid generalizations?

---

**Feasibility** [ high / medium / low ]

Can the indicator be defined for reliable data collection?

---

Does the indicator require special knowledge or training (e.g., medical, engineering) for data collection?

---

Use the reverse to identify any sources (other than the literature review) used for this evaluation and to make any additional comments.

## APPENDIX D

### EXPERT TEAM RATINGS OF CANDIDATE INDICATORS OF BELT USE LAW IMPACTS

- Notes: "+" = an indicator with promise that should be fully explored.  
"0" = an indicator with unknown promise that should be given some attention during the project.  
"- " = an indicator with little or no promise that should be eliminated from further consideration during this project.  
"DK" = no opinion about this indicator (includes no response).

Items marked 0/+ and 0/- were tallied as 0.

[A listing of the experts' comments on each candidate indicator may be found in Volume II, Part B.]

**Expert Team Ratings of  
Candidate Indicators of Belt-use Law Impacts**

Data Type/Example	+	Rating 0	-	DK
<b>1. Police/EMS-related Measures (MV Trauma)</b>				
___ Incidence of accident reports -- by police --by driver	10	7	6	0
___ Incidence of emergency medical service (EMS) calls for crashes; frequency/rate	11	5	6	1
___ Ambulance run reports	10	5	6	2
___ Trauma Score (Champion, 1981)	11	5	2	5
___ Number/percent of cases transported by ambulance	5	5	11	2
___ Helicopter run reports	3	4	13	3
___ Number/percent of cases transported by helicopter	3	3	13	4
___ Number/rate of ejections	19	4	0	0
___ EMS reported belt-use among crash victim; percent of belt wearers found among crash victims and fatalities	16	6	1	0
<b>2. Trauma Center/ER Treatment (MV Trauma)</b>				
___ Emergency room visits	7	9	6	1
___ Reduction or change in type or nature of visit	14	5	2	2
___ Number of cases treated versus number admitted	10	7	3	3
___ Average vehicle occupant treatment costs -- overall and between those admitted and those released	10	5	7	1

Data Type/Example	+	Rating		DK
		0	-	
___ Blood transfusions/component consumption	2	3	13	5
<b>3. Hospital/Medical-related Measures (MV Trauma)</b>				
___ Hospital/inpatient admissions: frequency/rate	9	6	5	3
___ Hospital bed occupancy rate/percent	5	4	7	7
___ Number of hospital bed-days	7	4	6	6
___ Average hospital stay per (100 ?)	7	3	7	6
___ Motor vehicle-related admissions	15	5	1	2
___ Frequency/percent of cases involving surgical intervention	8	4	8	3
<b>4. General Injury Information (MV Trauma: incidence/nature)</b>				
___ Abbreviated Injury Scale (AIS) Classification by body region (see below)	18	3	0	2
___ Classification by injury severity AIS-1 to AIS-6 (Minor to Maximum)	17	4	0	2
___ Assessment of multiple injuries: Maximum AIS (MAIS) codes	17	3	0	3
___ Injury Severity Scores (ISS)	18	2	1	2
___ Probability of Death Score (PODS)	8	6	2	7
___ Motor vehicle external (E) codes	15	4	0	4
___ Nature of disease (N) codes	7	3	3	10
___ Occupant-to-occupant injuries	7	4	5	7
___ International Classification of Diseases (ICD - 9CM) to AIS 85 Scores: Conversion table (MacKenzie et al., 1986)	9	4	1	9

Data Type/Example	Rating			
	+	0	-	DK
___ AIS 85:Condensed Chart Classifications Codes	7	3	1	12
___ General shifts/changes in severe/moderate/minor injury patterns	18	3	2	0
<b>5. Specific Injury Type: MV Trauma Incidence/Nature (Based on AIS Body Region)</b>				
<b>5.1 <u>External</u> (surface/integumentary any body region)</b>				
___ Skin (includes abrasions, contusions, lacerations)	9	4	7	3
___ Burns	2	4	12	5
<b>5.2 <u>Head</u></b>				
___ Cranium (includes fractures)	16	3	1	3
___ Brain injuries: Coma (Glasgow scale) Amnesia 3rd/4th collisions Other major injuries	17	3	0	3
<b>5.3 <u>Face</u> (includes eye, ear and mouth)</b>				
___ Face tissue/whole area	10	5	2	6
___ Facial bone/cranium separations	12	4	1	6
Eye:				
___ Eye injuries (general)	9	5	2	7
___ Penetrating eye injuries	8	5	2	8
___ Partial/permanent loss of visual acuity	5	5	6	7
___ Ear (including inner organs)	4	7	5	7
Mouth:				
___ Fractured mandible	11	2	4	6

Data Type/Example	Rating			
	+	0	-	DK
___ Type/nature of dental repairs	9	5	2	7
<b>5.4 <u>Neck/Throat</u></b>				
___ Neck (includes whiplash)	11	3	3	6
___ Throat	6	4	7	6
<b>5.5 <u>Thorax (organs, including rib cage)</u></b>				
___ Belt-induced injuries	16	1	2	4
___ Chest organ injuries (heart/lung)	11	3	3	6
___ Chest wall	10	4	3	6
___ Bruised/fractured sternum	14	3	1	5
___ Bruised/fractured ribs	13	3	1	6
<b>5.6 <u>Abdomen/Pelvic Contents</u></b>				
___ Abdomen (includes kidneys, spleen and liver)	12	3	2	6
___ Pelvic organs	10	3	4	6
<b>5.7 <u>Spine Injuries: Cervical, Thoracic and Lumbar</u></b>				
___ Cervical spine	13	3	1	6
___ Thoracic spine	12	4	1	6
___ Lumbar spine	12	4	1	6
<b>5.8 <u>Extremities and Bony Pelvis</u></b>				
___ Upper extremities	7	4	5	7
___ Lower extremities	10	4	2	7
___ Pelvis	7	4	4	8
<b>6. Epidemiology</b> [no candidate indicators]	-	-	-	-

Data Type/Example	Rating			
	+	0	-	DK
<b>7. Effectiveness Evaluations: SBULs and Others</b>				
— Expected vs. actual number of injuries	19	3	1	0
— Number of lives saved	17	3	1	2
— Number of noninjury crashes	15	2	4	2
<b>8. General Disability/ Rehabilitation Measures</b>				
— Membership changes in organization serving people disabled by crash injuries	1	8	12	2
— Sales volume of adaptive devices for vehicles of disabled persons	0	8	13	2
— Treatment cost of rehabilitation	7	9	4	3
— Incidence of secondary consequence for example: Crash-related epilepsy Post-blood transfusion hepatitis Pain-killer addictions	1	8	12	2
<b>9. Miscellaneous</b>				
<b><u>Insurance Measures</u></b>				
— Frequency/percent insurance collision injury claims	16	4	2	1
— Safety belt replacement claims/paid cases	4	6	7	6
— Windshield replacement/damage claims	6	6	8	3

Data Type/Example	Rating			
	+	0	-	DK
<u>Legal Cases: Safety-belt Defense</u>				
— Increased number of cases	6	3	10	4
<u>Manufacturer's Vehicle-case Data</u>				
— Injury patterns by occupant compartment parts (e.g., steering wheel, dash)	10	6	5	2

**APPENDIX E**

**RANKED LISTING OF CANDIDATE INDICATORS**

INDICATORS RANKED HIGH OVERALL

indicator	indicator profile features						expert rating (+/-)	OVERALL RATING	EXPERTS' REBUTTAL
	validity	objectivity	usefulness	sensitivity	generalizability	feasibility			
ejections	medium	high	high	low	medium	medium	20/4	HIGH	
all head injuries to front seat occupants, excluding drivers with severity > AIS 2	high	high	high	high	high	high		HIGH	3 MED
face injuries	high	high	high	medium	high	high	10/2*	HIGH	2 MED, 1 LO
upper extremities	high	medium	medium	medium	high	high	7/5	HIGH	4 MED, 1 LO
lower extremities	medium	high	medium	low		high	10/2	HIGH	2 MED
general shifts in frequency of injury cases or distribution by severity	high	high	high	medium	high	high	19/2*	HIGH	
head injuries, excluding ear, eye, and face	high	high	high	high	high	medium	16/1*	HIGH	1 MED
ratio of head injuries to cervical sprain or whiplash	high	medium	high	high	high	high		HIGH	3 MED, 1 LO
spinal cord injury	medium	high	high	low	low	medium	12/1*	HIGH	2 MED
penetrating eye injuries	high	high	high	high	high	high	9/2*	HIGH	4 MED, 4 LO

\*wording of indicator varies slightly from that rated by expert team

INDICATORS RANKED MEDIUM OVERALL

indicator	indicator profile features						expert rating (+/-)	OVERALL RATING	EXPERTS' REBUTTAL
	validity	objectivity	usefulness	sensitivity	generalizability	feasibility			
neurosurgical consultation (post motor-vehicle crash)	high	high	high	high	high	high		MEDIUM	3 HI, 3 LO
surgical operations (post motor-vehicle crash)	high	high	high	high	high	high	8/8*	MEDIUM	2 HI, 2 LO
frequency/per cent of multiple injury cases	high	high	high		high	high		MEDIUM	3 HI
lung injuries	high	high	high	high	medium	high	11/3*	MEDIUM	2 LO
treatment cost of rehabilitation (spinal cord injuries)	high	high	high	medium	high	high	7/4*	MEDIUM	2 HI, 2 LO
motor-vehicle related admissions	medium	high	high	high		high	15/1	MEDIUM	2 HI
number treated vs. number admitted	medium	high	high	medium	high	high	11/3	MEDIUM	2 HI, 1 LO
average medical treatment costs	high	high	medium	medium	high	high	10/7*	MEDIUM	2 HI, 4 LO
passenger compartment damage	high	high	medium	high	high	medium		MEDIUM	4 LO
number/percent of cases transported by ambulance	medium	high	high	medium	medium	high	5/12*	MEDIUM	2 LO
number of emergency room visits	medium	high	high	medium	medium	high	8/6	MEDIUM	2 LO
injury type (MV crash related)	high	medium	high	medium	medium	high		MEDIUM	1 LO
fracture of femur	high	high	medium	medium	medium	high		MEDIUM	2 HI
number of insurance claims for severe injury	high	medium	high	high	medium	medium		MEDIUM	1 LO
post-crash consciousness of accident victim	medium	high			medium	high		MEDIUM	1 HI, 1 LO
average hospital stay	medium	high	high	low	medium	high	8/7*	MEDIUM	3 HI, 1 LO
type/nature of dental repairs	high	high	low			low	9/2	MEDIUM	1 LO
facial scars	low	medium	low		low	low		MEDIUM	3 LO

\*wording of indicator varies slightly from that rated by expert team

INDICATORS RANKED LOW OVERALL

indicator	indicator profile features						expert rating (+/-)	OVERALL RATING	EXPERTS' REBUTTAL
	validity	objectivity	usefulness	sensitivity	generalizability	feasibility			
fractured sternum	high		medium	high	high	high	14/1	LOW**	2 HI, 2 MED
injury patterns by occupant compartment parts	high	medium	high	high	high	medium	11/5	LOW	1 HI, 1 MED
spinal fractures, sprains	medium	high		high	medium	high	12/1*	LOW**	2 HI
fractured mandible	high	high	low			high	11/4	LOW	1 HI, 2 MED
noncontact soft tissue neck injuries		medium	low	high	high	high	11/3*	LOW**	1 HI
occupant-to-occupant injuries	high	medium	medium	high	medium	low	7/5	LOW	3 MED
kidney injury	high	medium	low	medium	medium	high	11/2*	LOW	1 MED
pelvic injuries	high	high	medium	low	low	high	7/4	LOW	2 MED
safety belt replacement claims/paid cases	high	high	low	medium	medium	medium	4/7	LOW	1 MED
external injuries	high	high	medium	medium	low	low	9/7*	LOW	1 MED
aorta rupture	high	high	low	low	low	high		LOW	2 HI, 1 MED
leg and ankle fractures	high	high	low	low	low	high		LOW	1 HI
windshield replacement/damage claims	medium	high	low	medium	medium	medium	6/9	LOW	1 MED
facial bone/cranium separations	high	high	low			low	12/1	LOW	1 MED
facial lacerations (major soft tissue injuries)	high	high	low		low	low		LOW	4 MED
splenic injury	medium	high	low	low	low	medium	11/2*	LOW	2 MED
rib fractures	medium	medium	low	low	low	medium	13/1	LOW	1 HI, 2 MED
frequency of insurance injury claims	medium	medium	low	low	low	medium	16/2*	LOW	
general bruising (thorax)	medium	medium	low	low	low	low		LOW	2 MED

\*wording of indicator varies slightly from that rated by expert team  
 \*\*negative indicator

**APPENDIX F**

**GOVERNORS' HIGHWAY SAFETY REPRESENTATIVES  
AND AMERICAN COLLEGE OF SURGEONS  
INFORMATION SOLICITATION LETTERS**

March 28, 1989

^F1^

Dear ^F2^:

The National Safety Council is contacting Governor's Highway Safety Representatives throughout the nation to locate organizations that are collecting information useful in the continuing study of safety belt use law (SBUL) impact. We are interested in variables likely to reflect changes in motor vehicle crash effects in ways that would be expected after SBUL passage. For example, these effects might be manifested by changes in type, frequency, severity, or pattern of occupant injury; windshield or vehicle interior damage; disability or rehabilitation needs; legal or insurance claims activities; and societal costs.

The enclosure contains a list of potential data sources in your state already known to us. Please review the organizations listed and give us the names of any others that you feel we should contact to make our coverage of sources complete. Also, if any assessments of your state's SBUL have been mandated (e.g., report to legislature and/or insurance commission) or otherwise conducted, a copy of the report and the name of a contact with the organization responsible for the study would be appreciated.

As background for this request, the Council wants to obtain a more complete picture of the changes SBULs produce than is being provided by such measures as observed and self-reported safety belt use and traffic fatalities. We intend to recommend the most promising indicators of SBUL impact to the National Highway Traffic Safety Administration and to specify organizations that are in the best position to gather these data on an ongoing basis. It is our hope that the collection and analysis of additional impact measures will broaden the base of support for belt use laws, reduce repeal and referendum attempts, and raise compliance levels, thus improving the effectiveness of those laws already in place.

Again, any names or "leads" that you can supply will be appreciated. You may respond by completing the enclosed form or by contacting me directly at 1-312-527-4800, Extension 7301 or FAX 1-312-527-9381. If I am not available to take your calls, Alan Hoskin, the associate project director, Terry Miller or Kathy Race of the project staff will be pleased to record your input or answer any questions.

Sincerely,

Thomas W. Planek, Ph.D.  
Director, Research and  
Statistical Services

Enclosures

April 5, 1989

^F1^

Dear ^F2^:

The National Safety Council is contacting State Chairmen of Committees on Trauma at the suggestion of Dr. Kimball Maull. We are attempting to locate hospitals as well as medical/health treatment, rehabilitation, and other facilities or programs that identify motor vehicle accidents as a source of injury and record variables likely to be affected by increased safety belt use among motor vehicle occupants. For example, these effects might be manifested by changes in type, frequency, severity, or pattern of occupant injury; disability or rehabilitation needs; legal or insurance claims activities; and other societal costs.

Your assistance in providing the relevant data sources in your state will be appreciated. Those that we already know of are shown on the enclosed list.

As background for this request, the Council wants to obtain a more complete picture of the changes safety belts produce than is being provided by traffic fatalities. We intend to recommend the most promising indicators of safety belt use impact to the National Highway Traffic Safety Administration and to specify organizations that are in the best position to gather these data on an ongoing basis. It is our hope that the collection and analysis of additional impact measures will broaden the base of support for safety belt use and use laws.

Again, any names or "leads" that you can supply will be appreciated. You may respond by completing the enclosed form or by contacting me directly at 1-312-527-4800, Extension 7301 or FAX 1-312-527-9381. If I am not available to take your calls, Alan Hoskin, the associate project director, Terry Miller or Kathy Race of the project staff will be pleased to record your input or answer any questions.

Sincerely,

Thomas W. Planek, Ph.D.  
Director, Research and  
Statistical Services

Enclosures

**APPENDIX G**  
**DATA SYSTEM PROFILE FORM**



**National  
Safety  
Council**

---

**Exploration of Impact Measures of Safety Belt Use Laws  
DTNH22-88-Z-07391**

**DATA SYSTEM PROFILE**

Data system name: \_\_\_\_\_

Institution: \_\_\_\_\_

Contact name: \_\_\_\_\_

Address: \_\_\_\_\_  
\_\_\_\_\_

Telephone: \_\_\_\_\_

Associated indicator(s): \_\_\_\_\_  
\_\_\_\_\_

Indicator description/definition: \_\_\_\_\_  
\_\_\_\_\_

Evaluated by: \_\_\_\_\_ Date: \_\_\_\_\_

**INSTRUCTIONS:** Evaluate the data system on each of the following features by (1) answering as many of the questions for which information is available and (2) rating the data system high, medium, or low with respect to each feature. "High" means that the data system exhibits the desirable aspect of the characteristic to a great degree. "Low" means that the data system exhibits the desirable aspect of the feature to a low degree. For example, a very accessible data system would be rated "high" on accessibility, but a data system that was very expensive (high cost) to obtain would be rated "low" on cost.

**Representativeness of the data system** [ high / medium / low ]

What is its scope (local, state, regional, national, etc.)?  
\_\_\_\_\_

Describe the geographical coverage.  
\_\_\_\_\_

Describe the population covered by the system.

---

Is it a census, statistical sample, or nonstatistical sample of the covered population?

---

If a sample, how was the sample drawn?

---

**Timeliness** [high/medium/low]

What is the time lag between event and measurement?

---

What changes may occur to measurement due to this time lag?

---

What is the lag time between measurement and data availability?

---

How often are data collected?

---

How often is the data set made available for analysis?

---

Are data available pre- and post-MUL?

---

**Reliability/Quality** [high/medium/low]

Are the data coded and classified consistently over time and location?

---

Is a coding manual available?

---

Describe data collector background and special training.

---

Must data collectors have specialized knowledge?

---

Are the data coded into non-overlapping categories?

---

Does the coding scheme exhaust all possible responses including "unspecified" (UNS) and "not elsewhere classified" (NEC)?

---

What is the proportion cases in "unspecified" and "NEC" categories?

---

Is there a quality assurance system?

---

Is there a completeness assurance system?

---

Has interrater reliability been tested?

---

**Flexibility** [high/medium/low]

Can the system be modified easily to collect injury data not originally considered?

---

Can the system be modified cheaply to collect injury data not originally considered?

---

**Detail** [high/medium/low]

How detailed is the coding of the indicator(s) in this system?

---

Does the system distinguish between MV (occupant) and non-MV trauma causes?

---

If MV, does it record crash characteristics related to occupant injuries? (E.g., seating position, direction of impact, rollover, ejection, etc.)

---

**Nature of the system** [high/medium/low]

Is the system voluntary or mandatory?

---

Who pays the costs of operating the system?

---

Is it a long term, continuing system or a short term, special-purpose system?

---

Is the data system growing, stable, or declining in terms of number of cases?

---

Who administers the system?

---

**Specificity** [high/medium/low]

Does the data system define its variables clearly, and unambiguously?

---

Does it measure a singular attribute?

---

What is its measurement error (i.e., false positives or false negatives)?

---

**Accessibility**

[ high / medium / low ]

Is it automated for computer analysis?

---

If not, can it be automated easily and cheaply?

---

Can it be obtained from an institutional source?

---

Are there privacy constraints?

---

Is a data set available for testing?

---

If not, can one be made available? How soon?

---

**Cost** [high/medium/low]

What user fees or costs are associated with obtaining machine readable data sets?

---

**Compatibility** [high/medium/low]

Can the data set be linked to other data bases such as accident or driver records?

---

Are the data coded according to commonly accepted national standards?

---

If not, are the data compatible with other institutions or data bases?

---

**Disadvantages** [high/medium/low]

What shortcomings are associated with the data system that have not been noted already?

---

**Other Advantages** [high/medium/low]

What other advantages does this data system have that have not been noted already?

---

**Future plans** [high/medium/low]

Are there any planned changes to the data system that could affect its usefulness?

---

revised  
May 12, 1989  
syseval.rev

**APPENDIX H**  
**DATA SYSTEM PROFILE INTERVIEW FORM**



**DATA SYSTEM PROFILE INTERVIEW**

Organization: \_\_\_\_\_

Telephone: \_\_\_\_\_

Date: \_\_\_\_\_

[Introduce self.] I would like to speak with someone who can discuss your organization's data or information collection system.

[Re-introduce self, if necessary.] [Give brief explanation of project. Do not mention that study is funded by NHTSA.]

1. Does your organization collect or compile any information related to accidents or injuries?

If YES, go on.

If NO, end interview.

-or-

Ask for leads to other organizations and end interview.

1A. Ask for appropriate person for this contact and future contacts. Ask whether they prefer phone interview or mail questionnaire. Set up time for interview, if not convenient now.

Name: \_\_\_\_\_

Title: \_\_\_\_\_

Telephone number: \_\_\_\_\_

Address (if different from organization's):

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

[ ] Mail [ ] Phone: Date \_\_\_\_\_ Time \_\_\_\_\_

2. Are these data collected for administrative purposes or for research or special study purposes?

[ ] Administration [ ] Research [ ] Special study

3. Are these data coded or categorized so that motor-vehicle-related injuries (or accidents) can be distinguished from non-MV cases?

Yes  No

4. Can your data be used by researchers? Are there any restrictions on the use or dissemination of the data?

If AVAILABLE, go on.

If NOT available for research, go to Q-16.

5. Can you send me a copy of (1) the coding manual, and/or (2) the data collection forms, and/or (3) a complete frequency distribution of variables in the data file. (This will help us to indentify potential indicators in your system.)

Will send  Will NOT send

6. From what target population and geographical area are the data collected?

Population: \_\_\_\_\_

Area: \_\_\_\_\_

Does this population change from year to year?

If so, how does it change? \_\_\_\_\_

\_\_\_\_\_

7. What is the source of the data?

1 Public accident records (e.g., police reports)

2 Hospital records

3 EMS records

4 Other medical records

5 Insurance records

6 Association records

7 Corporate records

8 Other, specify: \_\_\_\_\_

8. What kinds of events are recorded in your system?

- 1 Deaths (MV and non-MV)
- 2 Deaths (MV only)
- 3 Injuries (MV and non-MV)
- 4 Injuries (MV only)
- 5 MV accidents
- 6 Medical treatment-related measures:
  - A Ambulance runs or EMS calls
  - B Helicopter runs
  - C ER visits
  - D Hospital admissions
  - E Hospital bed-days
  - F Medical treatment cases
  - G Disabilities or post-crash onset conditions

9. Are there any restrictions on what is counted (e.g., only spinal cord injuries)?

No       YES, explain: \_\_\_\_\_

\_\_\_\_\_

10. Which variables are collected? For each variable, indicate the name of the system used to code it (e.g., ICD, AIS, Z16, D16, etc.), or describe the various values the variable may take.

<u>Variable</u>	<u>Coding System</u>
1 Severity of injury	_____
2 Part of body	_____
3 Nature of injury (e.g., fracture, burn, etc.)	_____
4 Source of injury (e.g., steering wheel, windshield, etc.)	_____
5 Accident type (e.g., fixed object, other MV, noncollision, etc.)	_____
6 Speed	_____
7 Seating position	_____
8 Crash configuration (head-on, rear end, etc., <u>or</u> direction of impact)	_____
9 Make/type of vehicle	_____
10 EJECTION	_____
11 SEAT BELT USE	_____

11. For what time period (years) are the data available? Is the date of the event recorded so that changes over time can be determined?

Years: \_\_\_\_\_

12. How many cases are collected annually? How many in total are on file?

Annually: \_\_\_\_\_ Total: \_\_\_\_\_

13. Are the data stored on a computer or in manual files?

Computer       Manual       Combination

14. Can the records be linked to other data sources (e.g., police linked to hospital or EMS, or vice versa)?

NO

Yes

15. Are there any planned changes to the data system in the future?

---

16. Have you performed any analyses or studies of the MV accident/injury data in your system?

---

Has it been used to study the effects of safety belts on injury outcome?

---

Has it been used to study the effects of mandatory safety belt use laws?

If so, may we have a copy of each study?

Yes

No

Would you describe briefly the study or studies?

---

---

---

17. Are regular, periodic analyses, summaries, or reports produced from the data?

If so, how frequently?

---

Is a copy of the most recent one available?

Yes

No

Thank you very much for your time. You have been quite helpful. If we need additional information, we will get back to [person named in Q-1A].

**APPENDIX I**

**DATA SYSTEM SURVEY SUMMARY AND  
DATA SYSTEMS REJECTION SUMMARY**

Data System Survey Summary

Source	Mailing		Total Systems	Total Initial Contacts <sup>1</sup>	Telephone Follow-up <sup>2</sup>			
	Number Sent	Number Returned			Total	Completed	Positive <sup>3</sup>	Negative
Surgeons <sup>4</sup>	66	23	34	29	21	21	6	15
Gov Reps <sup>5</sup>	51	30	57	18	16	16	4	12
Exp Team <sup>6</sup>	90	35	24 <sup>7</sup>	23	3	3	1	2
Unknowns <sup>8</sup>	52	20	23	23	6	6	2	4
Knowns <sup>9</sup>	...	...	24	24	20	20	6	14
COTR	...	...	1	1	1	1	0	1
	---	---	---	--	--	--	--	--
TOTAL	259	108	163	118	67	67	19	48

<sup>1</sup> Initial mail or telephone contact was not made with some recommended systems because the descriptions of them indicated they were not suitable for this project. Most common reasons for not contacting were that the systems used police reports, vital statistics, observational studies, or opinion surveys.

<sup>2</sup> Telephone follow-up was not made with some initially contacted systems because the initial contact indicated that they were not suitable for this project. Most common reasons for not following up were that the source either did not collect any data or merely used data from other sources.

<sup>3</sup> Full "Data System Profiles" will be completed for these systems.

<sup>4</sup> State and regional trauma committee chairmen on the American College of Surgeons Committee on Trauma. Telephone follow-up was made if the description looked promising or needed more information to decide.

<sup>5</sup> Governors' Highway Safety Representatives. Telephone follow-up was made if the description looked promising or needed more information to decide.

<sup>6</sup> First expert team mailing, January 1989, and recommendations from expert team member David Sleet, MD.

<sup>7</sup> Some recommended systems were added to "unknowns" list for follow-up.

<sup>8</sup> "Unknowns" means potential data systems that were not known to have data. Mailed an initial inquiry; followed up by telephone if mail response was promising.

<sup>9</sup> "Knowns" means potential data systems that were known to have data. All contacts were made by telephone. No follow-up was done if details were already known to project staff.

DATA SYSTEMS REJECTION SUMMARY

Organization Name	Follow up	Results
AAA Foundation for Traffic Safety rejection reason: no data	no	
AAA - Hoosier Motor Club rejection reason: no data	yes	neg
Advocacy Center for Persons with Disabilities, Inc rejection reason: no data	yes	neg
Alabama Dept of Public Health rejection reason: usage survey data	no	
Alcohol and Drug Problems Assn. of North America rejection reason: no data	no	
Alliance for Traffic Safety rejection reason: no data	no	
American Academy of Family Physicians rejection reason: membership data only	no	
American Academy of Neurology rejection reason: no data	no	
American Academy of Ophthalmology rejection reason: no data	no	
American Academy of Physical Medicine and Rehabil. rejection reason: no data	no	
American Assn. for Adult and Continuing Education rejection reason: no data	no	
American Assn. of State Hwy. & Transp. Officials rejection reason: no data	no	
American Association of Neurological Surgeons rejection reason: no data	no	
American Automobile Association rejection reason: no data	no	
American College of Physicians rejection reason: no data	no	
American Congress of Rehabilitation Medicine rejection reason: no data	no	
American Dental Association rejection reason: no data	no	
American Insurers Highway Safety Alliance rejection reason: no data	no	
American Medical Association rejection reason: no data	yes	neg
American Optometric Association rejection reason: no data	no	
American Optometric Foundation rejection reason: no data	no	
American Paralysis Association rejection reason: no data	yes	neg
American Physical Therapy Association rejection reason: membership data only	no	
American Trauma Society rejection reason: summary data only; not case files	yes	neg

DATA SYSTEMS REJECTION SUMMARY

Organization Name	Follow up	Results
Arizona Dept. of Transportation rejection reason: police reports	no	
Ark. Dept. of Hlth., Off. of Disability Prevention rejection reason: administrative data; not available for research	yes	neg
Arkansas State Spinal Cord Commission rejection reason: administrative data for victim compensation	yes	neg
Assn. for the Advancement of Automotive Medicine rejection reason: no data	yes	neg
Associated Public-Safety Communications Officers rejection reason: no data	no	
Association of Physician Assistant Programs rejection reason: no data	no	
Auburn University, Computer Science & Engineering rejection reason: police reports	no	
Automotive Occupant Protection Association rejection reason: no data	yes	neg
Automotive Safety for Children rejection reason: no data	yes	neg
Barrow Neurological Institute (Phoenix, Ariz.) rejection reason: not available for research	yes	neg
Baystate Medical Center (Springfield, Mass.) rejection reason: contact not completed	yes	
Brigham & Womens Hospital (Boston, Mass.) rejection reason: contact not completed	yes	
Cabel Huntington Hospital (Huntington, W. Va.) rejection reason: part of state-wide system	yes	neg
California Highway Patrol rejection reason: police reports	no	
Calspan Research (Buffalo, N.Y.) rejection reason: contact not completed	yes	
CDC, Div. of Injury Epidemiology and Control rejection reason: SCI registry in formative stages; no data yet	yes	neg
Center for Auto Safety rejection reason: no data	no	
Centers for Disease Control / CDC rejection reason: opinion surveys	yes	neg
Centers for Disease Control / CDC rejection reason: self-report data	no	
Charleston (W.Va.) Area Medical Center rejection reason: part of state-wide system	yes	neg
Colorado Seat Belt Network rejection reason: no response to follow up	yes	
Colorado State Patrol rejection reason: police reports	no	
Colorado Trauma Institute rejection reason: in formative stages; no data yet	yes	neg
Consumer Product Safety Commission rejection reason: collected MV data 12/78 to 12/81 only	yes	neg

DATA SYSTEMS REJECTION SUMMARY

Organization Name	Follow up	Results
Delaware Division of Public Health	no	
rejection reason: vital statistics (death certificates only)		
Delaware Office of the Insurance Commissioner	yes	neg
rejection reason: no data on mv accidents or injuries		
Early Spinal Cord Injury Notification System (NJ)	yes	neg
rejection reason: bad address; could not contact		
Emergency Medical Services Institute (Pa.)	yes	neg
rejection reason: nonstandard coding; does not use AIS or ICD		
Georgia Dept. of Human Resources	no	
rejection reason: vital records not of interest		
Georgia Dept. of Human Resources, EMS Division	yes	neg
rejection reason: in formative stages		
Georgia Dept. of Public Safety	no	
rejection reason: police reports		
Governor's Highway Safety Program	no	
rejection reason: police reports		
Harborview Medical Center, Nrthwst Reg Trauma Cntr	yes	neg
rejection reason: single-hospital trauma registry		
Harborview Medical Center (Wash.)	no	
rejection reason: misc. special studies		
Hawaii Dept. of Health, EMS Systems Branch	no	
rejection reason: in formative stages		
Highway Users Federation	no	
rejection reason: no original data		
Hoosiers for Safety Belts	yes	neg
rejection reason: no data		
Illinois Department of Public Health	yes	neg
rejection reason: in formative stages		
Indian Health Services, Environ. Health Program	no	
rejection reason: limited population		
Indiana State Board of Health, Bureau of Disease	yes	neg
rejection reason: no data		
Indiana State Dept. of Traffic Safety	yes	neg
rejection reason: no data base; uses state police data		
Institute for Injury Reduction (Md.)	yes	neg
rejection reason: in formative stages; no data yet		
Institute of Transportation Engineers	no	
rejection reason: no data		
Insurance Corporation of British Columbia	no	
rejection reason: foreign		
Insurance Institute for Highway Safety	yes	neg
rejection reason: no data		
Iowa Dept of Public Safety--Traffic Acc. Investig.	no	
rejection reason: police reports		
Iowa Dept. of Transp., Office of Drivers Services	no	
rejection reason: FARS data		
Iowa Dept. of Transp., Office of Drivers Services	no	
rejection reason: violations data		

DATA SYSTEMS REJECTION SUMMARY

Organization Name	Follow up	Results
Iowa Dept. of Transp., Office of Drivers Services rejection reason: convictions data	no	
Iowa Dept. of Transp., Office of Drivers Services rejection reason: observational studies	no	
Iowa State Patrol rejection reason: enforcement data	no	
Iowa State University, Occ. and Traffic Safety rejection reason: misuse/use study	no	
Iowa Traffic Safety Now rejection reason: no original data	no	
Lutheran General Hospital (Park Ridge, Ill.) rejection reason: one time special study (data covers 6 mo. period)	yes	neg
Medical Center Hospital of Vermont Trauma Registry rejection reason: contact not completed	yes	
Medicine in the Public Interest rejection reason: no data	no	
Mississippi Department of Health, EMS rejection reason: in formative stages	yes	neg
Mississippi Department of Public Safety rejection reason: police reports	no	
Mississippi Dept. of Health, Injury Prevention rejection reason: same system as Miss. Dept of Health, EMS	yes	neg
Missouri State Highway Patrol, Stat. Analysis Cntr rejection reason: police reports	no	
Motor Vehicle Manufacturers Association of the US rejection reason: no data (sponsors UMTRI work)	no	
Muscular Dystrophy Association rejection reason: no data	no	
National Accident Sampling System rejection reason: police reports	no	
National Association of First Responders rejection reason: manual system; very small (<100 cases)	yes	neg
National Association of Fleet Administrators rejection reason: no data	no	
National Association of Health Data Organizations rejection reason: no data	yes	neg
National Capital Coalition for Safety Belt Use rejection reason: no data base	yes	neg
National Easter Seal Society rejection reason: data access restricted to Easter Seal affiliates	no	
National Foundation for Facial Reconstruction rejection reason: no data	no	
National Head Injury Foundation rejection reason: no data	yes	neg
National Health Council, Inc. rejection reason: no data	no	
National League for Nursing rejection reason: no data	no	

DATA SYSTEMS REJECTION SUMMARY

Organization Name	Follow up	Results
National Rehabilitation Information Center rejection reason: no data	no	
National Spinal Cord Injury Statistical Center rejection reason: data available only through member SCI centers	yes	neg
Nevada Bureau of Business & Economic Research rejection reason: one-time cost study	no	
Nevada Department of Transportation rejection reason: police reports	no	
Nevada Instructional Media Services rejection reason: observational and opinion surveys	no	
Nevada Office of Traffic Safety rejection reason: FARS data	no	
New Jersey University of Medicine and Dentistry rejection reason: in formative stages; no data yet	yes	neg
New York State Injury Control Program rejection reason: no response to follow up	yes	
Newton-Wellesley Hospital (Mass.) rejection reason: manual file covering Jan'85 to Sep'87 only	yes	neg
Northwestern University Spinal Cord Injury Center rejection reason: safety belt use not recorded	yes	neg
NYU Medical Center Head Trauma Program rejection reason: cannot identify mv accident as source of injury	yes	neg
Ohio Department of Highway Safety, OGHSR rejection reason: police / field observation data	no	
Ohio State University Neuroscience Research Lab rejection reason: no data	no	
Oklahoma Dept. of Public Safety rejection reason: police reports	no	
Oklahoma DoT Highway Safety Division rejection reason: observational surveys	no	
Oregon Motor Vehicle Division, Public Affairs rejection reason: police reports	no	
Oregon Traffic Safety Commission rejection reason: police reports	no	
Oregon Traffic Safety Commission rejection reason: FARS data	no	
Palmetto Safety Council (Fla.) rejection reason: no original data	no	
Paralyzed Veterans of America rejection reason: no continuing data collection; special topics only	no	
Queens Medical Center, Trauma Services (Hawaii) rejection reason: part of state-wide system	yes	neg
Rehabilitation Institute (Detroit) rejection reason: in formative stages; no data yet	no	
Rhode Island Safety Belt Coalition rejection reason: no original data	no	
Safety Belts for South Carolina rejection reason: no data base	yes	neg

DATA SYSTEMS REJECTION SUMMARY

Organization Name	Follow up	Results
Sister Kenny Institute (Minneapolis, MN) rejection reason: data not available; low number of cases	no	
South Carolina Trauma Registry rejection reason: in formative stages	no	
Southern Region Emergency Medical Services Council rejection reason: pilot project	yes	neg
Spinal Cord Society rejection reason: no data	no	
St. Joseph's Hospital Trauma Center (Phoenix, AZ) rejection reason: contact not completed	yes	
St. Luke's Hospital (Fargo, ND) rejection reason: single-hospital trauma registry	no	
St. Mary's Hospital (Huntington, WV) rejection reason: part of state-wide system	yes	neg
St. Vincent Hospital and Medical Center (CT) rejection reason: no data	yes	neg
Texas Transportation Institute rejection reason: police reports	no	
The Safety Society rejection reason: no data	no	
Traffic Related Injuries Study (Irvine, CA) rejection reason: pediatric cases only (ref #95)	yes	neg
Traffic Safety Now, Inc. rejection reason: entirely manual system; some data proprietary	no	
Transportation Research Council (Va.) rejection reason: uses DMV police report data	yes	neg
University Hospital, Dept. of Surgery (Fla.) rejection reason: no description of data	no	
University of California, Davis Medical Center rejection reason: part of Champion's Major Trauma Outcome Study	yes	neg
University of Hawaii rejection reason: contact not completed	yes	
University of Michigan, Transp. Research Institute rejection reason: police reports	no	
University of New Mexico rejection reason: no data now; plan to in future	yes	neg
University of North Carolina Hwy Safety Res Cntr rejection reason: police reports	no	
University of Tennessee Transportation Center rejection reason: police accident reports	yes	neg
Valley Research (Salt Lake City, UT) rejection reason: observational studies	no	
Virginia DMV, Occupant Protection Section rejection reason: police reports	no	
Vocational Rehabilitation (Jackson, Miss.) rejection reason: small number of cases	yes	neg
Washington Traffic Safety Commission rejection reason: police reports	no	

DATA SYSTEMS REJECTION SUMMARY

Organization Name	Follow up	Results
Wayne State University Bioengineering Center rejection reason: no data	yes	neg
Wayne State University, Biomechanics Laboratory rejection reason: no data	yes	neg
West Virginia Dept. of Health rejection reason: vital statistics	no	
West Virginia Dept. of Highways rejection reason: police reports	no	
West Virginia University Hospital rejection reason: contributes to state-wide system	yes	neg

**APPENDIX J**  
**INDICATOR PROFILES**

General Shifts in Frequency or Distribution by Severity: KABC Scale .....	J-1
General Shifts in Frequency or Distribution by Severity: Abbreviated Injury Scale (AIS).....	J-3
General Shifts in Frequency or Distribution by Severity: Maximum AIS, Overall AIS .....	J-4
General Shifts in Frequency or Distribution by Severity: Injury Severity Score .....	J-5
Ejections .....	J-7
Head .....	J-10
Face .....	J-14
Eye .....	J-17
Spine .....	J-20
Upper Extremities .....	J-22
Lower Extremities .....	J-23
Index of Head Injuries to Whiplash .....	J-25

[See also Volume II, Part C, Indicator Catalog, for a brief evaluation of all 52 indicators considered in the project.]

**General Shifts in Frequency or Distribution  
by Severity: KABC Scale**

Most police reports of motor vehicle accidents use the "KABC" scale for recording the presence and severity of injuries. The scale is defined in sections 2.3.2 through 2.3.5 of the Manual on Classification of Motor Vehicle Traffic Accidents, ANSI D16.1-1983 (National Safety Council, 1984).

K = "Fatal injury. A fatal injury is any injury that results in death."

A = "Incapacitating injury. An incapacitating injury is any injury, other than a fatal injury, which prevents the injured person from walking, driving or normally continuing the activities he was capable of performing before the injury occurred.

Inclusions: Severe lacerations, broken or distorted limbs, skull or chest injuries, abdominal injuries, unconscious at or when taken from the accident scene; unable to leave accident scene without assistance. And others.

Exclusions: Momentary unconsciousness. And others."

B = "Nonincapacitating evident injury. A nonincapacitating evident injury is any injury other than a fatal injury or an incapacitating injury which is evident to observers at the scene of the accident in which the injury occurred.

Inclusions: Lump on head, abrasions, bruises, minor lacerations. And others.

Exclusions: Limping (the injury cannot be seen). And others."

C = "Possible injury. A possible injury is any injury reported or claimed which is not a fatal injury, incapacitating injury or nonincapacitating evident injury.

Inclusions: Momentary unconsciousness. Claim of injuries not evident. Limping, complaint of pain, nausea, hysteria. And others."

"A" injuries are also called "serious" injuries in some states, "B" injuries are also called "moderate," and "C" injuries are called "minor." While not defined in ANSI D16.1, a code for "no injury" ("O") is usually added to the scale.

Three studies were identified which used the KABC scale to assess safety belt use laws. All were done by the University of North Carolina Highway Safety Research Center using data from several states.

Reinfurt et al. (1988) used a time series model of North Carolina data to forecast fatal (K) injuries, A+K injuries, and B+A+K injuries. The 57-month pre-law period was used to forecast the 15 post-law months of the "warning phase." Similarly, 72 months of data (57+15) was used to forecast the first 18 months of the "\$25 citation phase." Statistically significant reduc-

tions were observed for K, A+K, and B+A+K injuries for groups covered by the law. Groups not covered by the law were used for comparison and for the most part did not experience statistically significant reductions. The analysis technique allowed the researchers to estimate the numerical reduction in fatal, serious, and moderate injuries attributable to the law.

Campbell and Campbell (1986) reported preliminary results from the same study just cited. Here, however, time series was not used to establish "expected" values. A simple examination of the changes in percentages of moderate or greater and serious or greater injuries was reported. They stated: "The injury trends indicate a favorable belt law effect, in that the trend line breaks and resumes at a distinctly lower level."

Hunter et al. (1988) reported a preliminary analysis of Pennsylvania and New Jersey data. They looked at injury trends across time, compared injuries in various crash configurations, and compared restrained and unrestrained occupants and concluded that "Inferences can be made from changes in injury pattern over time, but they are especially difficult to quantify."

It appears from the literature that sophisticated statistical techniques, such as time series, can produce more conclusive results than simple descriptive and comparative statistics when applied to injuries counted under the KABC system.

The KABC system is intended to be a measure of apparent severity of injury as judged by plainly visible evidence at the crash scene. Unlike AIS, it is not a measure of threat to life. There is, however, some agreement between the two. An appraisal of the KABC system was done in the mid-1970's by Sherman, Murphy, and Huelke (1976) which found that "A" injuries had a mean AIS value of 2.12, "B" injuries had a mean AIS of 1.24, "C" injuries were 1.13, and "O" injuries were 0.64. Also, the Sensitivity Index Project, which linked police accident reports with EMS and hospital records, found that about 40 percent of "A" injuries were admitted to the hospital and about 10 percent of "B" injuries were admitted. Together these indicate that KABC does provide a coarse measure of injury severity.

The KABC system may be subject to some reporting biases. In an effort to more effectively deploy their manpower, some police departments may restrict the kinds of accidents investigated by an officer. This can result in an artificial change in average severity unrelated to any safety program. There is also some concern about the uniformity of classification from one jurisdiction to another. It is not known how the amount and quality of training in the use of KABC varies from jurisdiction to jurisdiction.

While KABC is not closely linked to the AIS and may be subject to unknown biases, the advantage of the measure is that it is widely used by police agencies and is routinely incorporated into computerized police accident report data bases.

### General Shifts in Frequency or Distribution by Severity: Abbreviated Injury Scale

The Abbreviated Injury Scale (AIS) (American Association for Automotive Medicine, 1985) is commonly used to code the part of body, nature of injury and severity of injury in terms of threat to life for acute traumatic injuries. Each injury is assigned a six digit numerical code that identifies (1) the general body region, (2) the organ or specific area, (3) the severity level assigned in succession within each organ or body part entry, and (4) the AIS severity code number. The AIS severity codes are:

1	Minor	5	Critical
2	Moderate	6	Maximum injury virtually unsurvivable in AIS 85
3	Serious		
4	Severe	9	Unknown

It should be noted that while other severity rating systems assign one number to the whole patient, the AIS assigns a code to each injury. Therefore, the basis for analysis with AIS data is injuries and not persons injured. Many studies, such as States, et al (1986), report both AIS and ISS or MAIS in their analyses.

Two Swedish studies used the AIS to evaluate a safety belt use law. Norin, Carlsson, and Korner (1984) reported the percentage change in the injury rate from before to after the law, by AIS level, using data on 5,000 accidents involving Volvo automobiles (3,000 before and 2,000 after). For front seat occupants (both belted and unbelted), the total injury rate decreased by 19%, the rate of minor to moderate injures decreased by 16% and the rate of severe to fatal injuries by 51%. No statistical tests of significance were applied.

Einar-Nilsson (1976) reported similar research involving about 250 Saab automobiles. He reported an increase in minor injuries (+20%), a decrease in moderate injuries, and a 46% decrease in severe to fatal injuries.

The AIS is most often used for injury coding in trauma registries and ER records. Most hospitals use ICD codes rather than AIS codes for inpatient records. While there is an algorithm which can translate ICD to AIS, only about two thirds of the codes can be translated unambiguously. On the other hand, most trauma registries record only AIS codes, but some record both AIS and ICD codes.

The principal liability to AIS as an indicator is its limited application. Only those injured persons who enter into the medical system (generally through an EMS contact or emergency room visit) will be coded. Those who are uninjured, seek treatment through other sources, or die before reaching medical assistance will not be evaluated and assigned AIS codes.

The AIS was a more precise measure of injury severity than the KABC scale, and thus a more desirable indicator, but its more narrow application limits its usefulness and poses some methodological problems which are discussed later in this report.

**General Shifts in Frequency or Distribution  
by Severity: Maximum AIS, Overall AIS**

While the Abbreviated Injury Scale (AIS) severity code is assigned to an injury, the Maximum AIS (MAIS) and Overall AIS (OAIS) are assigned to a patient. The Abbreviated Injury Scale assigns to each injury a severity code number. It is the single digit AIS severity code number from which the MAIS is derived. The MAIS is defined as the highest severity code assigned to any of a patient's injuries. The OAIS is the physician's assessment of the overall severity of the patients injuries and may differ from the MAIS.

Vallet, et al (1986) used the full range of OAIS (1-6) plus "0" for no injury to examine the differences in injury severity among 452 belted and unbelted drivers and front seat passengers in 320 frontal-impact crash-involved vehicles in France. The percentage distribution of OAIS for belted occupants was shifted toward the lower severity compared to unbelted occupants. The OAIS, however, is now considered obsolete because it is too subjective.

Rutherford, et al (no date) reported the MAIS (1-6) of drivers, front seat passengers and rear seat passengers both before and after the mandatory safety belt law in the UK. Data were collected on more than 750 patients from 15 hospitals. Compared to rear seat passengers who were not compelled to wear safety belts, injuries to front seat occupants were greatly reduced at all MAIS severity levels. No statistical tests were performed to assess significance of the changes because the researchers felt that the MAIS was too rough a measure of overall injury severity; multiple injuries at a lower severity grade may be a greater threat than a single injury at a higher severity. Rutherford stated that MAIS "...is a simple rough guide to overall severity. It is obvious that a patient with a MAIS5 is going to be in a more critical condition than one with MAIS1. However, a patient with 20 AIS1 injuries has an MAIS1, and might well be more ill than a patient with one AIS2 injury (MAIS2). Similarly a patient with four AIS4 injuries (MAIS4) will probably be more ill than one with a single AIS5 injury (MAIS5)."

**General Shifts in Frequency or Distribution  
by Severity: Injury Severity Score**

The Injury Severity Score (ISS) is derived from the individual Abbreviated Injury Scale (AIS) severity codes for all of a patient's injuries. The ISS is the sum of the squares of the highest AIS severity codes in each of the three most severely injured body regions. For the purposes of the ISS, the body regions are defined differently from the AIS body regions:

ISS Body Regions

- |                 |                                 |
|-----------------|---------------------------------|
| 1. Head or neck | 4. Abdominal or pelvic contents |
| 2. Face         | 5. Extremities or pelvic girdle |
| 3. Chest        | 6. External                     |

The ISS has a range of 1 to 75; injuries coded AIS-6 are automatically assigned an ISS of 75. An ISS > 10 is usually considered severe.

Rutherford et al (no date) used the ISS for statistical analysis of the changes in injury severity following implementation of a mandatory safety belt use law in the UK. Specifically, they used analysis of variance to determine the influence of seating position, belt use, and year (before or after law) on mean ISS. With regard to the year, they found that the mean severity values were greater for the second year (post-law) than for the first (pre-law). This result

...is at first surprising until it is remembered that the total number of casualties diminished by 15 per cent. If we adjust the means of severity scores in the second year by supposing there were as many casualties in each seating position but that the difference had zero severities, then the mean values would be much less for the second year than for the first. (p. 70)

Christian (1984) also used mean ISS to evaluate the effects of the British safety belt use law using hospital records of about 2,500 front and rear seat occupants injured in m-v accidents during the 12 months before and 12 months after the law took effect. Christian reported that before the law 6.6% of drivers suffered serious injuries (ISS>12) with a mean ISS of 16.3 and maximum of 47; 3.7% were wearing belts. After the law took effect 3.4% of drivers had serious injuries with a mean ISS of 20.0 and a maximum of 35; 47% were wearing belts. No statistical tests were performed on the data.

Pye and Waters (1984) evaluated the U.K. belt use law using 437 patient records from one hospital covering 3 months before and 3 months after the law. They divided the ISS range into three groups which they labeled "mild" injury (ISS 0-3), "moderate" injury (ISS 4-8), and "severe" injury (ISS ≥9). They

reported statistically significant reductions in the number of injuries in each category with the greatest reductions occurring in moderate and severe injuries.

States, et al (1986) also used mean ISS to evaluate the New York safety belt use law. Their data consisted of linked hospital records and police accident reports of 495 motor-vehicle accident victims in Monroe County during the first six months of 1984 and 1985. A "subject" group was defined as motor vehicle occupants required by law to use restraint systems and rear seat occupants in general. A "control" group consisted of motor-cyclists, bicyclists and pedestrians. They reported a 14.0% reduction in mean ISS for the subject group and +0.1% change for the control group. Again, no statistical tests were performed.

## Ejections

The general purpose of this indicator is to evaluate safety belt use laws by examining changes in the frequency of partial or total ejections. Total ejection occurs when the entire body is thrown from the vehicle through windows, or door or other openings in the vehicle due to forces of a crash. Partial ejection occurs when one or more parts of the body project from windows or door or other openings in the vehicle during the crash.

In terms of frequency of cases, about 43,200 people were ejected from passenger cars in 1981, according to the National Accident Sampling System (NASS). Of these, about 6,000 were killed (Clark & Sursi, 1984).

Theoretically, ejection can be determined easily by empirical observation. However, there are certain difficulties in data collection for this variable. Ejection is one of the few potential indicators which relies on police data or other crash site data collection. Often, bodies are moved before police arrive, and other judgmental problems may occur. Partial ejection is usually judged by investigators by blood on the hood or dirt in the hair, etc., and may well be under-reported. Crash simulation work finds partial ejection far more frequently than whole body ejection, yet data bases most often find partial ejections to be a relatively small portion of all ejections (Clark & Sursi, 1989).

Police reports appear to be the best system for identifying ejections with additional medical data supplied from ambulance runs, emergency room, and subsequent hospital records. This would necessitate linking the various records. As a national database, NASS contains ejection information, but questions about its representativeness may limit its usefulness in this area. Modifications of other data collection systems may be more appropriate.

The literature shows a strong consistent relationship between seat belt usage and rate of ejection (O'Day & Scott, 1984a, 1984b; Hartemann et al., 1984; Turnbridge et al., 1988; Carlsson, 1983; Peterson, 1988; Thomas et al., 1980; Cameron & Nelson, 1977). This has been confirmed in studies in the U.S. and in foreign countries. Many studies show no cases of belted occupants being ejected, while others attribute the small number of belted ejections to the partial ejection phenomenon (e.g. an arm or hand of a belted occupant) or to extraordinary circumstances.

Likewise, the relationship between ejection and rate of severe injury (including death) is supported in both foreign and U.S. literature (O'Day & Scott, 1984a, 1984b; Hartemann et al., 1984; Turnbridge et al., 1988; Carlsson, 1983; Thomas et al., 1980; Cameron & Nelson, 1977; Clark & Sursi, 1984; Huelke, O'Day, & Mendelsohn, 1981; Huelke, 1981; Hunter et al., 1988). These studies use a variety of sources -- ranging from the National Crash Severity Study (NCSS), NASS, or state motor-vehicle data

bases for U.S. studies, to hospital data and auto manufacturers' data in foreign studies.

Given these clear relationships, ejections might seem to be an ideal indicator. Indeed, Hunter, Reinfurt, and Hirsch (1988) suggest that:

"another strategy [to look at mortality and morbidity reduction arising from seat belt use laws] is to examine a variable like ejections (or ejection rates) which is affected by belt use. Increases in belt usage rates in the population should yield decreases in ejections (or ejection rates), without having to examine the belt use category."

An opposing view is presented by Clark and Sursi (1989), who believe that while ejections may be highly correlated with seat belt usage, ejections are not likely to be influenced greatly by the passage of seat belt use laws. They reason that while the laws may increase usage in the general population, laws are not likely to increase belt usage in the group of "high risk" individuals who are most likely to be involved in violent crashes with ejection situations.

There was virtually no literature found which examined ejection data with respect to passage of mandatory belt use laws. Hunter, Reinfurt, and Hirsch (1988) investigated ejections in one state with a belt law and one state without, but findings were inconclusive and no data over time were presented.

Clark and Sursi defend their objections to the use of ejections as an indicator by citing FARS data from 1983 through 1987. These data show that while the NHTSA 19-city observed seat belt use increased from about 14 % to about 42 % during that time, ejected fatalities made up consistently 23 or 24 per cent of the total fatalities during the period.

There are two problems with their analysis which should be noted. First, those with unknown ejection status are handled as not ejected, even though the number of unknowns changed dramatically during the period. Apportioning the unknowns, or including them with the ejections, would have changed the results significantly. Second, FARS is not the most appropriate data base to use since it automatically excludes effects one is trying to measure, i.e., those individuals who are now wearing their belts, not being ejected, and not being killed.

The argument that laws will not affect seat belt usage in the crash population as much as in the general population is one which is likely true, but which would affect all the indicators under consideration, not just ejections. (As usage rates rise, belt wearing should begin to increase even in the high risk groups.) Whether the ejected population differs significantly from others in the crash population in terms of likelihood of belt use is not known. If this is a weakness in the ejection indicator, it may be balanced by the especially strong association between ejection and belt use. On the other hand, since

ejection is so strongly related to fatality, the same problems with using fatalities to measure effects of seat belt laws may apply to ejections.

Even if the group of individuals at especially high risk of ejection were affected less by seat belt laws than others, studies could control for such risk factors as type of crash and type of vehicle. In that way, the positive effect of belt wearing could still be measured.

While ejections and fatalities are similar indicators of seat belt use, the much larger number of nonfatal ejectees makes their experience worthwhile investigating separately. The potential impact of the ejection indicator on state legislators may also be significant as a corollary to fatality information.

Interest in ejections and measurement of risk associated with it will increase in the near future as airbags are introduced. There will be increased emphasis on belt wearing to protect against the ejections that airbags are not designed to prevent. In fact, Evans (1988) estimated that drivers switching from lap/shoulder belts to airbags only would increase their fatality risk by 41 per cent.

## Head

Head injuries, excluding ear, eye, and face and defined by AIS (1985) to include cranium injuries, anatomic lesions, and non-anatomic (concussive) injuries.

The head is the part of the body best protected by safety belts. In a collision, belted vehicle occupants are less likely than unbelted to be ejected or to contact the windshield, dashboard, support pillars and other objects inside the vehicle. As a result, front seat occupant head injury frequency, severity, and patterns should be affected by SBULs.

The evidence supporting head injuries as a high potential indicator of SBUL impact comes mainly from non-U.S. sources such as U.K., France, and Sweden where seat belt use levels are reported to be quite a bit higher than is the case in the U.S. These studies describe analyses of data drawn from emergency room and associated hospital records, accident investigation records collected by automotive manufacturers (e.g., Volvo, Renault), and samples of records from in-depth investigations conducted by official agencies.

Results are based typically on pre/post study designs without comparison groups or on samples that compare belted vs. unbelted occupants. Reports of these investigations consistently show substantial decreases in head injury frequency and severity that are associated with safety belt use. Nevertheless, study samples are not statistically representative and usually are biased toward moderate to high severity accidents likely to result in occupant injuries and/or fatalities.

A number of variables interact to affect type, frequency, and severity of head injury for motor vehicle occupants such as impact speed (Delta-V), type/angle of collision, and type and amount of vehicle deformation as well as occupant age, physical condition and seating position. For belted occupants, type, condition and adjustment of the safety belt can also influence injury severity and pattern. Although cross tabulations of head injury data with these interacting variables would enable a more exact interpretation of SBUL effect on head injury, they are not always reported in the literature.

The largest and most impressive recent pre/post SBUL study was conducted by Rutherford et al. (no date) in the U.K. It compared the injury experience of occupants involved in motor vehicle accidents in the year prior to SBUL enforcement (2-82 through 1-83) with a similar post period (2-83 through 1-84) as reported by 14 hospitals cooperating in the investigation. Some 14,019 patients were included in the study, and injury was graded by AIS and its associated scales. Safety belt use among the patients increased from an estimated low to mid 20% pre-SBUL to over 90% post-SBUL.

On the basis of their findings, the investigators report overall post-SBUL reductions in all varieties of front seat passenger head injuries and reductions in all minor brain

injuries (AIS  $\leq 2$ ) for drivers. Major brain injuries (AIS  $\geq 3$ ) as well as scalp contusions and abrasions increased for drivers, however. The brain injury pattern shown in Table J-1 reflects the influence of seating position on head injuries, in which front seat passengers appear to benefit more from the SBUL than do drivers.

Table J-1  
Brain Injury

AIS	Driver			Front Seat Passenger		
	Pre	Post	%	Pre	Post	%
	N	N	Change	N	N	Change
$\leq 2$	606	399	-34.2	296	124	-58.1
$\geq 3$	32	46	+43.8	22	13	-40.9
Total	638	445	-30.4	318	137	-56.9

The front-seat passenger benefit is supported by Norin et al. (1984) who studied 5,000 Volvo accidents (3,000 pre SBUL and 2,000 post SBUL) in which relatively similar vehicle types, driver ages, percentages of front seat passengers, and accident types were compared. Also, the level of belt use was estimated to have increased from 50% pre-SBUL to 93% post-SBUL. Although number of injuries were not reported, the relative changes in head injury rate of accident involved front seat occupants according to AIS are shown in Table J-2.

Table J-2  
Head Injury

AIS	Drivers			Front Seat Passengers		
	Pre	Post	Relative	Pre	Post	Relative
	%	%	Change	%	%	Change
$\leq 2$	15.1	9.0	-40%	14.3	6.9	-52%
3-6	1.0	.4	-60%	1.2	.3	-75%

In this case, the high severity head injury pattern for drivers differs markedly from that shown in Table J-1. This difference may be due to the inclusion of fatalities in this study, which was not possible in the Rutherford study; or to Volvo's interior design, which may provide above average protection for both belted drivers and front seat passengers. Similarities between the pre/post study groups may also play a role in creating a more sensitive and controlled comparison. In any case, the driver/passenger differential in head injury reduction post SBUL is apparent.

Head injury reductions of a magnitude similar to those found in the preceding pre/post SBUL reports are also provided by investigations of belted vs. unbelted occupants. For example, Thomas et al. (1980) compared the experience of 1,624 belted vs. 3,242 nonbelted occupants selected from a sample of more than 2,300 bodily injury accidents, which had occurred in a zone west of Paris since 1970. Each of these accidents was investigated by a team including doctors and technicians who gathered detailed injury and impact data. From the original sample, these investigators selected accidents involving frontal impacts with a relatively similar distribution of degree of estimated impact violence (Delta-V) for the belted and unbelted groups. Table J-3 shows degree of severity of injuries to the head, which in this study included the face.

Table J-3  
Head and Face Injury

	Drivers			Front Seat Passengers			Total		
	Belted	Un-Belted	Differ-ence	Belted	Un-Belted	Differ-ence	Belted	Un-Belted	Differ-ence
AIS	%	%	%	%	%	%	%	%	%
0	63.5	32.7		76.0	19.9		68.8	28.3	
≤2	32.7	60.6	-46	23.3	74.3	-68	29.3	65.3	-55
≥3	3.8	6.7	-43	.7	5.8	-88	2.7	6.4	-58
	N=263	N=551		N=146	N=281		N=409	N=960	

In another in-depth crash injury investigation, Mills and Hobbs (1984) looked at belted vs. unbelted experience in frontal and oblique frontal impacts. They found that frequency of head injury at the level of AIS ≤2 was significantly lower for belted front seat occupants (26%) than for unbelted (65%) but that

belted drivers had more head injuries (31%) than belted front seat passengers (17%).

The study also looked at impact velocity (Delta-V) compared with the probability of injury at a particular severity level, using probit analysis. The findings were that head injury, particularly to the driver, was influenced by impact severity, with benefits of safety belts losing strength at Delta-V levels of  $\geq 30$  mph. Commenting on the increase in belted driver head injuries, the investigators observed that 66% of the facial and 44% of the cranial injuries involved contact with the steering wheel and that belted drivers whose faces contacted the steering wheel were involved in more severe accidents (mean Delta-V = 19 mph) than those whose faces did not (mean Delta-V = 11 mph).

These studies and others that were reviewed leave little doubt about the effectiveness of safety belts in reducing total head injuries among front seat occupants. Even so, the sensitivity of head injuries as an impact measure in U.S. pre/post SBUL situations is less certain, because safety belt use rates in SBUL States are much less than the 90% levels reported in the U.K. and Swedish studies.

Also, numerous factors can influence the sensitivity of head injuries as a measure of SBUL impact. Some were mentioned and others could be added to the list such as changes in traffic safety programs, engineering, etc. Nevertheless it would appear that the front seat passenger receives the most benefit from safety belts and that this benefit is demonstrated clearly across severity levels. Driver head injury reductions at  $AIS < 2$  are also sizeable but because of the presence of the steering wheel, the magnitude of the reduction is likely not to be as great, particularly as level of crash severity increases. In this regard, it is likely that many unbelted drivers who die immediately in high severity crashes, would if belted, be received at the hospital with a severe ( $AIS \geq 3$ ) head injury. For this reason, whenever possible, driver fatalities should be autopsied and included in any study sample that uses head injury as an SBUL impact indicator.

## Face

Face injuries, excluding eye, and defined by AIS (1985) to include penetrating and tissue loss injuries, damage to internal organs (ear and mouth), and skeletal injuries (including teeth).

For occupants involved in injury-producing passenger car crashes, the facial area is the most frequently injured body region. Using National Crash Severity Study (NCSS) data, Huelke and Compton (1983) found that one-third of these injury cases involved the face, suggesting that the tolerance of facial bones to impact with major points of vehicle contact such as windshield, steering wheel and instrument panel is very low.

Often it is the face which is the most severely injured area, although the majority of facial injuries are minor (AIS 1) as shown in Table J-4, with lacerations, abrasions and contusions being most common.

**Table J-4  
Facial Injuries for All vs. Restrained  
Occupants**

Severity level	Occupants	
	All (%)	Restrained (%)
Minor (AIS 1)	88	91
Moderate (AIS 2)	10	8
Severe, Serious (AIS 3,4)	2	1

Source: Huelke & Compton (1983). Based on 14,927 facial injury cases overall and 632 facial injuries to belted occupants.

Huelke and Compton (1983) report a 25% reduction in facial injuries of all severity levels by the use of safety belts. The more serious facial injuries (AIS 3 and 4) are reduced by about 66%. Although more minor facial injuries occurred in restrained occupant cases analyzed by Huelke and Compton (1983) this difference was not statistically significant. More important, restrained occupants escaped from passenger car crashes uninjured 12% more often than the unrestrained occupant.

Previous studies have shown that the windshield ranks high in the vehicle structures that are contacted in facial injury impacts (Huelke & Sherman, 1975). For the unrestrained occupant, however, almost any interior car component can be contacted, such

as: the windshield and support posts, steering wheel and rim, instrument panel, other occupants, or objects outside the car when complete or partial ejection of the occupant occurs. In contrast, restrained occupants more typically hit the steering wheel or spokes; much fewer collide with the windshield, roof/sunvisor, instrument panel or interior side (Huelke & Compton, 1983).

Most of the evidence for the use of facial injuries as a high potential indicator of SBUL impact again comes mainly from the Rutherford et al. (no date) U.K. study. Based on this 14 hospital study, Great Britain's belt law was associated with the following statistically significant reductions in facial injuries. Rutherford reported a 60% reduction in facial abrasions, that is, there was a marked decrease in such injuries both for drivers (49% reduction) and front seat passengers (61% decrease). Similar reductions were reported for facial bruising for drivers (-66%) and front seat passengers (-69%) as well as facial wounds of drivers (-44%) and front seat passengers (-63%). When all facial fractures were considered there was a statistically significant reduction. However, facial fractures actually increased for drivers (10%) while front seat passengers showed a 46% decrease in this type of injury to the face.

Other studies, however, suggest that reductions in facial fractures are also associated with belt use. Trinca and Dooley (1977) reported a 50% decrease in severe facial injuries following seat belt legislation in Victoria, Australia. In addition, Hobbs (1980) reported an incidence of facial fractures of 5.5% among non-belt users as compared to 2.6% among belt-users. Kahnberg and Gothberg (1987) report more mixed results based on 301 maxillofacial fracture cases collected from 1969 to 1982 in Denmark, during which time a safety belt use law became effective in 1975. They found a noted decrease in more severe maxillary fractures of the type Le Fort I, II and III but also found an increase in partial maxillary fractures.

Although more limited, there is supportive evidence based on U.S. data. For example, Hunter, Reinfurt and Hirsch (1988) found that the percent of facial injuries is clearly smaller when belts are used than when they are not used. Further, based on U.S. and Canadian data, Backaitis and Dalmotas (1985) found that belted occupants had significantly fewer severe and serious facial injuries as compared to unrestrained occupants. Most recently, Reath, Kirby, Lynch and Maull (1989) found significantly fewer upper- and mid-face fractures for restrained occupants as compared to unrestrained occupants although no significant differences were found in lower face (jaw) fractures between these two groups.

With regard to facial injuries as an indicator of SBUL effectiveness, there are some cautionary notes. Not all studies have found reductions in facial injuries due to belt use but the small number of reported injury cases often associated with these studies precludes any suggestion of contradictory findings. More important, changes to the interior structure of the vehicle (such

as, steering wheel, dashboard or windshield improvements) and especially the airbag for the driver may significantly change the profile of facial injuries -- thus confounding any causal link of these injury reductions with passage of SBULs.

## Eye

Eye injuries as defined by AIS (1985) but includes only those with significant risk of permanent visual impairment (AIS >1).

Most of the supportive evidence for the effectiveness of belt-use laws in reducing eye injuries again comes from non-U.S. sources. In Queensland, Australia, Briner (1976) found a progressive and persistent decline in penetrating eye injuries sustained in motor vehicle accidents after passage of a belt-use law based on a 6-1/2 year prelaw and 2-1/2 year postlaw comparison. Although the overall numbers were small, he reported an average of 17.7 eye injuries per year before the law versus an average of 9.6 such cases after the law. Trinca and Dooley (1977) report a 16% reduction in eye injuries as a result of safety-belt legislation.

Similar results have been found in the United Kingdom. In a review of 700 occupants involved in motor vehicle accidents, Ashton, Mackay and Gloyns (1973) found that 39% of the injured occupants suffered impairment or loss of vision in one or both eyes. Based on a much smaller sample, Vernon and Yorston (1984) reported 24 eye injury cases in 1981 before England's belt-use law and only 6 cases during a comparable period in 1983 after passage of the law. Cole, Clearkin, Dabbs and Smerdon (1987) looked at 378 perforating eye injuries during the time period from 1981 through 1983 and they concluded that the belt use law was effective in reducing serious eye injuries. Rutherford et al. (no date) found a decrease of 44% for eye abrasions and a decrease of 50% for foreign-body eye injuries in the first year after the law. Further, minor eye wounds were reduced by 18% and major eye wounds were significantly reduced by 85% for front seat passengers during this same time period. In Northern Ireland, Johnston and Armstrong (1986) found a 60% reduction in ocular injuries.

After introduction in August 1984 of a fine for failure to wear a safety belt, usage in West Germany rose to above 90%. Based on a cooperative study of 22 large eye clinics (see Table J-5 as reported by Friedel & Marburger, 1986) and other data, Marburger and Friedel (1987) found a marked decline in eye injuries caused by contact with the windshield since this fine was introduced.

The small number of eye injury cases for vehicle crash occupants in the United States, however, may preclude its usefulness as an indicator of SBUL impact. Based on NCSS data, Huelke, O'Day and Barhydt (1982) identified 86 eye injury cases. Of these, 17 cases resulted in visual impairment. Based on this finding and in an attempt to account for unclassified cases, they estimated a relative frequency of permanent eye-impairment cases of 17-26 per 100,000 occupants. No ocular injuries were observed among belted occupants.

**Table J-5**  
**Eye Injuries in Selected Two Years with Belt-Law and in**  
**First Year with Law-Plus-Fine Combination: West Germany**

Metropolitan Area	Year with Belt Law		Belt-law and fine
	1978	1982	1984/85
Berlin	4	3	3
Duisburg	15	4	1
Erlangen	--	50	12 <sup>a</sup>
Frankfurt	12	11	6
Gottingen	25	14	9
Hamburg	50	14	4
Heidelberg	39	17	10
Cologne	35	21	1
Lubeck	19	16	4
Mainz	13	7	7
Mannheim	4	9	1
Munich	41	33	5
Munster	30	30	10
Ulm	30	11	1
Wurzburg	71	31	13
<b>Total</b>	<b>388</b>	<b>271</b>	<b>87</b>

Source: Friedel and Marburger (1986). Based on sample of 22 large eye clinics in West Germany.

<sup>a</sup>Unsupported value.

The eye injury experience in foreign countries may not be comparable to the U.S. because of significant differences in vehicle windshields. That is, beginning with 1966 models, U.S.-manufactured cars used a High Penetration Resistance (HPR) windshield made of laminated glass (a layer of plastic sandwiched between two layers of highly tempered glass). This improved laminated windshield does not shatter and is not penetrated until an impact velocity of at least 30 mph is reached (Huelke, O'Day & Barhydt, 1982; Vernon & Yorston, 1984). In contrast, many of the cars in Europe, England, Australia and Asian countries have tempered windshields. Although this glass breaks into small pieces when impacted, the jagged glass retained in the lower windshield frame frequently causes ocular perforations. In a review of the eye injury literature, MacKay (1978) estimated that at least 70% of serious eye injuries in Britain each year were due to tempered windshields. In support of this, earlier studies by Huelke and his colleagues found that laminated windshields markedly reduced head penetration through the glass and decreased the extensive and disfiguring facial lacerations previously seen

from windshield impacts (Huelke, Grabb & Dingman, 1964; 1966; 1967; 1968; Huelke, Grabb & Gikas, 1966).

It is important to note that the literature presented and discussed here does not, in the main, specify the nature nor severity of the eye injuries analyzed. Thus, it is not always clear if these injury cases conform to AIS (1985) classification, but it does seem reasonable to assume that a broader definition of eye injury was probably used in many of these studies as compared to the proposed indicator. As suggested by the data analyzed by Huelke, O'Day and Barhydt (1982), the present restrictive definition will no doubt reduce the already small number of eye injury cases, with additional limitations on the usefulness of these data therefore likely. Nevertheless, the probability of permanent disability in terms of partial or complete blindness in one or both eyes does suggest that these injury cases may need to be kept separate from other types of facial injuries.

## Spine

Spinal cord injuries, excluding strain, acute (no fracture or dislocation), and defined by AIS (1985) to include cervical, thoracic and lumbar spine injuries including injury to the cord, such as fracture, dislocation or laceration (AIS >1).

The National Spinal Cord Injury Data Research Center reported an estimated incident rate of 30 to 50 spinal cord injuries per million population with approximately 50% of these cases resulting from motor-vehicle crash induced trauma (Stover & Fine, 1986). Research studies evaluating the effectiveness of safety belts or belt-use laws support the rare event nature of this injury. Consequently, the numbers reported in these studies are often too few to be statistically meaningful.

The Colorado Department of Health (1987) identified 76 cases of spinal cord injury caused by motor vehicle accidents during 1986 through 1987. Of those injured, 65 were not wearing a safety belt. There were fewer cases of motor-vehicle related spinal cord injuries after Colorado passed their belt-use law but the numbers are too small for any meaningful comparison (15 post law versus 24 cases during a similar period before enactment).

Huelke, O'Day & Mendelsohn (1981), based on National Crash Severity Study data (NCSS), estimated that of passenger cars damaged severely enough to be towed from the accident scene, one in 300 occupants sustained a cervical neck injury of a severe, serious, critical-to-life or fatal nature. This neck-injury rate rose to one in 14 occupants for ejections, although many of these injuries resulted from contact within the car before or during the process of being ejected. Although severe neck injuries were most common in frontal impacts, they found that rollover accidents had the highest rate. Due apparently to more violent car crashes, 16-25 year-old occupants had cervical spinal injuries more than twice as often as those in any other age group. Huelke et al. (1981) further estimate that nationally 5,940 deaths or approximately 20% of all in-car deaths include fatal cervical spine injuries and that about 500 cases of quadriplegia per year result from automobile accidents.

Evidence from non-U.S. sources is scant. Burke (1973) reported a 27% reduction in the frequency of spinal cord injuries as well as a reduction in severity of such injury after Australia passed a safety belt. Friedel and Marburger (1986; Marburger & Friedel 1987) also report reductions in the number of fractures of the cervical spine after West Germany added a penalty to their belt use law.

Though the small number of cases may preclude its usefulness as an indicator of SBUL effectiveness, the effects of spinal cord injury are often devastating with profound implications of lifetime paralysis and multiple clinical problems. A spinal-cord injury can affect virtually all bodily systems and predisposes

the patient to a host of medical complications some of which may become chronic (Stover & Fine, 1986).

On the positive side, the long-term prognosis of spinal cord injury cases has improved dramatically, largely as a result of improved medical management practices. Presently, fewer patients are dying from spinal cord injury-related causes and patients are living longer than was previously the case. A clear consequence of these medical and clinical improvements, however, is that costs of acute care and long-term rehabilitation and treatment are high. For example, average bill hospital charges (from stay until first definitive discharge) were estimated as \$90,000 in 1983 for quadriplegics and \$58,800 for paraplegics during this same year, based on Consumer Price Index adjusted 1985 dollars (Stover & Fine, 1986).

Clearly, the care of spinal-cord injury individuals range far beyond initial medical treatment and rehabilitation, permeating all aspects of an individual's lifestyle from simple activities of daily living to career and family. The broad physical consequences to the individual and the high societal costs of such injuries seem to suggest that preventing even a small number of these injuries through SBULs could have a large effect on the public's positive perceptions of safety belt use.

## Upper Extremities

Upper extremity injuries as defined by AIS (1985) to include the shoulder girdle and joints and all structures of the arm, elbow, forearm, wrist, hands and fingers.

Nearly all of the supportive evidence for the effectiveness of belt-use laws in reducing upper extremity injuries comes from non-U.S. sources. In Sweden, Nygren (no date) reported a consistently smaller percent of arm injuries for belted as compared to nonbelted occupants. In West Germany, Friedel and Marburger (1986) also found a reduction in upper arm injuries for belted versus unbelted front seat occupants.

Based on a study of U.K. motor-vehicle injury data of AIS >1, Sabey, Grant and Hobbs (1977) found an arm injury rate of 20 per 1000 occupants for belt users versus a rate of 39 per 1000 for non-users. Similarly, she and her colleagues found a shoulder injury rate of 14 per 1000 for belted occupants and a rate of 21 per 1000 for unbelted occupants. Newman and Jones (1984) also found fewer arm injuries for belted versus unbelted occupants for injury severity levels of AIS 1 and AIS 3. Moreover, Prentice (1979) found fewer shoulder and arm injuries classified as minor, moderate or severe when he compared belted and unbelted occupants. Rutherford et al. (no date) also found marked reductions in driver and front-seat passenger clavicle, forearm and hand fractures after passage of a safety belt use law in the UK, and noted that there was no evidence to suggest that belt use induced these reported clavicle fractures.

With regard to upper extremity injuries as an indicator of SBUL effectiveness, most studies support a reduction in such injuries as a result of increased belt use. Some studies contradict this finding, but the number of cases analyzed in them is too small to give them much significance. More important, because upper extremity injuries are most often minor and rarely life-threatening it may be difficult to position this reduction in such a way that the public will recognize it as a meaningful benefit of safety belt-use.

It is also important to note that, in the main, the literature presented and discussed here does not define the parameters of the term "upper extremity" injury. It seems clear that in many studies this term is used in a way that is compatible with the above indicator definition (Huelke, Lawson, Scott, & Marsh, 1977); however, it also appears evident that in other studies an "arm injury" may have been used as an ill-defined equivalent of upper extremity injuries.

## Lower Extremities

Lower extremity injuries as defined by AIS (1985) to include all structures of the thigh, knee, leg, ankle, foot and toes.

As has been the case for all of the injury-indicators presently discussed, supportive evidence for the usefulness of this potential indicator of SBUL effectiveness comes largely from non-U.S. sources.

As shown in Table J-6, Sabey, Grant and Hobbs (1977) found reduced injury frequency rates for all lower extremity regions except feet/ankles for belted versus nonbelted occupants, based on an injury experience of AIS >1 in the U.K. Also in the U.K., Prentice (1979) found lower extremity injuries to be less frequent for belted occupants in the following regions: thigh, knee, lower leg and foot/ankle. Mills and Hobbs (1984) reported that safety belts reduced the incidence and severity of lower limb injuries at all severity levels though most of these injuries were minor. They found no pelvic injuries among belted occupants but the overall number of these injuries were small. Similarly, Newman and Jones (1984) found fewer leg injuries at AIS 1 and AIS 3 severity levels for belted as compared to non-belted occupants. While Rutherford et al (no date) found a decrease in major lower-extremity injuries for drivers (32% reduction) and a reduction in fractures of the femur for drivers (24%) and front seat passengers (23%), there was a small but significant increase in minor leg injuries for drivers.

In West Germany, Friedel and Marburger (1986; Friedel & Marburger, 1987) report a significant decrease in knee fractures and soft-tissue injuries to the lower extremities after a monetary penalty was added to their safety belt use law.

In a notable U.S. study, Huelke, Lawson, Scott and Marsh (1977) reported fewer lower extremity injuries for belted versus unbelted occupants. Moreover, there was also an increase in the frequency of "no injury cases" in the lower-extremity body region among belted occupants.

As was mentioned for upper extremity as well as other injuries, the literature presented and discussed here does not always operationally define the injury terms as used. Thus, while it is clear that in many studies this term is used in a compatible manner with the above indicator definition; it is also evident that "leg" is sometimes used as an equivalent to "lower extremity."

Regarding its usefulness as an indicator of SBUL effectiveness, lower extremity injuries may have some potential. Though not life-threatening, lower extremity injuries can be very painful and can result in lingering discomfort. In some cases, such injury can lead to post trauma arthritis or osteoarthritis (Pietrafesa & Hoffman, 1983).

**Table J-6**  
**Lower Extremity Injury Rates**  
**for Belted versus Unbelted**  
**Occupants**

Body Region	Per 1000 Occupants	
	Belted	Unbelted
Pelvis	4	7
Hip joints	0	6
Thigh	6	21
Knees	18	22
Lower legs	6	15
Feet and ankles	24	15

Source: Sabey, Grant and Hobbs, 1977

## Index of Head Injuries to Whiplash

This indicator is an index equal to the ratio of the number of head injuries to the number of cervical sprain or whiplash injuries. The literature suggests that there is a large frequency of both head injuries and whiplash from frontal collisions, and that whiplash is reasonably well reported. The major advantage of this indicator is that a ratio is useful in lieu of other denominator data, such as number of drivers, which may be difficult to measure.

MacKay (1985) summarizing Rutherford's study before and after the United Kingdom SBUL reports large reductions in overall head injury but increase in neck sprains: concussion, -45%; skull fractures, -46%; neck sprains, +21%. This is typical of such studies and suggests that there is a reciprocal relationship between head injuries and neck sprains. Because of this relationship, one advantage of the ratio of head injuries to whiplash is that it tends to measure a greater effect than head injuries alone.

Sabey et al. (1977) of the Transport and Road Research Laboratory, England, reports on a study of occupants in accidents including injured and non-injured, which gives a measure of the actual likelihood of injury to seat belt or non-seat belt wearers. There were 1,163 unbelted and 490 belted individuals. The table lists data on all occupants sustaining injury greater than AIS 1.

Table J-7  
Comparison of Belted and Unbelted Occupants  
Sabey et al. (1977)

	Injuries per 1000 Occupants		
	Unbelted	Belted	% Change
Head	237	106	-55%
Neck	12	16	+33%
Index	19.75	6.44	-67%

Head injuries were reduced by 55%, but the head/neck index was reduced by 67% by wearing belts.

Cameron and Nelson (1977) reported on a survey in Victoria using data from coroners and hospitals during the period from June 1971 to June 1973 which followed enactment of a SBUL. Most injuries were reduced in seat belt users, but whiplash and "transient" cervical cord injuries were increased. A total of 6,696 injured occupants was selected by matching procedures. Quality audit of data was done. There is bias toward rural incidents and over-reporting of seat belt use. Rural bias exaggerates the benefits of seat belt use whereas over-reporting

diminishes the benefits. Figures in the table below are significant at  $p < .05$  by the Chi square test and include fatalities which amount to roughly 5% of total.

**Table J-8**  
**Comparison of Belted and Unbelted Occupants**  
**Cameron and Nelson (1977)**

	Belted	Unbelted
Skull Fracture	2.1%	5.8%
Brain Damage	5.4	10.7
Whiplash	4.0	2.7

Head injuries were reduced by 61%, while the head/neck index was reduced by 69%.

Friedel and Marburger (1986) compared 571 belted front seat occupants vs. 576 unbelted in an in-depth study with "at the scene" analyses. He reported a 47% reduction in head injuries but an increase in "cervical distortions". Assuming that these distortions are strains, the reduction in the head/neck ratio would be 78%.

**Table J-9**  
**Comparison of Belted and Unbelted Occupants**  
**Friedel (1986)**

	Belted	Unbelted
Cranio-cerebral	4.9	6.5
Neck, vertebral distortions	2.1	0.6

Studies showing a decrease in head injuries with increased belt usage have already been discussed. Additional references which report an increase in neck sprains or whiplash comparing belted occupants to nonbelted include: Huelke et al. (1977), Andreasson and Roos (1977), Nordentoft (1977), Grime (1979), Hartemann et al. (1984), Newman and Jones (1984), Freedman (1984), Larder et al. (1985), Olney and Marsen (1986), Sato (1987) and Deans et al. (1987). Freedman (1984) showed an increase in minor neck injuries following introduction of the mandatory use law in Britain. Pye and Waters (1984) were the only researchers to report decreases in neck injuries.

Despite the advantages of this indicator, whiplash can be difficult to diagnose, so that measuring frequency of cases is not always reliable. Partially for this reason, legislators may be somewhat skeptical of an indicator which relies on it, and may

be reluctant to use a "negative" indicator (one which shows undesirable effects) of safety belt use laws.

It is also possible that the ratio could show a decrease, implying a positive effect of the law, even if neck injuries increased while head injuries remained the same.

**APPENDIX K**

**SUMMARY OF EXPERT TEAM RANKINGS OF  
HIGH-POTENTIAL INDICATORS**

**Note:** Numbers (e.g., #33) are used to identify expert team members. The same number is used for a particular expert in all parts of this report.

**Summary of Expert Team Rankings of High Potential Indicators**

Indicator	Expert																				
	#2	#5	#7	#9	#12	#14	#16	#17	#19	#26	#27	#29	#31	#37	#38	#8	#13	#18	#28	#32	#33
Head	6*	9.5+	3	1	3	2	3	1	2	1	9	4	1*	5	5	1	2	1	4	3*	2
Face	12	9.5+	2	..	4	1	5.5	6	4*	2	4	5	1*	9	6	3	1	2	5*	7	6
Eye	7	9.5+	1	..	12	5	5.5	11	5	8	8	6	3*	13*	9	7	poor	7	5*	9	9
Spinal Cord	11	9.5+	9	..	5	8	3	3	..	11	3	8	4*	6	7	9	poor	8	8	12**	8
Upper Extr.	9	9.5+	4	6	6	7	*	10	6	9	14	12	6*	12	8	11	poor	9	6	10	7*
Lower Extr.	10	9.5+	10	4	7	6	*	9	7	10	11	7	5*	11	11	4	?	4	9	8	5*
Head/Whip	4	9.5+	5	..	11	4	3#	7	3+	7	15	9	12+	10**	10	10	4	6	(#)	11#	4
Ejections	2**	9.5+	6	2	1*	3	1	4	1	12	1	1	7	1	1	5	3	5	3	1##	3
KABC	5	1	11	..	2	12	..	12	11	6	13	2	11	8	12	6	?	3*	2	6+	10
MAIS	8	4.5+	12	..	10	11	..	2	9	5	12	10	10	3	3	12	yes	3*	6	5++	13
ISS	1+	4.5+	7	..	9	9	..	8	8	4	7	11	8	2	2	2	yes	3*	1	4@	11
AIS	3+	3+	8	3	8	10	..	5	10	3	10	3	9	4	4	8	yes	3*	3	2@	12
Other		2*		5*							5*			7+							
Other											6**										
Other											2+										

**#2:** \*\*"Needs refinement" \*\*\*"May not be typical" +"Needs good medical recording"

**#5:** \*\*"Shifts in mv occ fatality as reflected in FARS". +"Not feasible. No data bases exist or are contemplated which will yield 'N's' large enough to evaluate SBUL."

**#7:** "I claim little confidence in this ranking, much preferring a weighting or grading approach."

**#9:** \*\*"Chest (thorax) injuries"

**#12:** \*\*"As safety belts essentially eliminate ejection, reductions in ejections after enactment should [be] readily observed -- basically 100% of ejected occupants are unbelted. Because the enhanced risk from ejection is undisputed, and eliminating ejection alone reduces fatality risk by 18% (Evans, 1989), this aspect of the benefits of belt wearing is the most readily observable beneficial consequence."

### Summary of Expert Team Rankings of High Potential Indicators

#16: "Low." # "If well explained."

#19: "if AIS<sub>≥</sub>3; particularly fractures" + "This seems like an interesting index but how reliable is whiplash injury info."

#27: "Average Medical Treatment Costs." \*\*\* "Average Hospital Stay." + "Permanent Disability."

#31: "I rate these high because the public and legislators as well as doctors and scientists can understand them." + "I rate this low because I have little confidence about the numbers of patients who report their neck pain to hospitals."

#37: "Doesn't seem specific to belt use. Case reviews show unique/unusual circumstances of injury." \*\* "Sweden shows that whiplash injury goes up with belt use in the many low-speed crashes." + "The idea of ratios seems intriguing and could be evaluated with Swedish Folksam or German H(?)K data for a broad range of injury types. How about ratio of internal to skeletal chest injuries."

#18: "combine"

#28: "combine" # "Need to establish denominator for calculating incidence rates. Would not use whiplash as denominator. What about instead ratio of head injuries to total injuries."

#32: "use brain" \*\*\* "sample too small" # "include(?) in neck injuries" # "seems OK" + "not sensitive enough" ++ "only hospital admissions, good" @ "only hosp. admiss., good" @@ "only hosp. admiss." (Also recommended but did not rank "'well years' produced (aggregated)" and "YPLL".)

#33: "AIS 3" Also recommended and ranked #1 "SPARCS (New York State) and similar hosp. patient statewide reports and police accident reports" as "source for data" for all of the indicators except ejections and KABC.

**APPENDIX L**

**DATA SYSTEM PROFILE SUMMARIES**

Bay Area Trauma Registry .....	L-1
Boston City Hospital Trauma Registry .....	L-2
Emergency Medical Services Major Trauma Records .....	L-3
Florida Trauma/Head/Spinal Cord Injury Registry .....	L-4
Injury Prevention and Analysis Group .....	L-5
Iowa Safety Restraint Assessment .....	L-6
Major Trauma Outcome Study .....	L-7
Maryland Automated Accident Reporting System (MAARS) .....	L-8
Missouri Bureau of EMS Ambulance Reporting System .....	L-9
Missouri Head and Spinal Cord Injury Trauma Registry .....	L-10
National Electronic Injury Surveillance System (NEISS) ....	L-11
New York Department of Motor Vehicles Records .....	L-12
New York State Safety Belt Use Law Evaluation .....	L-13
Oregon Injury (Trauma) Registry .....	L-14
Sensitivity Index Project .....	L-15
Spinal Cord and Head Trauma Center .....	L-16
Spinal Cord Injury Early Notification System .....	L-17
University of Massachusetts Trauma Registry .....	L-18
University of New Mexico Hospital Trauma Registry .....	L-19
West Virginia Trauma Registry .....	L-20

DATA SYSTEM PROFILE SUMMARY

System name: Bay Area Trauma Registry

Institution: California Emergency Medical Services Authority  
Contact name: Kirby Cooper, PhD, Director  
Address: 50 Glacier Drive  
City/state/zip: Martinez, CA 94553

General background: Trauma registry including eight participating trauma centers in four counties of the San Francisco Bay area and five additional facilities in counties north to Oregon border.

What was counted: patients and injuries  
How it was reported: frequencies and percents  
How it was used: descriptive statistics, patient care analysis  
Source records used: EMS and hospital  
Part of body: all  
Crash factors: type of veh; seating position; restraint; ejection  
Severity scale: ICD, AIS, ISS, GCS, trauma score  
Associated indicators: part of body, AIS, ISS, ejection

Internal validity: High / good coverage of Bay and northern counties  
External validity: Med / mix of urban/rural

Scope/population: patients presenting at 8 hospitals in Bay area.  
Annual cases: 8,000-10,000; 17,000 total  
Years in operation: 1987 to present  
Pre/post law data: post-law only

Data System Features:

Representativeness: Med / nonstatistical sample of area  
Timeliness: Med / continuous update; post-law only  
Reliability/Quality: High / consistent coding; has QA system  
Flexibility: High / can be modified  
Detail: High / very detailed  
Nature of partic.: High / mandatory  
Nature of support: High / state and local funding  
Specificity: High / well defined variables  
Accessibility: High / automated and available  
Cost: High / no cost at present for data requests  
Compatibility: Med / cannot link; standard coding  
Disadvantages:  
Other advantages: High / variables easily added and deleted  
Future plans: Med / may expand to statewide coverage

Other observations:

DATA SYSTEM PROFILE SUMMARY

System name: **Boston City Hospital Trauma Registry**  
Institution: **Boston City Hospital**  
Contact name: **Erwin Hirsch, MD**  
Address: **818 Harrison Avenue**  
City/state/zip: **Boston, MA 02118**  
General background: **Local trauma registry serving Boston area and patients brought in by helicopter.**

What was counted: **patients and injuries**  
How it was reported: **descriptive statistics**  
How it was used: **utilization review, quality assurance, trends**  
Source records used: **special form using hospital records**  
Part of body: **all**  
Crash factors: **driver/passenger only**  
Severity scale: **Injury Severity Score (ISS)**  
Associated indicators: **ISS**

Internal validity: **High / good coverage of hospital catchement area**  
External validity: **Low / urban coverage plus helicopter cases**

Scope/population: **Boston area**  
Annual cases: **1,200**  
Years in operation: **January 1984 to present**  
Pre/post law data: **yes**

Data System Features:

Representativeness: **Low / local urban area**  
Timeliness: **Med / available before, during and after repeal**  
Reliability/Quality: **Med / completed by MD; quality assurance unknown**  
Flexibility: **High / can add and modify variables**  
Detail: **Med / good injury data; no crash data**  
Nature of partic.: **High / mandatory**  
Nature of support: **High / hospital supported**  
Specificity: **High / clearly defined variables**  
Accessibility: **Med / automated, accessible, some privacy constr.**  
Cost: **Med / varies with complexity of request**  
Compatibility: **Low / cannot be linked; use only ISS not AIS**  
Disadvantages:  
Other advantages:  
Future plans:

Other observations:

## DATA SYSTEM PROFILE SUMMARY

System name: **Emergency Medical Services Major Trauma Records**

Institution: **San Diego County Emergency Medical Services**  
Contact name: **Jan Limneos**  
Address: **6255 Mission George Rd.**  
City/state/zip: **San Diego, CA 92120**

General background: **Comprehensive trauma registry incorporating pre-hospital, inpatient, and coroner's records.**

What was counted: **patients and injuries**  
How it was reported: **frequencies and percents**  
How it was used: **descriptive statistics**  
Source records used: **EMS reports, trauma registry forms, coroner's form**  
Part of body: **Abbreviated Injury Scale (AIS) and ICD; all parts**  
Crash factors: **seating position, restraint, ejection**  
Severity scale: **AIS, ISS, Glasgow Coma Scale, Trauma Score**  
Associated indicators: **AIS, ejection, part of body**

Internal validity: **High / thorough coverage of entire county**  
External validity: **Med / depends on representativeness of county**

Scope/population: **San Diego County**  
Annual cases: **120,000 EMS; 4,400 trauma reports; 750 coroner's\***  
Years in operation: **August 1984 to present**  
Pre/post law data: **yes; law took effect 1/1/86**

### Data System Features:

Representativeness: **High / census of major trauma cases in county**  
Timeliness: **High / 3-4 month lag to data availability**  
Reliability/Quality: **High / good training and quality assurance system**  
Flexibility: **Low / cannot modify system**  
Detail: **Med / several MVA-related variables**  
Nature of partic.: **High / mandatory system**  
Nature of support: **High / state/county supported**  
Specificity: **High / clearly defined variables**  
Accessibility: **High / automated and available**  
Cost:  
Compatibility: **Low / cannot be linked; some nonstandard coding**  
Disadvantages: **Low / 8/84-12/85 data reportedly of poor quality**  
Other advantages:  
Future plans: **Med / plan to add variables; reduce time lag**

Other observations: **\*Figures reported include all sources of trauma. Auto/truck crashes (excluding motorcycle, pedal-cycle, pedestrian, etc.) were 34-37% of total.**

DATA SYSTEM PROFILE SUMMARY

System name: Florida Trauma/Head/Spinal Cord Injury Registry  
Institution: Florida Office of Emergency Medical Services  
Contact name: Freida B. Travis, Sr. Human Services Prog. Spec.  
Address: 1317 Winewood Blvd.  
City/state/zip: Tallahassee, FL 32301  
General background: Trauma registry covering all hospitals >300 beds.  
By October 1990 will cover hospitals >100 beds.

What was counted: patients  
How it was reported: EMS/hospital staff  
How it was used: very new record collection system  
Source records used: special form using EMS and hospital records  
Part of body: all, but mostly head and spine  
Crash factors: ejection; restraint; steering wheel deformation  
Severity scale: Glasgow Coma Scale  
Associated indicators: head, spinal cord injury, ejection

Internal validity: / new system; codes not always completed  
External validity: / depends on representativeness of state

Scope/population: state of Florida, including visitors  
Annual cases: 6,000-8,000/month all causes; >72,000 total cases  
Years in operation: November 1988 to present  
Pre/post law data: no

Data System Features:

Representativeness: Med / covers hospitals >100 beds only  
Timeliness: Med / continuous data entry  
Reliability/Quality: Med / trained coders  
Flexibility: Med / can be modified  
Detail: High / 5-digit E-code; little crash data  
Nature of partic.: High / mandatory  
Nature of support: High / state funded; growing  
Specificity: High / well defined variables  
Accessibility: High / automated and available  
Cost: High / no cost  
Compatibility: High / can be linked; standard coding  
Disadvantages: Med / could use better crash data  
Other advantages: Med / willing to improve system  
Future plans: High / adding linkage to motor vehicle records

Other observations: System includes feedback to participating hospitals to help improve record keeping.

**DATA SYSTEM PROFILE SUMMARY**

**System name:** Injury Prevention and Analysis Group

**Institution:** Brookhaven Nat'l Lab and SUNY at Stony Brook  
**Contact name:** Jerome A. Barancik  
**Address:** Brookhaven National Laboratory, Bldg. 475  
**City/state/zip:** Upton, NY 11973

**General background:** Epidemiological study to test the effect of New York safety belt use law on vehicular injury patterns in Suffolk County, NY, funded by NHTSA and N.Y. State Governor's Traffic Safety Committee.

**What was counted:** MV accident cases resulting in trauma  
**How it was reported:** incidence rates and distribution by body region  
**How it was used:** evaluate NY safety belt use law in Suffolk Co.  
**Source records used:** hospital inpatient and emergency room  
**Part of body:** all areas: head, face, thorax, cervical spine, etc  
**Crash factors:** none  
**Severity scale:** modified version of Abbreviated Injury Scale  
**Associated indicators:** AIS, part of body, discharge status

**Internal validity:** High / well designed random sampling procedure  
**External validity:** High / representative of Suffolk Co.

**Scope/population:** entire population of Suffolk Co.; 1.3 million pop.  
**Annual cases:** approx. 1,200  
**Years in operation:** N/A / one-time retrospective study  
**Pre/post law data:** 1983-84 pre-law; 1985 post-law

**Data System Features:**

**Representativeness:** High / stratified random sample of ER m-v cases  
**Timeliness:** N/A / retrospective study  
**Reliability/Quality:** High / sampling and coding well supervised  
**Flexibility:** Med / system can be modified for future studies  
**Detail:** Med / limited by hospital records  
**Nature of partic.:** High / voluntary, but all hospitals participated  
**Nature of support:** Low / short term special purpose study ended 6/89  
**Specificity:** High / well defined  
**Accessibility:** High / report available  
**Cost:** N/A / fees not established at this time  
**Compatibility:** Low / cannot be linked to other records  
**Disadvantages:** Med / costly data recovery operation  
**Other advantages:**  
**Future plans:** Low / project ends June 1989

**Other observations:** None.

**DATA SYSTEM PROFILE SUMMARY**

**System name:** Iowa Safety Restraint Assessment

**Institution:** Iowa Methodist Medical Center  
**Contact name:** Timothy D. Peterson, MD  
**Address:** 1200 Pleasant St.  
**City/state/zip:** Des Moines, IA 50309

**General background:** One-time special study of injuries, hospital utilization and costs associated with use/nonuse of safety belts.

**What was counted:** deaths, injuries, patients, inpatient costs  
**How it was reported:** frequencies, percents, means  
**How it was used:** safety belt evaluation  
**Source records used:** special form using hospital and autopsy records  
**Part of body:** all  
**Crash factors:** speed/alcohol/veh type/ejection/seat position\*  
**Severity scale:** AIS, ISS  
**Associated indicators:** part of body, AIS, ISS, ejection

**Internal validity:** Med / about 20% of MVA cases included in study  
**External validity:** Med / depends on representativeness

**Scope/population:** MVA victims presenting at 16 hospitals  
**Annual cases:** 1,454 cases total  
**Years in operation:** November 1987 to March 1988  
**Pre/post law data:** post-law only

**Data System Features:**

**Representativeness:** Med / limited coverage of state  
**Timeliness:** Low / one-time study  
**Reliability/Quality:** High / special form central coordination  
**Flexibility:** Low / no modification possible  
**Detail:** High / good injury and crash data  
**Nature of partic.:** Low / mandatory, but for limited time period  
**Nature of support:** Low / one-time grant  
**Specificity:** High / well defined variables  
**Accessibility:** Med / accessible; combination computer and manual  
**Cost:**  
**Compatibility:** Med / cannot link; uses standard coding  
**Disadvantages:**  
**Other advantages:**  
**Future plans:**

**Other observations:** \* impact direction/restraint use.

**DATA SYSTEM PROFILE SUMMARY**

**System name:** Major Trauma Outcome Study

**Institution:** Washington Hospital Center, Trauma Research Center  
**Contact name:** Dr. Wayne S. Copes, Director, Trauma Research  
**Address:** 100 Irving St., N.W., Room 3120  
**City/state/zip:** Washington, DC 20010

**General background:** Standardized set of data contributed by approximately 90 trauma centers, mostly large level 1.

**What was counted:** patients and injuries  
**How it was reported:** n/a  
**How it was used:** to evaluate trauma care systems  
**Source records used:** special form: pre-hosp., acute care, outcome data  
**Part of body:** all  
**Crash factors:** E-code, restraint system use (from 1/1/89)  
**Severity scale:** Abbreviated Injury Scale, Glasgow Coma Scale  
**Associated indicators:** Abbreviated Injury Scale, part of body

**Internal validity:** Low / changing set of reporting centers  
**External validity:** Low / not geographically representative

**Scope/population:** depends on reporting centers; fluctuates  
**Annual cases:** 40,000 annual; 120,000 total  
**Years in operation:** 1982 to present  
**Pre/post law data:** depends on area

**Data System Features:**

**Representativeness:** Low / multi-state but not a constant sample  
**Timeliness:**  
**Reliability/Quality:** High / one form completed by trained records clerk  
**Flexibility:** Low / large system with many participating units  
**Detail:** High / detailed medical data  
**Nature of partic.:** Low / voluntary  
**Nature of support:** High / Amer Coll of Surg Comm on Trauma  
**Specificity:** High / well defined variables  
**Accessibility:** Low / automated, but not available at this time  
**Cost:**  
**Compatibility:** High / links pre-hosp with hosp; standard coding  
**Disadvantages:**  
**Other advantages:** High / large number of cases; used for research  
**Future plans:**

**Other observations:** may be confidentiality problems

DATA SYSTEM PROFILE SUMMARY

System name: Maryland Automated Accident Reporting System--MARS  
Institution: Maryland Institute for Emergency Medical Services  
Contact name: Dr. Belavadi S. Shankar  
Address: 22 S. Green St.  
City/state/zip: Baltimore, MD 21201

General background: The Institute maintains a copy of the statewide file of police-reported motor vehicle crashes. It uses this file for routine data analysis and, for special studies, supplements it with injury data obtained from medical records matched with the police accident reports.

What was counted: deaths and injuries  
How it was reported: descriptive and inferential statistics  
How it was used: routine and special studies  
Source records used: police & EMS reports; hospital records  
Part of body: all  
Crash factors: vehicle and collision type, seating position\*  
Severity scale: KABC [AIS, ISS, and ICD for special studies]  
Associated indicators: KABC and ejection [AIS and part of body for special studies]

Internal validity: High / good statewide coverage  
External validity: Med / depends on representativeness of state

Scope/population: state of Maryland; 4.2 million population  
Annual cases: 120,000 annual; 1.2 million total  
Years in operation: 1980 to present  
Pre/post law data: yes

Data System Features:

Representativeness: High / good mixture of urban and rural experience  
Timeliness: Med / reasonable lag time  
Reliability/Quality: Med / some missing data  
Flexibility: Low / not easily modified  
Detail: Med / good detail on police report portion  
Nature of partic.: High / mandatory  
Nature of support: High / state supported long-term project  
Specificity: High / well defined variables  
Accessibility: High / automated and available  
Cost: High / nominal fees for most data requests  
Compatibility: Med / standard coding but linking difficult\*\*  
Disadvantages:  
Other advantages:  
Future plans: High / planning to make records linking easier

Other observations: \* speed, alcohol, driver restraint use, etc  
\*\*no name or social security number on police accident reports provided by the state.

**DATA SYSTEM PROFILE SUMMARY**

**System name:** Missouri Bureau of EMS Ambulance Reporting System

**Institution:** Missouri Department of Health  
**Contact name:** Margaret Kratochvil, Research Analyst  
**Address:** State Center for Health Statistics, P. O. Box 570  
**City/state/zip:** Jefferson City, MO 65102

**General background:** Mandatory ambulance run reporting system used for administrative purposes, resource allocation, service evaluation, and injury control programming.

**What was counted:** patients  
**How it was reported:**  
**How it was used:** descriptive statistics  
**Source records used:** ambulance run report  
**Part of body:** yes, general  
**Crash factors:** restraint only  
**Severity scale:** Trauma Score, Glasgow Coma Scale  
**Associated indicators:** severity

**Internal validity:** High / complete coverage  
**External validity:** Med / depends on representativeness

**Scope/population:** state of Missouri  
**Annual cases:** 368,000  
**Years in operation:** 1976 to present  
**Pre/post law data:** yes

**Data System Features:**

**Representativeness:** Med / only pre-hospital data  
**Timeliness:** High / little time lag, continuously updated  
**Reliability/Quality:** High / consistent coding over time  
**Flexibility:**  
**Detail:** Med / no detailed diagnosis, severity, crash data  
**Nature of partic.:** High / mandatory by state law  
**Nature of support:** High / state dept. of health support and admin.  
**Specificity:** High / well defined variables  
**Accessibility:** High / automated and available  
**Cost:** High / no costs  
**Compatibility:** High / attempting to link to police and hospital  
**Disadvantages:** Med / lack of detailed medical and crash data  
**Other advantages:** High / large number of cases  
**Future plans:**

**Other observations:** none

**DATA SYSTEM PROFILE SUMMARY**

**System name:** Missouri Head/Spinal Cord Injury Trauma Registry  
**Institution:** Missouri Dept. of Health, Div. of Health Resources  
**Contact name:** Margaret Kratochvil, Research Analyst  
**Address:** P.O. Box 570  
**City/state/zip:** Jefferson City, MO 65102  
**General background:** Head and Spinal Cord Injury (SCI) trauma registry.

**What was counted:** head and SCI  
**How it was reported:** n/a  
**How it was used:** n/a  
**Source records used:** pre-hospital, emergency and operating room records  
**Part of body:** head, spinal cord  
**Crash factors:** ICD E-code; Blood Alcohol Concentration; restraint  
**Severity scale:** Glasgow Coma Scale  
**Associated indicators:** head and spinal cord

**Internal validity:**  
**External validity:**

**Scope/population:** state of Missouri  
**Annual cases:** 7,000 annual; 12,000 total  
**Years in operation:** July 1987 to present  
**Pre/post law data:** no

**Data System Features:**

**Representativeness:** Med /  
**Timeliness:** Med / updated continuously; available any time  
**Reliability/Quality:** High / special form completed by trained clerk  
**Flexibility:** Med / may be possible to modify  
**Detail:** High / standard coding  
**Nature of partic.:** High / mandatory  
**Nature of support:** High / state funded and operated  
**Specificity:** High / well defined variables  
**Accessibility:** High / automated and available  
**Cost:**  
**Compatibility:** High / can be linked; standard coding  
**Disadvantages:** High / not available pre-law  
**Other advantages:** High / large number of MV cases  
**Future plans:** High / expand to general trauma registry

**Other observations:** none

## DATA SYSTEM PROFILE SUMMARY

**System name:** National Electronic Injury Surveillance System

**Institution:** U. S. Consumer Product Safety Commission  
**Contact name:** Art McDonald, Dir., Div. of Injury Data Systems  
**Address:** 5401 Westbard Avenue (301-492-6539)  
**City/state/zip:** Bethesda, MD 20207

**General background:** NEISS is a nationwide sample of 63 emergency rooms which report data on product-related injuries. Surveillance data is obtained from emergency room records and in-depth data may be obtained from telephone follow-up interviews. MV injury data was collected from 1978 to 1982.

**What was counted:** emergency room visits  
**How it was reported:** national estimates  
**How it was used:** descriptive statistics  
**Source records used:** emergency room records; telephone follow-up  
**Part of body:** yes  
**Crash factors:** n/a  
**Severity scale:** special scale unique to NEISS; can use AIS  
**Associated indicators:** n/a

**Internal validity:** High / standardized methods and codes  
**External validity:** High / representative sample

**Scope/population:** National / total US population  
**Annual cases:** 250,000 - 300,000  
**Years in operation:** Since 1972  
**Pre/post law data:** pre-law only

**Data System Features:**

**Representativeness:** High / well designed sample  
**Timeliness:** High / data available immediately to gov't. users  
**Reliability/Quality:** Med / small sample means large error of estimate  
**Flexibility:** High / has been modified to collect added data  
**Detail:** Med / limited by data sources noted above  
**Nature of partic.:** High / hospitals paid to participate  
**Nature of support:** High / funding has been continuous  
**Specificity:** High / well-defined variables  
**Accessibility:** High / machine readable; no time lag  
**Cost:** High / approx. \$10/case surv.; \$100/case follow-up  
**Compatibility:** High / could be linked to police accident report.  
**Disadvantages:** High / lack of pre-law data since 1981  
**Other advantages:** High / has been used in the past by NHTSA  
**Future plans:**

**Other observations:** Surveillance and follow-up data can be obtained from a sub-sample of hospitals if desired (e.g., non-SBUL states).

**DATA SYSTEM PROFILE SUMMARY**

**System name:** New York Department of Motor Vehicles Records

**Institution:** Institute of Traffic Safety Management & Research  
**Contact name:** Debra Rood, Program Manager  
**Address:** 260 Washington Avenue  
**City/state/zip:** Albany, NY 12210

**General background:** A series of studies on the NY safety belt law using police accident reports together with attitudinal measures (telephone surveys), observational data and data on conviction/citation for nonuse.

**What was counted:** deaths, injuries and noninjuries involved  
**How it was reported:** time series analyses  
**How it was used:** SBUL evaluation  
**Source records used:** police accident reports via DMV  
**Part of body:** yes  
**Crash factors:** yes, full range of factors on the police report  
**Severity scale:** KABC  
**Associated indicators:** severity, part of body, ejection

**Internal validity:** High / statewide coverage; all reports on file  
**External validity:** High / good representativeness

**Scope/population:** entire state of NY  
**Annual cases:**  
**Years in operation:** pre-law through 1987  
**Pre/post law data:** yes

**Data System Features:**

**Representativeness:** High / statewide  
**Timeliness:** Low / long lag time for state to automate data  
**Reliability/Quality:** Med / limited by accuracy of police reports  
**Flexibility:** Low / limited to reported variables  
**Detail:** High / all entries on police report available  
**Nature of partic.:** Med / mandatory accident reporting  
**Nature of support:** Med / funded by NY DMV  
**Specificity:** Med / could be improved with linking  
**Accessibility:** Low / yes through ITSM&R (not from NY DMV)  
**Cost:** / don't know  
**Compatibility:** Med / can be linked; coding uniform within state  
**Disadvantages:** Med / does not use AIS  
**Other advantages:** Med / others have used the data for good studies  
**Future plans:** Low / none

**Other observations:** none

**DATA SYSTEM PROFILE SUMMARY**

**System name:** New York State Safety Belt Use Law Evaluation

**Institution:** University of Rochester Medical Center  
**Contact name:** John D. States, MD  
**Address:** 601 Elmwood Ave.  
**City/state/zip:** Rochester, NY 14642

**General background:** One-time special study of m-v injuries in Monroe County, New York. Before/after with control group design. Preliminary results show hospital admissions -18%; average ISS decreased from 15.1 to 13.0; belt use increased from 11% to 72%.

**What was counted:** patients and injuries  
**How it was reported:** numbers and scores  
**How it was used:** sbul evaluation  
**Source records used:** police, EMS, hospital  
**Part of body:** all  
**Crash factors:** acc type, seat position, vehicle, ejection, etc  
**Severity scale:** modified Abbreviated Injury Scale (AIS)  
**Associated indicators:** AIS, Injury Severity Scale, part of body

**Internal validity:** High / thorough coverage of entire county  
**External validity:** Med / depends on representativeness of county

**Scope/population:** Monroe Co., N.Y., 700,000 pop.  
**Annual cases:** 1,775 total cases  
**Years in operation:** cases occurred from July 1983 to June 1986  
**Pre/post law data:** yes

**Data System Features:**

**Representativeness:** High / good coverage of case in catchment area  
**Timeliness:** n/a / retrospective study  
**Reliability/Quality:** High / well-trained coders; quality control system  
**Flexibility:** Low / cannot be modified  
**Detail:** High / crash data; medical diagnoses; treatment  
**Nature of partic.:** High / mandatory participation by hospitals  
**Nature of support:** Med / supported by grants  
**Specificity:** High / well-defined variables  
**Accessibility:** High / automated and available  
**Cost:** High / \$50 fee to qualified users  
**Compatibility:** High / can be linked; standard coding  
**Disadvantages:** Med / no veh crush data or occ contact points  
**Other advantages:** High / detailed medical and drug use data  
**Future plans:** Low / study ended mid-1989

**Other observations:** none

DATA SYSTEM PROFILE SUMMARY

System name: Oregon Injury Registry

Institution: Oregon Department of Human Resources, Health Div.  
Contact name: Gena Turner  
Address: 1400 S.W. Fifth Ave.  
City/state/zip: Portland, OR 97201

General background: Trauma registry including (1) all deaths due to injury, (2) hosp admissions for injury and poisoning, (3) hosp admissions for any external cause except E870-E879, and (4) re-admissions within 6 months after original discharge for treatment of injury.

What was counted: patients and injuries  
How it was reported: frequencies, percents, population rates  
How it was used: descriptive statistics  
Source records used: special form; hospital, pre-hospital, discharge  
Part of body: region  
Crash factors: ICD E-code, restraint usage  
Severity scale: Abbreviated Injury Scale (AIS), Glasgow Coma Scale  
Associated indicators: AIS, ICD diagnosis

Internal validity: Low / about half of cases not reported  
External validity: Med / depends on representativeness of area

Scope/population: six counties in Oregon covering 80% of population  
Annual cases: 8,500  
Years in operation: 1987 to present  
Pre/post law data: Law enacted 1987; repealed before it took effect\*

Data System Features:

Representativeness: Med / partial coverage of state  
Timeliness: Med /  
Reliability/Quality: High / consistent coding; QA system  
Flexibility: High / can be modified  
Detail: Med / ICD detail for the most part  
Nature of partic.: Low / voluntary  
Nature of support: Med / funded by Oregon Traffic Safety Commission  
Specificity: High / well defined variables  
Accessibility: High / automated and available  
Cost:  
Compatibility: Med / cannot be linked, standard coding  
Disadvantages:  
Other advantages:  
Future plans: Med / expanding to statewide coverage by 1990

Other observations: \*There is currently a SBUL that covers only 16 year old drivers.

DATA SYSTEM PROFILE SUMMARY

System name: **Sensitivity Index Project**

Institution: **Maine Health Information Center**  
Contact name: **Sandra Johnson, Dir.**  
Address: **81 Winthrop Street**  
City/state/zip: **Augusta, ME 04330**

General background: **A long-term study to evaluate the effectiveness of EMS using linked police crash reports, ambulance run reports, hospital discharge diagnosis data, death certificates, and census data.**

What was counted: **patients**  
How it was reported: **frequency, percent, mean, index**  
How it was used: **EMS effectiveness evaluation**  
Source records used: **police, ambulance & hospital records; death cert.**  
Part of body: **yes**  
Crash factors: **restraints**  
Severity scale: **Champion trauma score, KABC**  
Associated indicators: **severity**

Internal validity: **Med / many unmatched records**  
External validity: **Low / unique to Maine**

Scope/population: **state of Maine**  
Annual cases: **approximately 3,900**  
Years in operation: **1982 to present**  
Pre/post law data: **no law**

Data System Features:

Representativeness: **High / statewide**  
Timeliness: **Med / 3-6 month lag**  
Reliability/Quality: **Med / many missing data elements**  
Flexibility: **Med / linking is cumbersome**  
Detail: **High / data from multiple sources**  
Nature of partic.: **High / uses mandatory records**  
Nature of support: **Med / state funded with federal assistance**  
Specificity: **High / if linking is complete**  
Accessibility: **Med / some links done manually; data available**  
Cost: **High / if using most accessible data as is**  
Compatibility: **Med / standard coding; some manual linking**  
Disadvantages: **Med / some manual linking -- cumbersome**  
Other advantages: **Med / continuity of yearly data**  
Future plans: **Med / plan to use EMS run # as common ID**

Other observations: **none**

DATA SYSTEM PROFILE SUMMARY

System name: **Spinal Cord and Head Trauma Center**  
Institution: **Roosevelt Warm Springs Inst. for Rehabilitation**  
Contact name: **Sharon Short**  
Address: **P. O. Box 1000**  
City/state/zip: **Warm Springs, GA 31830**

General background: **Statewide registry of spinal cord injury (SCI) and disease resulting in neurological deficit; head injury resulting in temporary or permanent decrease in cognitive, behavioral, social, or physical functioning.**

What was counted: **spinal cord injury and head injury**  
How it was reported: **frequencies only**  
How it was used: **descriptive statistics**  
Source records used: **hospital records, referral form**  
Part of body: **spine, head**  
Crash factors: **veh. type; alcohol/drugs/seat belt/helmet**  
Severity scale: **Glasgow Coma Scale**  
Associated indicators: **head, spinal cord injury**

Internal validity:  
External validity:

Scope/population: **state of Georgia, with a few exceptions**  
Annual cases: **Head: 369 in 1988. Fewer SCI.**  
Years in operation: **SCI: 1981 to present. Head: 1985 to present.**  
Pre/post law data: **yes**

Data System Features:

Representativeness: **Med / includes some out of state cases**  
Timeliness: **Med / may be long lag between injury and report**  
Reliability/Quality: **Low / coding scheme not complete; no QA system**  
Flexibility: **Med /**  
Detail: **Low / little detail**  
Nature of partic.: **Med / mandatory**  
Nature of support: **Med / Roosevelt Inst. supports and administers**  
Specificity: **Med / well defined variables**  
Accessibility: **Low / not automated; accessible**  
Cost:  
Compatibility: **Med / cannot be linked; standard coding**  
Disadvantages: **Low / few cases; complete coverage uncertain**  
Other advantages: **Med / in place; continuous; available pre/post**  
Future plans:

Other observations: **none**

DATA SYSTEM PROFILE SUMMARY

System name: **Spinal Cord Injury Early Notification System**

Institution: **Colorado Dept. of Health, Div. of Prevention Prog.**  
Contact name: **Ken Garhart, MS, Coordinator**  
Address: **4210 E. 11th Ave.**  
City/state/zip: **Denver, CO 80220**

General background: **Registry of spinal cord injuries (SCIs) involving (1) traumatic origin, (2) neurological deficit, (3) residents of Colorado or Wyoming at time of injury, (4) injury sustained after 1/1/86, and (5) reported to the ENS surveillance system.**

What was counted: **SCI patients**  
How it was reported: **numbers, per cents**  
How it was used: **epidemiology and rehabilitation**  
Source records used: **hospital and other medical records**  
Part of body: **spinal cord**  
Crash factors: **ICD accident type and seating position; belt use**  
Severity scale: **Frankel coding system**  
Associated indicators: **SCI**

Internal validity: **High / census of cases**  
External validity: **Med / probably good but needs to be tested**

Scope/population: **residents of Colorado and Wyoming**  
Annual cases: **80; 250 total**  
Years in operation: **1986 to present**  
Pre/post law data: **yes**

Data System Features:

Representativeness: **Med / limited scope**  
Timeliness: **Med / annual assessment of status and db update**  
Reliability/Quality: **Med / consistent over time; no data quality check**  
Flexibility: **Low / cannot be modified**  
Detail: **Low / focuses on treatment and rehabilitation**  
Nature of partic.: **Med / voluntary**  
Nature of support: **High / long term system; stable administration**  
Specificity: **Med / uses common coding systems**  
Accessibility: **Med / automated but privacy constraints**  
Cost: **Low / cannot be linked, uses ICD**  
Disadvantages:  
Other advantages:  
Future plans: **Med / will include deaths; add police reports**

Other observations: **none**

**DATA SYSTEM PROFILE SUMMARY**

**System name:** University of Massachusetts Trauma Registry

**Institution:** University of Massachusetts Trauma Center

**Contact name:** Tim O'Hern, Data Manager

**Address:** 55 Lake Avenue, N.

**City/state/zip:** Worcester, MA 01655

**General background:** Hospital-based trauma registry covering patients admitted or expired in ER

**What was counted:** Patients and injuries

**How it was reported:** Frequencies and percents

**How it was used:** Patient care analysis, examine specific inj types

**Source records used:** Special form using hospital, ER, and pre-hospital

**Part of body:** All

**Crash factors:** Ejection, entrapment, speed, driver/passenger

**Severity scale:** AIS, ISS, Trauma score, GCS

**Associated indicators:** ejection, part of body, ISS, AIS

**Internal validity:** Med / good coverage of catchment area

**External validity:** Low / limited catchment area

**Scope/population:** Patients presenting at the institution

**Annual cases:** 1,300; more than 4,000 total

**Years in operation:** 1982-1985 and 1989 forward

**Pre/post law data:** Yes, but not continuous

**Data System Features:**

**Representativeness:** Low / catchment area is central MA, northeast CT

**Timeliness:** Med / continuously updated, break in data years

**Reliability/Quality:** Med / consistent coding

**Flexibility:** Med / was modified recently

**Detail:** Med / depends on completeness of data form

**Nature of partic.:** High / mandatory

**Nature of support:** Med / hospital supported

**Specificity:** High / well defined variables

**Accessibility:** High / automated and available

**Cost:**

**Compatibility:** High / can be linked; standard coding

**Disadvantages:** Low / break in data collection during SBUL period

**Other advantages:**

**Future plans:** Low / recently revised; no changes planned

**Other observations:**

DATA SYSTEM PROFILE SUMMARY

System name: University of New Mexico Hospital Trauma Registry

Institution: University of New Mexico Hospital  
Contact name: Leticia M. Rutledge  
Address: 2211 Lamas Blvd., N.E.  
City/state/zip: Albuquerque, NM 87131

General background: Statewide trauma registry. Includes patients admitted due to falls, mv crashes, motorcycle, gunshots, stabbings, pedestrian, blunt assault, bicycle, blunt trauma, and other trauma. Excludes burns, poisonings, hangings, drownings, electrical shock, DOA, treated & released in ER.

What was counted: patients and injuries  
How it was reported: number, percents, rates, scores  
How it was used: descriptive statistics  
Source records used: special form plus some hospital records  
Part of body: all  
Crash factors: none  
Severity scale: trauma score, AIS, and local system  
Associated indicators:

Internal validity: Med / statewide coverage but limited case def'n.  
External validity: Low / depends on representativeness

Scope/population: state of New Mexico  
Annual cases: 2,000  
Years in operation: 1984 to present  
Pre/post law data: yes

Data System Features:

Representativeness: Med / limited case definition  
Timeliness: Med / data available annually  
Reliability/Quality: Med / problem with missing data  
Flexibility: High / can be modified  
Detail: Low / little m-v related data  
Nature of partic.: High / mandatory  
Nature of support: Med / funded and administered by UNM Hospital  
Specificity: Med / seat belt use self-reported  
Accessibility: Med / automated, but availability unknown\*  
Cost:  
Compatibility: Med / uses standard codes for only some elements  
Disadvantages: High / problem with incomplete and incorrect data  
Other advantages: High / was used to enact SBUL and defeat repeal  
Future plans: High / expand coverage to include all trauma cases

Other observations: \* It is not clear who has authority to release the data for research.  
Number of participating hospitals is increasing.

DATA SYSTEM PROFILE SUMMARY

System name: West Virginia Trauma Registry  
Institution: W. VA. Department of Health, Office of EMS  
Contact name: Dr. Fred Cooley, Director  
Address: 1411 Virginia Street, E.  
City/state/zip: Charleston, WV 25301  
General background: Relatively new general trauma registry.

What was counted: patients, injuries  
How it was reported: frequencies, percents  
How it was used: descriptive statistics  
Source records used: special form using ER and inpatient records  
Part of body: all  
Crash factors: BAC, seat belt, ICD E-code  
Severity scale: trauma score, abbreviated injury scale  
Associated indicators: part of body

Internal validity: Med / 11 major hospitals participated in 1988  
External validity: / depends on representativeness of state

Scope/population: state of West Virginia, 1.6 million population  
Annual cases: 1,400-1,600 motor vehicle excluding motorcycle  
Years in operation: January 1988 to present  
Pre/post law data: no law

Data System Features:

Representativeness: Med / incomplete coverage of state  
Timeliness: Med / 6 month lag to data availability  
Reliability/Quality: Med / trained coders; no QA system  
Flexibility: Med / can be modified  
Detail: Med / 5-digit ICD; no crash data  
Nature of partic.: Med / voluntary  
Nature of support: High / state supported; long term  
Specificity: Med / well defined variables  
Accessibility: High / automated and available  
Cost: / public domain  
Compatibility: High / can be linked; standard coding systems  
Disadvantages: / record completion is variable  
Other advantages: Med / uses AIS  
Future plans: High / plan to include more crash data

Other observations: System will eventually conver all hospitals within the state.

## **APPENDIX M**

### **EXPERT TEAM COMMENTS ON METHODOLOGICAL ISSUES**

**Note:** Numbers (e.g., #33) are used to identify expert team members. The same number is used for a particular expert in all parts of this report.

**SUMMARY OF WRITTEN COMMENTS SUBMITTED BY EXPERT TEAM  
ON METHODOLOGICAL ISSUES**

**A. What is the best way to handle the causal influences of other factors affecting high-potential SBUL indicators (e.g. raising the 55 mph speed limit, increased travel, and increased DWI enforcement)?**

**#33:** Control groups are helpful but expensive. Using other states without SBULs is imperfect and very expensive. I prefer using other patients who sustained injury from motor vehicle accidents in the same environment; i.e., motorcyclists, pedestrians and bicyclists.

**#28:** Control through statistical adjustment where they are identified and then relationship to outcome is known.

**#18:** 1. Changes in data collection practices/reportability. 2. Changes in enforcement patterns because of legislation, regulation, political pressure, licensing practices. 3. Standardization of definitions across sites.

**#5:** Time series analyses can handle this. Seat belt laws have specific dates of onset. The intervention test can deal with that date. Each law can be evaluated on its specific date of onset. Few if any of those onset dates correspond to the date the 55 mph law was changed. (See my paper.)

**#2:** These confounders would affect the results of the high-potential SBUL indicators. This and the fact that not all people are going to adhere to the SBUL and looking at the data as if all were adhering.

**#9:** Acknowledge that changes in these variables occur. Get as much data from as many years as possible. In some cases you may be able to find regions or states without changes, which can be compared with those having changes in laws.

**#14:** Increased travel is not useful because there are no policy decisions that win results for consideration of this as a factor. However, both the speed limit and DWI represent policy decisions that can be altered or can impact on SBULs.

**#19:** You can use other jurisdictions which do not pass an SBUL as a control; preferably one that is similar in terms of socio-economic and travel pattern factors. Also you can use road users who are not directly affected by SBUL as a control (e.g., pedestrians, bicyclists, motorcyclists) as a control for such changes as speed limit and travel changes.

#27: These, and several other subjects, should have individual data analyzed. Those listed will all affect the frequency of accidents. Speed and alcohol will intuitively increase the severity of injuries.

#29: There is no question about the relationship between the level of enforcement and increased usage. However whether a given level of enforcement can be high enough to capture the high risk group is not known. That is, even at 90% usage (due to enforcement) perhaps the results would not be what would be expected because the 10% least likely to wear belts are the highest-risk group.

#31: It is important to scrutinize the legislation, as it is not unlikely that with SBUL, other measures will be introduced. It then becomes difficult to quantify which improvement is due to which measure. In before/after studies total population is important, and miles travelled. If this is not being assessed, consumption of gasoline may give an indication.

#37: Crash severity is a critical indicator linking to injury risk. Delta V is most widely accepted measure based on CRASH3 analysis of vehicle deformations (CDC).

Alcohol use also influences injury severity as well as crash occurrence. Pre-crash factors need to be included in traffic accident records for subsequent analysis.

#38: Obviously a serious problem, but as long as we have non-SBUL states and comparable states the effects (speed and travel) should balance.

# # #

B. What is the utility of pre/post SBUL data without comparison groups?

#33: Use motorcyclist, pedestrian, bicyclist control group from same geographical area.

#28: Comparison group essential.

#18: Better than nothing. Poorly designed comparison groups may be worse than eliminating them.

#5: You can have comparison groups. Within each state create a comparison group based on casualties not addressed by the belt law. (e.g. back seat occ's.; occ's. of vehicle not covered by the law; non-occupants, etc.) (See my paper.)

#2: The results would be more conclusive if comparison groups

were possible but general results can be presented with pre/post SBUL data without comparison groups.

#9: If your population is a representative one you don't need comparison groups, just pre- and pos-SBUL results! However, it's always better to look at results in comparison groups.

#14: Better to have one good study than many insupportable by a control. Your research summaries show plenty of less than great studies.

#19: If you have a long enough series of reliable data points before and after you can do interrupted time series analysis but effect of SBUL must be fairly large to detect shift.

#27: Should match pairs (belted with unbelted) in pre and post data sets to enhance credibility.  
Even if this data is not available some extrapolation could be made.

#31: In the UK our pre/post SBUL assessment worked reasonably well without outside assessment. In the USA if some states introduce legislation and other don't, nonSBUL data at the same time would obviously be valuable.

#37: We must emphasize use of consistent reporting at fixed intervals to demonstrate cause/effect of SBUL. However, this is a difficult issue for many reasons. We need to speak up for data collection needs so funds are committed by state and federal agencies.

#38: For scientific purposes very little utility without some control over factors above. However, may have utility for administrative decision making in which strong correlational data are often used. For such purposes "indicators" not causes may suffice.

# # #

C. What are the merits of retrospective analysis of pre/post SBUL indicator data based on existing records vs. prospective collection of data in SBUL states?

#33: Enactment or repeal of SBULs are highly unpredictable. It follows that prospective studies will probably be impossible to set up. I see no alternative but to perform retrospective studies.

#28: Use combination of both designs: (a) retrospective pre-post-comparison group on KABC0 (use states with good reporting

systems); (b) prospective study on new indices; (c) also retro on (b) if pre-post data available.

#18: May be difficult to have an impact on changing data collection formats to coincide with new SBUL. Will probably have to use best retrospective data possible--but still try to influence collection to generate the needed data. Thus--need both retrospective and prospective data.

#5: I think retrospective data is adequate to detect the intervention. (See my paper.)

#2: Although the retrospective analysis based on existing records may not give all information wanted it is usually much cheaper and less time consuming than prospective studies.

#9: Prospective data collections enables determination of causation. Retrospective data can help determine relative risk, but it is subject to bias. See papers by Alvin Feinstein, MD, at Yale, Nathan Mantel, Journal of Chronic Disease, 1989.

#14: Why must this be a choice? Both types of study contribute to policy and can be very reinforcing.

#19: It is always preferable to conduct prospective studies in which the most reliable and valid data needed to assess the impact of the countermeasure is gathered. However, such a luxury rarely exists and researchers must fall back onto retrospective data which approximates the required levels of reliability and validity. Ideally, this retrospective data could be validated against some prospective data, where available.

#27: Retrospective data is usually deficient in details for crash injury studies due to a lack of a uniform data set and variable documentation skills.

#29: Using extant data bases would be far less expensive, but their usefulness would have to be examined (e.g., do they contain info on belt use pre-law?).

#31: Might work for fatalities. Possibly also for some injuries with fairly low occurrence and high likelihood of record (spinal injuries with paraplegia). Could also try road traffic accidents that had used a treatment facility, like admission to an intensive care bed.

Following SBUL, some would-be fatalities survive, usually becoming patients in hospital, and some drivers and passengers who would have been patients have no injuries. The severity proportions within the dead as the hospital patients do not change, only the absolute numbers.

#37: (1) We should encourage/support/fund innovative analyses of data that already exist, as through new techniques like the double pair comparison by Evans (1986).

(2) Prospective data collection needs a purpose, one of which should be to track the cost-savings of SBUL in terms of injury claims, and other burden-related aspects.

#38: Some prospective well-controlled studies will be necessary for validation. However, again for administrative decision making, retrospective data may be adequate. The anti-smoking campaign and decisions are based on correlational not causal data, much of the early decisions were also based on retrospective data. In addition, for seat belt (I know different from SBUL) effects we do have crash test data.

# # #

D. How can the lack of population-based data sources be addressed? (I.e., data collected from a population with known characteristics.)

#33: Population-based data sources are essential for rate determination and should be used whenever possible.

#5: Yes, this is a problem. FARS won't help, but certain state data bases do address this issue (see my paper).

#2: The problem with the lack of population-based data sources is that one cannot generalize results to the population and one doesn't have estimates for uninjured occupants.

#9: This is always a problem. Why not study tollways, where practically every crash with some damage or injury is known.

#14: This problem is inherent in the US health care system. It is a problem. State health care data agencies or their association, the National Association of Health Data Organizations here in Washington may help. Mark Epstein is the Executive Director.

#17: Number of motor vehicle accidents not that important but the speed at impact, delta V, BEV, etc., are important in the estimates.

#19: If you cannot at least count the number of occupant injuries before and after SBUL, then it is fruitless to attempt to assess the law's impact.

#27: This data, if it were available, would mostly contain those who are not injured (mostly belted) and fatalities (mostly unbelted) and serve to increase the relative risk ratio for the unbelted.

#31: This makes various calculations impossible, but does not totally negate the value of others.

#37: We have not had the resolve to spend the money for population based reporting. In large measure because we have annually 15,000,000 crashes with 3,000,000 injuries but only 40,000 fatalities and 300,000 serious injuries. Statistical data collection appears reasonable.

Trauma registries through state health sponsorship for severe head and spinal cord injury are very important to collect the 10,000-15,000 paralyzing injuries due to MVA. The fact that passenger car-related injuries account for half of injuries also complicates the job.

#38: Not sure.

# # #

E. How can an evaluator handle the fact that medical indicators are limited to those who appear at hospital and do not include those who are uninjured or die before reaching the hospital?

#33: Fatality data is readily available but autopsies are necessary to provide useful information. Such data should always be a part of any study. Uninjured motorists are difficult to identify. Uninjured status would be more difficult to verify.

#5: Yes, such data sources are not much good and I wouldn't use them.

#2: Better information could be gotten from car insurance companies but, since that is not possible, we will have to use the available medical indicators with limitation. Special studies could be done to get estimates of those uninjured as result of seat belt use and FARS could be investigated on the fatalities.

#9: This problem is similar to the above. One always can institute SBU surveys at representative locations.

#17: Fatalities are rare and won't significantly affect the data. But all MV fatalities should be autopsied! "Walk-away" seat belt users from a "significant" crash are also rare.

#19: You may be able to get information from police accident reports concerning the number of occupants who were not injured or received only minimal injuries not requiring attention. However, the chances are good that this information is not reported reliably by the police.

#27: Need trauma registry systems to link data. Current data bases miss the extreme cases (no injury and injury so severe death occurs on scene).

#29: While this research aspect has its limitations, a good deal can still be learned from clinical information if the study design is developed recognizing those limitations. A neat trick would be to match the clinical data with police information.

#31: The absence of fatality data would be serious. It is hard to believe that some kind of fatality assessment would not be possible.

It might make the mathematics simpler if one knew after SBUL exactly who among the uninjured would have been injured had he/she not been wearing a belt. But this we do not and cannot know. We have to make the best assessment we can on the basis of the facts as we can establish them.

#37: The Swedish Folksam insurance procedure has solved this problem by being responsible for vehicles through EMS and rehabilitation service. The account for all customers and merge data with the four other insurance companies. If we had a central insurance analysis reporting at the federal level, these data could be reported potentially without influencing the competitive aspects that make current data guarded so secretively. This would suggest a federal reporting of summary insurance claims information.

#38: As long as we have non-SBUL states we're "OK" since effect should balance (assuming standard "all other things being equal"). Also, if we link changes in injury to observational use rates we may have sufficient correlational information for policy decisions (e.g., use increases 7% with corresponding AIS decrease) while such data not good enough to say x caused y, good enough for policy that x continue. Analogy: number of smokers down, lung cancer rate down, anti-smoking policy continued.

# # #