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Report to the Chairman, Subcommittee on Oversight and Investigations, Committee on Energy and Commerce, House of Representatives

November 1987

# MOTOR VEHICLE SAFETY

## A Review of the NTSB Report on Rear Seat Lap Belt Effectiveness

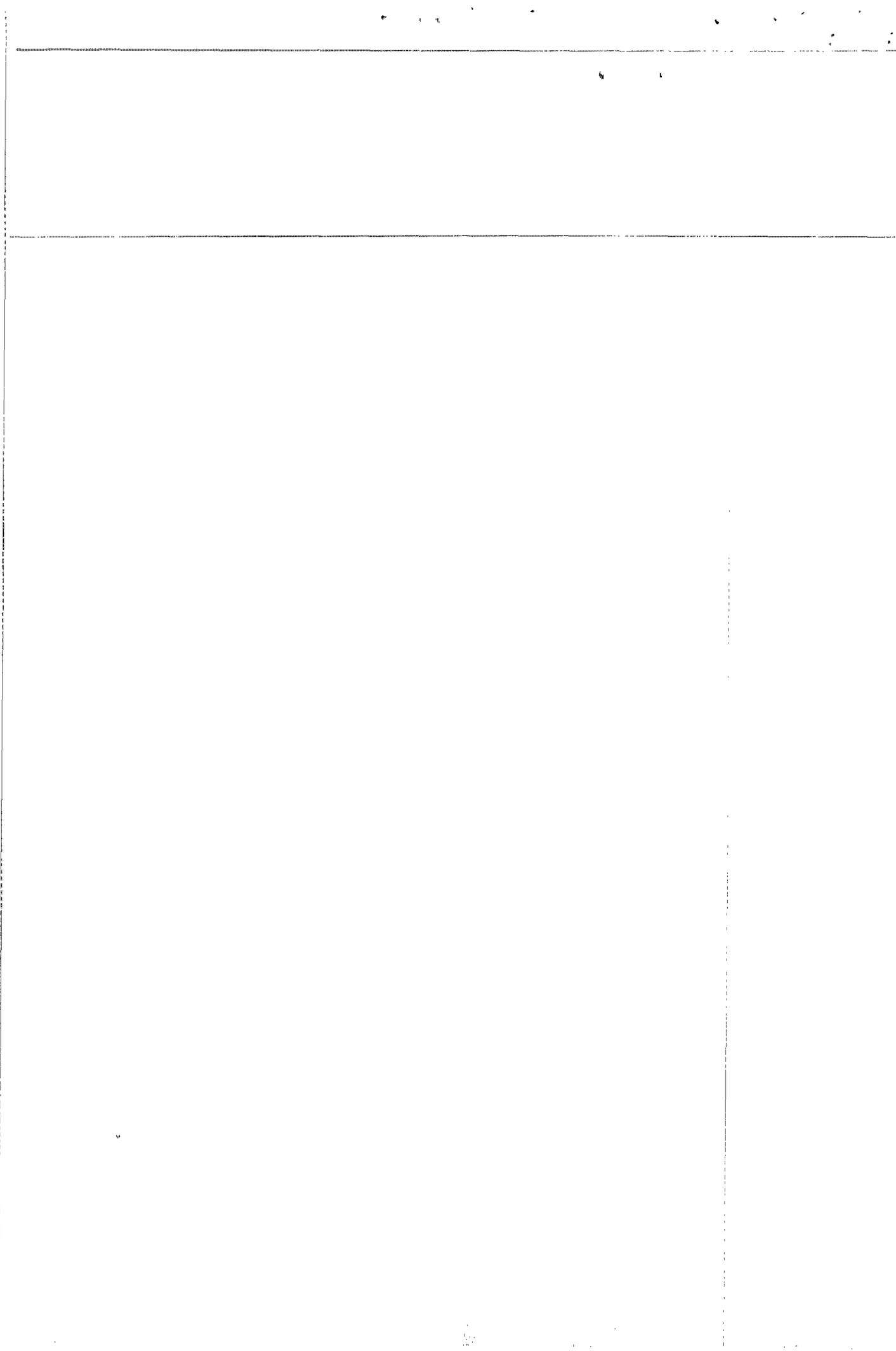


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Washington, D.C. 20548

**Resources, Community, and  
Economic Development Division**

B-223735

November 13, 1987

The Honorable John Dingell  
Chairman, Subcommittee on Oversight and Investigations  
Committee on Energy and Commerce  
House of Representatives

Dear Mr. Chairman:

This report is in response to your August 27, 1986, request that we review the study of rear seat lap belt effectiveness issued by the National Transportation Safety Board (NTSB). This report examines the methodology used by the Board and pays particular attention to the Board's criticisms of other research that shows lap belts to be effective protection for rear seat occupants.

As arranged with your office, unless you publicly announce its contents earlier, we plan no further distribution of this report until 30 days from the date of this letter. At that time, we will send copies to the Chairman, National Transportation Safety Board, and to the Secretary, Department of Transportation. Copies will also be made available to other interested parties.

This report was prepared under the direction of Herbert R. McLure, Associate Director. Major contributors are listed in appendix II.

Sincerely yours,

J. Dexter Peach  
Assistant Comptroller General

# Executive Summary

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## Purpose

Lap belts for rear seat automobile passengers have long been promoted as an effective life-saving device. However, a July 1986 study by the National Transportation Safety Board (NTSB) challenged this widely held belief. The study, Performance of Lap Belts in 26 Frontal Crashes, uncovered a number of cases in which passengers were injured because they wore lap belts. Given this evidence and the Board's belief that existing data were inadequate for showing lap belt effectiveness, NTSB concluded it could not advise people to wear rear seat lap belts.

Many members of the highway safety research community believed the Board did not have sufficient grounds for questioning rear seat lap belt effectiveness. The Chairman, Subcommittee on Oversight and Investigations, House Committee on Energy and Commerce, asked GAO to review the NTSB report paying special attention to the methodology the Board used to develop its conclusions. GAO also examined several recent studies prepared in response to the NTSB report, which reached a different conclusion as to the likely benefit from wearing lap belts. On the basis of an assessment of the available evidence, GAO sought to determine whether NTSB had sufficient basis for rejecting prior research that showed lap belts to be beneficial.

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## Background

In 1984 NTSB began an in-depth investigation of about 200 accidents to learn how well all types of restraint systems were performing in today's driving environment. Shortly after that study began, NTSB investigators came across several cases in which serious or fatal injuries were caused by lap belts. In response to this phenomenon, the Board shifted the focus of its study to lap belts and the July 1986 study reported on 26 accidents in which at least one occupant was wearing a lap belt. NTSB found that the belts themselves often caused death or serious injury to occupants who, the Board concluded, would have fared better had they been wearing lap/shoulder belts or even if they had been unbelted.

The Board recognized that to measure the overall effectiveness of rear seat lap belts, a larger, statistically representative database was necessary. However, the Board concluded that the databases used by the National Highway Traffic Safety Administration (NHTSA) and other highway safety researchers to analyze seat belt performance were so seriously flawed that they could not be relied on to demonstrate the effectiveness of rear seat lap belts. NTSB noted that most of the databases are derived from information contained in police accident reports and that these reports are often inaccurate when it comes to reporting belt usage and accident severity. The Board concluded that, given the

evidence of possible harm it observed in many of the accidents it investigated and the problems with the available data, it was unable to say whether or not passengers in the rear seat should be advised to wear lap belts. The Board recommended that all new cars be equipped with lap/shoulder belts and that older cars be refitted with them.

The critics of the Board's study claim that NTSB looked only at very severe accidents in which restraint systems are much less effective, and did not focus on cases in which lap belts might provide protection. With one exception, NTSB examined only frontal accidents, but one-half of all fatal accidents are nonfrontals. A more representative sample, they believe, would have shown that the net effect of rear seat lap belts is to save lives and reduce the number and severity of injuries.

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## Results in Brief

GAO does not dispute NTSB's finding that lap belts, in some instances, can cause death or serious injury to rear seat occupants wearing them. As the Board notes, this information has been known to the accident research community for many years. GAO agrees with NTSB that there may be inaccuracies in the data researchers have used to analyze rear seat lap belt effectiveness, but GAO believes that before rejecting all of these analyses and the widely held belief that lap belts protect rear seat passengers, NTSB must do more than simply point to the existence of limitations in the databases.

The Board has not shown that the various databases are so flawed they cannot be used to analyze rear seat lap belt effectiveness. A number of recent studies employing different methodologies and different databases, while finding that rear seat lap belts are less effective in the types of accidents investigated by NTSB, concur in finding that rear seat lap belts protect wearers more often than they harm them.

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## Principal Findings

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### The Board's Report

The 26 cases NTSB examined demonstrate that a performance problem exists with rear seat lap belts in severe frontal crashes. NTSB believes that the "conventional wisdom" that holds that rear seat lap belts are effective in reducing death and injury severity is based on highly unreliable data. Most highway safety research uses data originating in police accident reports which, according to NTSB, are riddled with inaccuracies.

The Board notes that databases that do not rely on police accident reports also are inadequate because they contain relatively few cases in which lap-belted occupants were involved. NTSB does not claim to have shown that lap belts are, on balance, ineffective, but that their overall effectiveness cannot be substantiated by analyzing the existing databases.

### Criticism of the Report

Although researchers do not dispute the NTSB finding that lap belts sometimes can cause death or serious injury, critics of the report claim that the Board examined a biased sample of accidents, which made lap belts appear to be less effective than they would have been had it studied a more typical collection of accidents. Several recent studies employing different databases and different analytical techniques all conclude that lap belts reduce the risk of death and serious injury to rear seat occupants. These studies also suggest that the protection afforded by rear seat lap belts is greater in nonfrontal accidents and at lower impact speeds. This is consistent with NTSB's finding that lap belts are less effective in frontal, high-impact accidents.

### GAO's Analysis

NTSB has identified a number of possible limitations in the data used by traffic safety researchers to analyze seat belt effectiveness. However, identifying possible limitations in the data is not sufficient to demonstrate that the data are unusable. GAO believes that before NTSB can dismiss all the research supporting the "conventional wisdom" that rear seat lap belts are, on balance, effective, it must demonstrate that the data problems are so extensive that the data cannot be used to determine rear seat lap belt effectiveness. Although little research has been done in this area, the analysis that has been done does not support the view that police reporting problems, such as presuming belt use by the uninjured and nonuse by injured occupants, are so severe as to render the data useless for analysis. Until research is done that contradicts this evidence, GAO concludes that it is imprudent to dismiss the evidence that lap belts in the rear seat are an effective safety countermeasure. NHTSA is studying ways to improve the quality of its data. Finally, GAO does not dispute NTSB's conclusion that lap/shoulder belts offer superior protection for rear seat passengers. Even those who have been most critical of the Board's study acknowledge that lap/shoulder belts provide better protection than lap-only belts.

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**Recommendations**

Since the purpose of GAO's review was to analyze and comment on NTSB's report, GAO is making no recommendations.

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**Agency Comments**

GAO briefed NTSB staff on the results of the review and took into account their comments and suggestions where appropriate. However, GAO did not obtain official agency comments on this report.

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**Abbreviations**

AIS	Abbreviated Injury Scale
DOT	Department of Transportation
FaAA	Failure Analysis Associates
FARS	Fatal Accident Reporting System
FMVSS	Federal Motor Vehicle Safety Standards
GAO	General Accounting Office
HSRC	Highway Safety Research Center at the University of North Carolina
KABCO	Scale of Injuries (K = killed; A,B,C = level of injuries; 0 = uninjured)
NASS	National Accident Sampling System
NCSA	National Center for Statistical Analysis
NCSS	National Crash Severity Study
NHTSA	National Highway Traffic Safety Administration
NTSB	National Transportation Safety Board
RSEP	Restraint Systems Evaluation Program
TAD	Traffic Accident Damage Scale



# Introduction

In July 1986 the National Transportation Safety Board (NTSB) released a report, The Performance of Lap Belts in 26 Frontal Crashes, which questioned the overall effectiveness of rear seat lap belts in passenger cars and vans. Lap belts are single straps that are brought across the pelvis and are usually found in the rear seat of passenger cars. (Figs. 1.1 and 1.2 show examples of lap and lap/shoulder belts.) In its study NTSB uncovered a number of cases where lap belts did more harm than good to passengers who wore them. NTSB also is highly critical of the data used in other studies that purport to show lap belts to be an effective device for protecting rear seat occupants. In this chapter we review the roles and responsibilities of the two federal agencies concerned with highway safety, NTSB and the National Highway Traffic Safety Administration (NHTSA); briefly describe the NTSB lap belt study; and outline our objectives, scope, and methodology in preparing this report.

## NTSB and Its Mission

The NTSB is an independent agency charged with determining the probable causes of transportation accidents and with promoting transportation safety. The Board investigates accidents, conducts safety studies, and evaluates the effectiveness of other government agencies' programs in preventing transportation accidents. The Board makes safety recommendations based on its studies to federal, state, and local government agencies and to the transportation industry regarding actions that should be taken to prevent accidents.

The Board's charter is the Independent Safety Board Act of 1974, but its origins trace back to the Air Commerce Act of 1926, which gave the U.S. Department of Commerce the responsibility for determining the causes of civil aviation accidents. The Board investigates accidents involving all modes of transportation. NTSB has 325 employees, 100 of whom are stationed in 10 field offices around the nation.

The lap belt study was done by NTSB's Bureau of Safety Programs. The Bureau was established as a part of NTSB in 1982 when the Board decided to place more emphasis on evaluating the performance of safety systems. The Bureau develops an annual work plan that must be approved by a majority of the five Board members.

Figure 1.1: Lap Belt



Figure 1.2: Lap/Shoulder Belts



NTSB generally does not undertake statistical analyses of accident causality; rather, it conducts in-depth analyses of individual accidents. In general, the Board investigates only those accidents brought to its attention by police or other highway safety agencies. Specially trained accident investigators make a thorough examination of the scene of an accident to determine, as precisely as possible, what occurred. NTSB highway accident investigators try to get to the scene of the accident

and to the vehicle within a few days before the evidence is disturbed by highway maintenance crews or motor vehicle repair shops. The highway accident investigator makes a number of measurements to calculate the force and direction of impact and the events that occurred inside the vehicle. In addition to examining the physical evidence at the scene, the investigator interviews witnesses, vehicle occupants, police, and emergency medical personnel. The investigator also reviews medical information on those injured when it is available. Using all the information available, the investigator attempts to reconstruct the accident and determine why the accident occurred and how the occupants were injured.

## Genesis of the NTSB Lap Belt Study

In the fall of 1984, the Board approved a plan to investigate the crash performance of seat belts in a sample of approximately 200 accidents. Initially, the Board was interested in evaluating the performance of all types of seat belts and did not intend to concentrate on lap belts. The Board wanted information on the real world performance of seat belts because it was concerned that recent changes in automobile design, such as downsizing, might be compromising seat belt effectiveness. In addition, the Board was concerned about the lack of dynamic testing of seat belt systems. The Board believed that not enough was known about how current belt systems performed in real world accidents.

After about a quarter of the approximately 200 investigations had begun, NTSB investigators noticed that in several frontal accidents, rear seat, lap-belted occupants were seriously injured, and that the injuries to the abdominal region sustained by those wearing the lap belts were caused by the belts themselves. After learning about this unexpected phenomenon, NTSB decided to refocus its effort and concentrate on the performance of lap belts. In the lap belt report, NTSB concluded not only that conditions could exist under which lap belts could be harmful but also that the data used by the National Highway Traffic Safety Administration (NHTSA) and other researchers are not sufficiently reliable to show that lap belts are effective. The Board recommended that NHTSA initiate a rulemaking immediately to require lap/shoulder belts in the rear outboard (side) seats of passenger vehicles. (See ch. 2.)

## The Role of the National Highway Traffic Safety Administration

NHTSA is an agency within the U.S. Department of Transportation (DOT) responsible for improving the safety performance of motor vehicles. Predecessor agencies created in 1966 were transferred in 1967 to the newly created Department of Transportation. The Federal-Aid Highway Act of 1970 established NHTSA as a separate administration within DOT.

To carry out its responsibilities, NHTSA promulgates and enforces regulations, including the Federal Motor Vehicle Safety Standards (FMVSS), dealing with the performance of vehicles and equipment. For nearly 20 years NHTSA has required that new automobiles sold in the United States be equipped with lap/shoulder belts in the front outboard seating positions and with lap belts in all other seating positions. In addition, since the late 1960s, NHTSA regulations have required manufacturers to provide anchorages for refitting the rear seats with lap/shoulder belts should the car owner want to install them.

In 1984 NHTSA was petitioned to require lap/shoulder belts for the rear outboard seats. At that time NHTSA refused to open a rulemaking, noting that the available data showed that lap belts reduced the likelihood of death and serious injury by 50 to 60 percent and that requiring lap/shoulder belts would provide little additional benefit. In 1986 NHTSA required automobile manufacturers to provide a diagram in the owner's manual showing the location of the shoulder belt anchorages for the rear seat.

NHTSA relies on the information contained in its major databases in deciding whether to open a rulemaking hearing and in formulating its regulations. Within NHTSA, the National Center for Statistics and Analysis (NCSA) collects and analyzes motor vehicle and traffic safety data. NCSA's most important data collection systems are the Fatal Accident Reporting System (FARS) and the National Accident Sampling System (NASS). FARS contains data on every fatal motor vehicle crash since 1975. NASS, established in 1979, contains detailed studies of a selection of crashes that, NHTSA believes, are statistically representative of all police-reported crashes occurring in the United States. In addition to the currently active FARS and NASS programs, NCSA also uses accident data gathered in two earlier studies, the Restraint Systems Evaluation Program (RSEP) and the National Crash Severity Study (NCSS). These accident data programs preceded NASS, but NHTSA still uses the information in them to study the performance of safety systems.

## Objectives, Scope, and Methodology

In August 1986 the Chairman of the Subcommittee on Oversight and Investigations, House Committee on Energy and Commerce, requested that GAO examine the basis for the Board's conclusions and recommendations regarding lap belts and the basis for the criticisms of the report by other researchers. We met with the Chairman's representatives and agreed to focus our study on how NTSB selected accidents for its sample and whether it had demonstrated that NHTSA and other accident databases cannot be used to evaluate the benefits of lap belts in reducing the risk of death and serious injury in motor vehicle accidents. We also agreed it would not be feasible for us to undertake an independent analysis of lap belt effectiveness. Instead, we agreed to examine the NTSB study and the analyses performed by others. In addition, we agreed to review the available literature and to interview NTSB personnel, including staff who worked on the lap belt report.

In addition to NTSB staff, we interviewed highway safety researchers at NHTSA, including those at NCSA. We interviewed several members of the highway safety research community who have worked in the area of restraint system effectiveness, including B.J. Campbell of the Highway Safety Research Center at the University of North Carolina in Chapel Hill; Frank Conley of the New York State Department of Motor Vehicles in Albany, New York; and Ken Campbell of the Transportation Research Institute at the University of Michigan. We also interviewed individuals from Physicians for Automotive Safety, the Center for Auto Safety, the American Association for Automotive Medicine, and representatives of both foreign and domestic automobile manufacturers. We attended a symposium sponsored by the Society of Automotive Engineers in Detroit in February 1987 that focused on the issues raised in the NTSB report. We also reviewed several critiques of the NTSB report, the Board's response to those critiques, and subsequent replies to the Board's responses. We did not independently verify the data used in cited research nor did we certify the accuracy of the statistical programs used to analyze the data.

We did not attempt to answer the question of how effective lap belts are for passengers riding in the rear seat. Instead, we tried to determine whether NTSB has shown that the problems with the available data are so severe that they cannot be used to support the "conventional wisdom" that wearing a lap belt is better than wearing no belt at all. NTSB does not claim to show that lap belts are ineffective but that the effectiveness is overstated and conceivably could be zero or negative. The Board contends that it is impossible to determine the effectiveness of lap belts through statistical analyses of the existing databases.

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We performed the review in accordance with generally accepted government auditing standards. We discussed the results of our review with agency officials and their views are incorporated as appropriate. In accordance with the request of the Chairman's office, we did not obtain official agency comments on the report.

Chapter 2 presents the details of the NTSB report. Chapter 3 contains several critiques of the NTSB report and several recent attempts to demonstrate the effectiveness of lap belts. Chapter 4 reports NTSB's response to these recent efforts. Chapter 5 summarizes our observations and conclusions on the NTSB report.

# The NTSB Study of the Performance of Lap Belts

In the course of a study of the performance of both the lap and lap/shoulder seat belts, NTSB investigators encountered several cases in which a person wearing a lap belt was seriously injured by the device. The Board refocused its study to concentrate on the lap belt issue and found that in frontal accidents lap belts could be detrimental instead of beneficial. When the Board sought to determine whether lap belts were beneficial in other types of accidents, and thus beneficial overall, it concluded that the available data are inadequate to make such a determination. NTSB decided that it could not advise people to wear lap belts when riding in the rear seats of passenger cars, and it recommended that rear seat occupants have the same protection as front seat occupants—lap/shoulder belts.

## NTSB Study Methodology

The NTSB report consists of two parts. The first is the Board's analysis of 26 accidents in which at least one vehicle occupant was wearing a lap belt. Other occupants may have been unbelted or wearing a lap/shoulder belt. The second part focuses on the Board's critique of the large accident databases that other researchers have used to support the position that lap belts provide reasonable protection to rear seat passengers who wear them.

With regard to the collection of data for the accidents it investigated, the Board directed its highway field investigators in eight cities to set up accident notification procedures with local law enforcement agencies, emergency medical services, and any other organizations or individuals who might be in a position to notify them immediately of any accidents that met the following criteria:

1. The vehicle must be a post-1974 car, light truck, or van.
2. At least one vehicle occupant must have been using a seat belt.
3. The crash must have been of sufficient severity to require that the vehicle be towed from the scene.
4. The crash must not have been so severe as to be deemed unsurvivable for belted occupants.

These criteria were employed primarily to ensure that the sample consisted of accidents where seat belts might be expected to influence the injury outcome. At first the regions were instructed to collect cases in a

50-mile radius from the regional offices. However, because some regions had difficulties obtaining cases, the geographic limits were expanded.

In addition to the accident analysis background that NTSB investigators usually bring to a study, the highway accident investigators who were to be involved in the seat belt study attended a 1-week training course to learn how to determine whether or not people involved in motor vehicle accidents were actually wearing seat belts. To verify belt use, the investigators were trained to look for evidence such as loading marks on the rings holding the belts or on the belts themselves that would indicate whether they had been worn during the accident. Thus, an NTSB investigator's conclusion about whether a person involved in an accident was wearing a seat belt is based not only on an occupant's testimony, but also on whether the physical evidence supports that testimony.

When the Board decided to emphasize cases involving lap belts, it did not change its accident notification criteria. Instead, the Board instructed its field staff to look especially carefully at potential cases involving occupants restrained by lap belts in the rear seat. By the end of the data collection period, NTSB had been notified of 26 accidents, involving 31 vehicles and 139 occupants, in which at least 1 occupant was wearing a lap belt and which also met the notification criteria.

Because the Board was aware that the 26 accidents it investigated were not representative of the range of real world accidents (nearly all 26 were frontal collisions and none were rollovers), it examined other studies that have been used in attempts to determine seat belt effectiveness. The Board did not attempt its own estimate of rear seat lap belt effectiveness.

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## **Synthesis of the 26 Cases NTSB Examined**

When NTSB investigators went to the accident scenes and documented how occupants were injured in the 26 crashes, they found lap belts more often than not caused more harm than good. Among the 50 persons who were reported to be wearing lap belts, NTSB found that 32 would have fared substantially better had they been wearing a lap/shoulder belt. The Board found that lap belts had caused a number of severe or fatal injuries that probably would not have occurred had the person not been wearing a lap belt. Moreover, the Board observed that the lap belt-induced injuries were not the result of improper use; even properly

employed belts were causing a problem. Twenty-six lap-belted occupants sustained serious to fatal injuries in crashes where other occupants, including those in the more vulnerable front seat, were less seriously injured or not injured at all.

**Table 2.1: Distribution of Accident Severity in 26 Crashes**

Belt use	Number of persons	Injury severity							
		Uninjured	Minor	Moderate	Serious	Severe	Critical	Maximum	Fatal
No belt	57	4	20	17	11	1	2	2	(4)
Lap belt	50	1	16	5	7	6	13	2	(13)
Lap/shoulder belt	32	2	12	10	3	4	1	0	(1)

The injuries sustained as a result of the lap belts were often among the most dangerous types of injuries: those to the head, spine, and abdomen. The distribution of the injuries sustained in the 26 crashes is shown in table 2.1. Of the 50 persons wearing lap belts in these crashes, only 1 was uninjured. Although 13 were killed, little or no evidence existed of intrusion or compression of the occupant space in the areas surrounding those fatally injured. All received their fatal injuries as a result of wearing the lap belt, according to the Board's investigators. The Board noted that of the 33 lap-belted persons who sustained moderate injuries or greater, 30 received one or more of these injuries as a direct result of the lap belt. Of the 29 persons who received injuries designated as serious or worse (or died later),<sup>1</sup> 21 sustained more than 1 injury at this level caused by the lap belt, and 3 persons received 10 such lap belt-induced injuries.

NTSB officials told us that they reviewed the literature on highway accidents and found that the problem of lap belt-induced injuries is one that has been known to the medical profession and highway safety researchers for more than 20 years. In addition, a number of studies by NHTSA and other highway safety researchers, both in the United States and abroad, have discussed the problem of lap belt-induced injuries. These injuries often are internal and not immediately discernible to police or emergency medical personnel at the accident scene. As a result, some accident victims, who initially appear to be uninjured, later die because of a lap belt-induced injury that went undetected and untreated in time.

<sup>1</sup>The Board told us that one person was recorded as having suffered only minor or moderate injuries, but later died from internal injuries the Board believes were caused by the lap belt.

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## Limitations of Existing Databases

The 26 cases that NTSB examined led it to question whether lap belts are an effective countermeasure against death or injury, especially in frontal collisions. Because the 26 cases examined were not a statistically representative sample of all accidents in which rear seat lap belts might make a difference, the Board turned to prior analyses of the national accident databases to answer the question of the overall effectiveness of rear seat lap belts. After it reviewed a number of government reports and studies by highway safety researchers, the Board concluded that very few studies had specifically addressed the effectiveness of lap belts, and what studies had been done were based on highly unreliable data.

NHTSA and others had previously estimated that lap belts were as much as 60 percent effective in preventing death or serious injury for wearers of rear seat lap belts.<sup>2</sup> NHTSA believes that this percentage was about the same for lap/shoulder belts. NTSB believes that these estimates are greatly exaggerated. Pointing out that the research claiming that rear seat lap belts are very effective is based on information originally recorded in police accident reports, NTSB believes that these reports often omit or misclassify important information, contain imprecise measures of accident and injury severity, and suffer from other drawbacks that limit severely their usefulness in evaluating rear seat lap belt effectiveness. NTSB is especially critical of the large national databases developed by NHTSA.

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## Omitted and Misclassified Data in Police Accident Reports

NTSB points out in its study that the primary source of accident information used by NHTSA and others is the reports filled out by the police at the accident scene. Some databases are augmented by information from medical personnel and witnesses, but the police reports form the heart of most databases used in analyzing accidents. NTSB believes that an accurate database is critical to an assessment of seat belt effectiveness.

In police accident reports, the Board notes, it is often unclear whether an occupant was actually wearing a seat belt or what type of belt was being worn. Given the need for the police to focus on who was at fault in an accident and whether any laws were broken, the officer usually has little time to assess accurately whether the occupants were wearing seat belts. Furthermore, NTSB claims the officers are generally not trained to examine the physical evidence that would allow them to determine

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<sup>2</sup>By "percent effective," highway safety researchers mean the percent reduction in deaths or injuries from using the safety device.

whether or not belts were worn. We examined the accident report forms used by the individual states and found that some do not even include a place to record belt use. In these cases belt-use information appears in computerized data files only if the officer included it in the narrative of the accident. In addition, accident reporting forms differ from state to state. Among states specifically recording belt use in accidents, some simply request the officer to record whether or not a restraint device was used while others ask the officer to code the restraint system available from a menu of six or seven different systems. NTSB officials told us that even when the form calls for recording belt use, individual officers sometimes do not record use or record the wrong type of system.

The Board cited several examples to show how extensive the problem of omitted data is. In the National Crash Severity Study undertaken by NHTSA from 1977 to 1979, seat belt use was reported as "unknown" in 33 percent of the cases. One large state had an "unknown" rate of 85 percent, while another state recorded 96 percent as unknown. NTSB claims that in some cases NCSS investigators appear to have changed recorded restraint use from "unknown" to "known" when entering the information into the database. There was also evidence in the FARS database of substantial misreporting as to the type of restraint system in place. For example, according to the Board, lap belts were frequently miscoded as lap/shoulder belts.

Even when belt usage is reported and the restraint system available appears to be properly identified, NTSB believes that there is a systematic bias in the data caused by the tendency of police to presume belt use by the uninjured and nonuse by injured occupants when, in fact, the police do not know if the belts were worn or not. This bias, to the extent it exists, produces an exaggerated estimate of the benefits from wearing seat belts.

## **Imprecise Measures of Crash Severity**

In addition to inadequacies in reporting belt use, NTSB points to a number of other problems with databases derived from police accident reports. It is important to know accident severity because seat belt use usually will play a more important role in serious accidents than in minor ones. Most reports rely on police officers' subjective evaluations of vehicle damage in deciding crash severity. NTSB investigators, on the other hand, calculate the change in velocity (delta V) as the measure of crash severity. Measurements of deformation from the crash are taken at several places near the point of impact; given information on the vehicle, the

investigator can calculate delta V. This is a more refined estimate of the seriousness of a crash than that made by the police at the scene.

NTSB notes that a correlation exists between restraint use and accident severity that needs to be controlled for in analyzing restraint system effectiveness. Recent evidence suggests that restrained drivers are less likely to be involved in collisions, especially serious ones. It has been estimated that unrestrained drivers have a 57 percent greater likelihood of being involved in collisions of sufficient severity to kill them than do restrained drivers. Estimates of seat belt effectiveness based on accident involvement are likely to be inflated because of marked differences in exposure between restrained and unrestrained occupants, particularly in terms of injury severity. Therefore, estimates of seat belt effectiveness must correct for collision severity or they will overstate the benefits.

## **Imprecise Measures of Injury Severity**

The Board also is critical of the broad injury classification system, known as the KABCO scale (K = killed; A, B, C = degrees of injury; and 0 = no injury), used by most states to record injury severity. To assess whether seat belts reduce injury severity, accurate data are needed on how seriously injured belt wearers and nonwearers are. The Board believes that the KABCO scale does not adequately differentiate between serious, life-threatening injuries and those that are relatively minor. For example, both a broken arm and a broken skull are "A" level injuries. Without accurate measures of injury severity, it is difficult to compare injury outcomes of belted and unbelted persons. In its report, the Board used the Abbreviated Injury Scale (AIS), which is based on the survivability of the injuries sustained.

The Board also questions the ability of police officers to assess injury severity accurately. This is particularly true with respect to the source of injuries. The Board believes that police officers are simply not trained to determine whether a lap belt caused an injury. Further, police accident reports often provide no information (such as age, sex, or seating position) on uninjured occupants or those who sustain only minor injuries, especially in cars with fatally or seriously injured persons. According to NTSB, these problems with injury reporting further limit the usefulness of data from police accident reports for estimating restraint system effectiveness.

## Limitations of NHTSA Databases

NTSB is highly critical of the databases used by NHTSA—the 1977-79 National Crash Severity Study (NCSS); its successor, the National Accident Sampling System (NASS); and the Fatal Accident Reporting System (FARS). According to NTSB the data contained in NCSS are dated and incomplete, while the data in NASS are largely irrelevant and include too few cases. NTSB believes FARS data are inaccurate because they rely completely on police accident reports. For example, in the case of FARS, the Board notes that in 1984 25 percent of rear seat-belted fatalities were recorded as being lap/shoulder-belted. However, because very few cars had lap/shoulder belts in the rear seats at this time, it is extremely unlikely that this many rear seat fatalities were wearing lap/shoulder belts.

NHTSA has estimated that rear seat lap belts are up to 60 percent effective in reducing injuries and fatalities. However, because of the weaknesses in the databases, NTSB claims that it is not possible to estimate even a range of effectiveness. NTSB believes that because the databases were not designed to permit analyses of belt-induced injuries, they are inappropriate bases for making such assessments. The Board believes that its detailed accident analysis offers a method of determining when lap belts fail to protect an occupant or induce an injury, something the existing databases cannot do.

## NTSB's Conclusions

NTSB's investigation of 26 accidents showed that lap belts can sometimes cause death or serious injury to those wearing them. The Board acknowledged that the 26 cases were not a statistically reliable sample for determining whether rear seat lap belts are effective overall; however, when the Board turned to the existing databases to answer the question of overall effectiveness, it found them too flawed to be used to answer the question raised by the 26 cases. Therefore, NTSB concluded that it is unable to make a recommendation as to whether or not rear seat occupants should wear lap belts. The Board did, however, recommend four actions by NHTSA:

1. Encourage manufacturers to provide retrofit assemblies for lap/shoulder belts and make their availability widely known.
2. Initiate a rulemaking immediately to require manufacturers to install lap/shoulder belts in the rear outboard (side) seats of new vehicles.
3. Until the new rule is effective, encourage manufacturers to equip all new vehicles with lap/shoulder belts in the rear outboard seats.

4. Determine the feasibility of three-point lap/shoulder belts for every seating position (i.e., including front and rear center seats) and, if feasible, require manufacturers to install them in all new vehicles.

## **GAO Observations**

We do not dispute the NTSB finding that, in a number of accidents, occupants wearing lap belts were seriously or fatally injured by the devices that were supposed to protect them. However, this problem, as the Board itself points out, has been known for many years. The Board did not need the evidence of the 26 accidents it studied to make the case that lap belts offer less protection than lap/shoulder belts and that in some types of accidents lap belts can kill or seriously injure the wearer.

NTSB says in its study that the 26 accidents it investigated were not meant to be representative of all accidents, but the Board also claims that these 26 accidents were neither particularly severe nor unusual ones. Therefore, while acknowledging that the 26 were not a scientific sample, the report suggests that the problem of lap belt-induced injuries may be more common than heretofore suspected. This possibility is what triggered the Board's search of the literature to decide net effectiveness.

NTSB offers a number of reasons why it believes the existing databases are flawed and provides a number of examples of data misreporting, but NTSB does not undertake any analysis to show that the data are so flawed as to be unusable.

# Reactions to the NTSB Report

Many members of the highway safety research community criticized the NTSB report on lap belt performance. They believe that NTSB exaggerated the shortcomings in the databases used in statistical analyses of seat belt effectiveness, while making serious methodological errors in its own analysis. In addition, they believe that in publicizing its findings, the Board may have undermined the public's confidence in seat belt systems generally. Highway safety researchers recently completed several studies that reexamined the question of lap belt effectiveness. Although they found lap belts to be less effective than did earlier studies and less effective in high-impact frontal accidents than in rollovers and other types of accidents, they all found that lap belts, on balance, make a positive contribution to rear seat occupant protection.

In this chapter we first review some of the general concerns raised by the critics of the NTSB report and then present analysis by several highway safety researchers who recently examined the evidence on lap belt effectiveness. These researchers employed several different databases and undertook different approaches to analyze these data.

## Overall Concerns of the Critics

Several critics of the report told us that although they agree with the NTSB's conclusion regarding the superiority of lap/shoulder belts, they believe the Board should have anticipated that its findings could be misinterpreted. They believe that not everyone would make the distinction between lap belts and lap/shoulder belts, and many people might mistakenly abandon all restraint systems. The critics also argue that the public might not understand that NTSB questioned only the reliability of the data supporting lap belt effectiveness; in other words, the public might read into the report that the Board had proved that rear seat lap belts are not effective. According to these critics, when a federal transportation safety agency questions the "conventional wisdom" about the effectiveness of such a widely accepted safety device as lap belts, there is the potential for misunderstanding.

Some critics also have expressed concern that the Board's report might influence the outcome of efforts to repeal mandatory seat belt use laws. Although the principal issue in the referenda on belt use laws has been "personal freedom," the critics note that voters in Nebraska and Massachusetts elected to repeal their mandatory use laws in November 1986, 4 months after the release of the Board's study. Although we were unable to find any evidence that the NTSB report influenced the outcome of either election, the vote in Nebraska was decided by less than 1,000 votes out of more than 500,000 cast.

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## Responses to the NTSB Report by Highway Safety Researchers

NHTSA and several other traffic safety researchers who rely on police accident report-based data to analyze highway safety programs responded almost immediately to NTSB's lap belt study. They recited the results of earlier studies that had found lap belts to be effective in reducing traffic deaths and injuries. In addition, several highway safety researchers prepared new analyses of lap belt effectiveness for a symposium sponsored by NHTSA and the Society of Automotive Engineers in Detroit in February 1987. Most of the analyses discussed in this chapter were prepared for presentation at this conference, but the authors briefed GAO staff on the progress of their research during the months preceding the conference.

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### Dr. B.J. Campbell of the Highway Safety Research Center

Perhaps the leading critic of the NTSB study has been Dr. B.J. Campbell, Director of the Highway Safety Research Center (HSRC) at the University of North Carolina at Chapel Hill.<sup>1</sup> Dr. Campbell is a widely known expert on motor vehicle safety and restraint systems and has himself called for lap/shoulder belts in the rear seats of passenger automobiles. Campbell is highly critical of the research methods the Board used in its report and of its challenge to the accuracy of databases underpinning the conventional wisdom that lap belts are an effective restraint system for rear seat passengers. Because Campbell's arguments are shared by and have been cited by others, we discuss them here in some detail.

According to Campbell, NTSB dismisses the existing evidence of lap belt effectiveness without any scientific basis for doing so. NTSB alleges a number of shortcomings in the databases that he and other researchers use; but, Campbell argues, the Board has not demonstrated that these shortcomings are so severe as to render invalid the use of these data for statistical analysis of lap belt effectiveness. Campbell says that if NTSB wants to discredit previous investigations, it must employ research methods at least as rigorous as those used in the studies it dismisses. Furthermore, he claims that the shortcomings that plague some databases do not affect all to the same degree. He notes that some data, including the North Carolina State data used by HSRC, are generally regarded by the highway safety research community as being more reliable than other state and national databases. HSRC staff have worked with North Carolina officials to improve the quality of police accident reporting.

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<sup>1</sup>B.J. Campbell, The Effectiveness of Rear-Seat Lap-Belts in Crash Severity Reduction, University of North Carolina Highway Safety Research Center (Chapel Hill: Nov. 1986).

Campbell notes that although NTSB advocates lap/shoulder belts as an improvement over lap belts, it bases its recommendation on much of the same evidence it dismissed when the same evidence was applied to lap belts. Campbell argues that if existing data and research are adequate to demonstrate the effectiveness of lap/shoulder belts, they are adequate for lap belts as well. Campbell believes that there is ample evidence in the literature to demonstrate that lap belts in the rear seat are an effective, if second-best, countermeasure.

## Critique of the NTSB 26 Cases

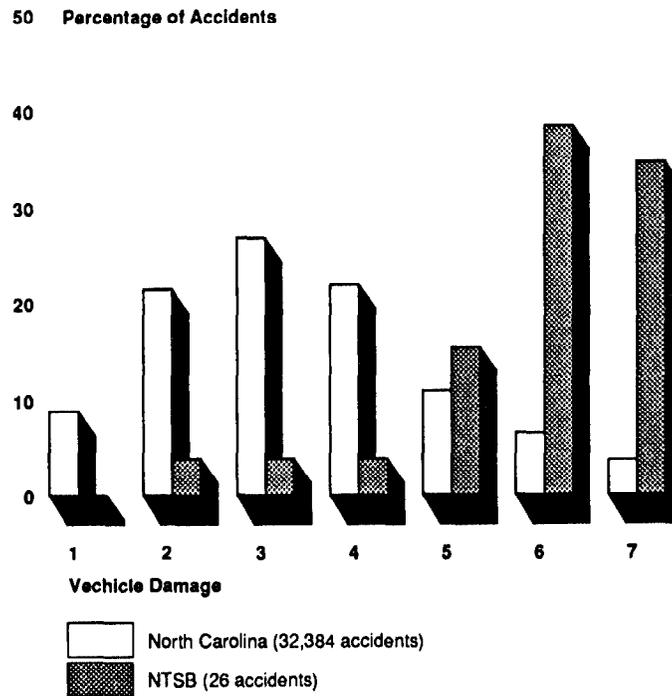
Campbell claims that the 26 cases that comprise the NTSB database on lap belts are examples of extraordinarily severe crashes. He notes that the stated criteria used by NTSB to select candidate crashes for investigation could have yielded many thousands of cases, yet the Board only investigated 200, of which 26 involved lap-belted occupants.<sup>2</sup> Campbell searched the North Carolina database (which derives from police accident reports) and uncovered 60,951 crashes that occurred over the 1979-85 period in North Carolina that met the NTSB criteria. About one-half of these (32,384 crashes) were also frontal collisions.

Campbell compares the 26 NTSB cases with the experience of the North Carolina drivers and passengers in his much larger sample and concludes that the 26 accidents examined by NTSB are extraordinarily severe and thus not representative of the range of accidents passengers may experience. Because NTSB and North Carolina employ different systems to measure accident and injury severity, Campbell transforms the NTSB case data into HSRC equivalents. With respect to crash severity, North Carolina uses a vehicle-deformation rating system, called the Traffic Accident Damage (TAD) scale, which relies on police officers to rate a crash on a 7-point scale based on vehicle crush. The officers are supplied with a pictorial guide to help them in making their ratings. NTSB investigators calculate "delta V," an estimate of the change in velocity at the time of impact. Roughly, this is the speed at which a passenger would be moving toward a point in a car's interior after the vehicle collided with an unyielding object. Delta V is a more sophisticated measure of impact forces and crash severity, but it cannot be used in rollovers or in sideswipe accidents. HSRC personnel reviewed photographs of the 26 NTSB accidents and assigned each a TAD rating.

<sup>2</sup>The Board told GAO that geographic limitations on the survey and the inability to undertake a detailed analysis of every eligible accident explain why it only investigated a small proportion of the total population of accidents that met the reporting criteria.

Campbell compares the frequency distribution of accident severity in the 26 NTSB crashes with that of the North Carolina crashes meeting the NTSB case selection criteria. He finds that the NTSB accidents are very skewed toward the high end of the accident severity distribution. A statistical test shows that the odds are more than 10,000 to 1 against drawing a sample with such an extreme distribution of accident severity. This suggests that the NTSB sample is unrepresentative of the distribution of accident severity found in the population of accidents meeting the Board's stated selection criteria (see fig. 3.1).

**Figure 3.1: Vehicle Deformation (TAD) Ratings in North Carolina Crashes and 26 NTSB Crashes**



Source: B.J. Campbell, The Effectiveness of Rear-Seat Lap-Belts in Crash Injury Reduction, 1986.

Campbell also compares the injury distribution in the 26 NTSB cases with the North Carolina experience. The scales employed to gauge injury severity also differ. NTSB uses the Abbreviated Injury Scale of injury severity in which a numerical rating of 1 through 6 is assigned to each injury received based on its threat to the victim's life. Thus, an AIS 1 injury would include superficial abrasions, while an AIS 5 would involve

spinal cord injuries, second or third degree burns, or a cerebral concussion where the victim is unconscious for more than 24 hours. AIS 1 through 5 injuries are usually survivable, while AIS 6 injuries are considered virtually unsurvivable. These ratings are based on medical evaluations of the accident victims. The state of North Carolina employs the more commonly used, but less precise, KABCO scale. This scale classifies injuries with visible signs of seriousness. A wound involving bleeding, a broken bone, or a dislocation would be rated "A." Other signs of injury, such as bruises and abrasions, would be rated "B." Complaints of pain or momentary unconsciousness with no visible sign of injury would be classified as "C." The KABCO rating is made by the police officer at the accident scene.

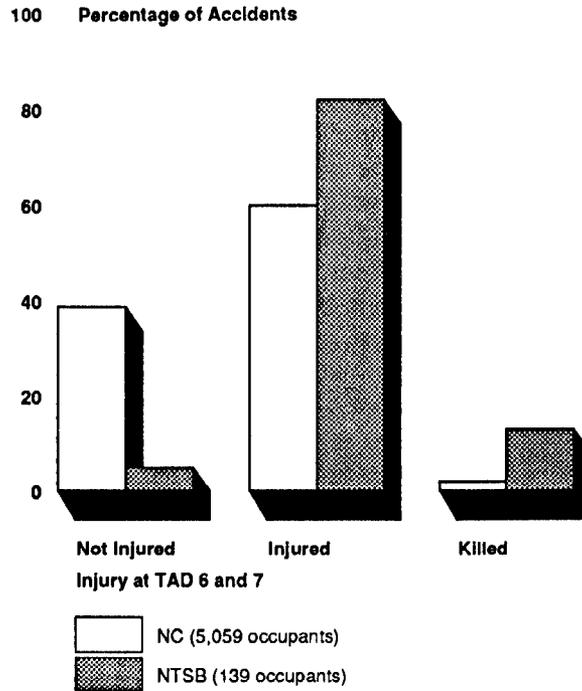
The only comparison that Campbell is able to make is on the basis of no injury, injury, or killed. Yet, even if the analysis is limited to only the most severe accidents in the North Carolina database—TAD-6 and -7 level crashes—the distribution of injuries experienced by more than 5,000 North Carolinians is again very unlike that experienced by the 139 occupants in the 26 NTSB cases. For example, only 2 percent of drivers in the severe North Carolina crashes were killed while 13 percent of the occupants in the NTSB vehicles died. Similarly, although almost 39 percent of the drivers in the North Carolina crashes escaped uninjured, only 5 percent of those in the NTSB crashes did so. The chance of differences in the proportions of fatalities, injured, and uninjured as great as those between the North Carolina and NTSB samples occurring randomly is very small. Figure 3.2 shows the differences in percentages of injured, uninjured, and killed from the North Carolina and NTSB samples. A statistical test shows that the probability of such differences resulting from random selection is also 1 in 10,000.

### Evidence of Lap Belt Effectiveness From North Carolina Data

Dr. Campbell believes that these differences offer strong evidence that the 26 accidents investigated by NTSB are extraordinarily severe. In very serious accidents both lap belts and lap/shoulder belts reach the limits of their effectiveness. To demonstrate this, Campbell compares the injury outcomes of lap/shoulder-belted and lap-belted drivers in crashes of different severity (TAD scale). He finds that the benefit for both systems declines as crashes become more serious. Nonetheless, he reports a significant positive reduction (27 to 32 percent depending on whether 1975-85 or 1972-85 model cars are included) in the frequency of serious injury for lap/shoulder belted drivers even in the most serious frontal accidents (TAD 7). Lap belts, on the other hand, reach the limit of their effectiveness in TAD 6 accidents; and in the most severe frontal accidents

(TAD 7), there appears to be no significant difference between wearing lap belts and wearing no belt at all.

**Figure 3.2: Injury Comparisons of 5,059 North Carolinians and 139 Occupants in the 26 NTSB Crashes**



Source: B.J. Campbell.

Campbell believes that those who reported accidents to the NTSB study probably chose to report only very serious accidents where belted persons were injured. He believes that cases where lap belts were beneficial were inadvertently screened out, and as a result, the Board was left with the impression that lap belts were of questionable benefit. But, according to Campbell, even those wearing lap/shoulder belts fared little better than those wearing no belt at all in the 26 accidents examined by NTSB. For example, about 16 percent of lap/shoulder-belted occupants received injuries rated AIS 4-6, while only 9 percent of unrestrained occupants received such serious injuries. Similarly, roughly the same proportion of lap/shoulder-belted and unrestrained occupants were uninjured or received only minor (AIS 1) injuries. A more representative sample, Campbell believes, would have shown that both lap- and lap/shoulder-belted passengers fared better, and that although lap belts

sometimes cause injury, they more often help reduce injury and injury severity.

Campbell also points out that the NTSB report focuses on cases where a lap-belted person fared worse than an unbelted occupant in the same vehicle. Again using North Carolina data, Campbell tries to demonstrate that such "wrong way" outcomes are to be expected even with lap/shoulder belts but that they do not predominate. The North Carolina data show that occupants wearing lap or lap/shoulder belts are injured more seriously than unbelted ones in the same vehicle 11 to 14 percent of the time. But injuries to belted occupants are less severe in an even greater proportion of the cases. For 314 accidents in which one person in the rear seat of a vehicle was wearing a lap belt and the other was unbelted, he finds that in 11.5 percent of the cases, the lap-belted person was more seriously injured, but in 19 percent of the cases, the lap-belted person fared better. In addition, on average, in the cases where lap-belted occupants fared better, they fared better to a greater degree than in cases where the unbelted occupant was better off. He arrives at similar results when he compares lap/shoulder-belted occupants with unbelted ones in the same vehicle. However, Campbell offers no evidence of the statistical significance of these findings.

Outcomes that are the reverse of what is expected are not unusual, according to Campbell, and give evidence to the uniqueness and complexity of each accident. Seat belts will not always be effective in preventing death or injury, and unbelted people will sometimes escape a serious accident unscathed. However, Dr. Campbell believes that the data support the finding that belted occupants, whether they wear a lap belt or a lap/shoulder belt, will, more often than not, fare better than unbelted occupants.

Finally, with respect to the allegation that police officers are unable to tell whether or not someone was wearing a seat belt, he argues that the existence of uncertainty in the data does not mean that the data are useless. He agrees with the Board that police sometimes presume belt use when a person is uninjured and sometimes presume nonuse when a person is injured, but he does not believe that this type of misreporting occurs frequently enough to rule out using the data for assessing lap belt effectiveness. Campbell cites earlier studies that attempted to measure police bias in reporting restraint use. These studies concluded that bias exists, but different studies found that the bias went in different directions, and none found that the bias was so pronounced that the data could not be used to analyze seat belt effectiveness.

## Failure Analysis Associates

An engineering consulting firm, Failure Analysis Associates (FaAA), also reviewed the NTSB study and issued a report critical of the Board's data collection procedures and the way the data were presented.<sup>3</sup> FaAA interviewed NTSB field staff and Washington officials, undertook a detailed analysis of the full record of the accidents in NTSB's sample, and contrasted NTSB's data with other databases. FaAA believes that NTSB's case accidents "are a seriously biased selection which is unrepresentative of any population of motor vehicle accidents in the United States." FaAA finds that NTSB violated its own selection criteria in choosing cases for investigation, received a biased distribution of cases with some regions reporting only very severe accidents, and selectively ignored pertinent information on the accidents it investigated that was readily available. Database entries on the accidents in the NTSB sample contradict the Board's assertion that police misreporting makes it impossible to determine belt effectiveness through statistical analysis of large accident databases.

FaAA notes that NTSB analyzed information from 30 case vehicles in 30 accidents (the 26 with lap-belted occupants and 4 others the Board later added for comparative purposes), but omits results from 25 other (non-case) vehicles involved in these accidents because they failed to meet one or more of the selection criteria. But, according to FaAA, NTSB did not consistently adhere to its selection criteria. For example, a 1967 Pontiac was included as a case vehicle despite the NTSB's stated criterion that vehicles were supposed to be post-1974 models. In addition, although NTSB claimed that its investigation began in the fall of 1984, several case accidents occurred in the late spring and summer of 1984.

FaAA found that the distribution of accident reporting by the NTSB regional offices was highly skewed with adverse consequences for the representativeness of the NTSB sample. Three regions reported only fatal accidents while the others reported mostly nonfatal ones. A statistical test showed that the odds of this distribution occurring by chance are less than 1 in 200. The implication is that different field offices interpreted the selection criteria differently and some reported only accidents where someone was killed. FaAA notes that field offices reporting only fatal accidents contributed a disproportionate share of lap-belted occupants.

<sup>3</sup>R.L. McCarthy, C.S. Davis, and J.A. Padmanaban, An Evaluation of the NTSB Report Entitled "Safety Study - Performance of Lap Belts in 26 Frontal Crashes," Failure Analysis Associates (Palo Alto, CA: July 1987).

FaAA is also critical of the way NTSB used the data it collected. For example, FaAA analysis of the full record of the 30 accidents revealed that 30 percent of the unbelted occupants in noncase vehicles were killed. This experience, FaAA observes, represents the worst record of any group of occupants in the sample accidents. NTSB does not even report this severe outcome in the noncase vehicles and focuses instead on how poorly lap-belted occupants fared in case vehicles.

Finally, although NTSB believes that police misreporting of belt use and injury severity seriously limit the usefulness of statistical analysis of large databases to measure belt effectiveness, it never examines the database entries of its accident sample to test its hypothesis. FaAA compared NTSB investigator reports of belt use with belt use reported for these 30 accidents in the FARS database. Both police and NTSB investigators recorded restraint use by 132 occupants. FaAA analysis of the record revealed that in only 5 cases (3.8 percent) was there disagreement between the police and NTSB investigator coding of belt use. Moreover, FaAA notes that the differences are balanced as to the direction of the coding error and injury level so that no bias can be inferred. With regard to injury reporting, police and NTSB investigators coded 176 injured occupants by injury level in both case and noncase vehicles. In only 13 of these cases (7.4 percent) was there disagreement between police accident reports and NTSB investigator determination of injury severity, according to FaAA. (The rate of disputed cases rises to 8.6 percent if only the records for nonfatally injured occupants are compared.) Nearly all of the differences in injury assessment are small and they go in both directions.

The FaAA study, therefore, is consistent with B.J. Campbell's conclusion that the NTSB accident sample is not representative of the accident population at large and that the NTSB conclusion is unfounded that the value of lap belts as an effective safety countermeasure is uncertain. In addition, FaAA analysis of the details of the accidents included in the NTSB report does not support NTSB's conclusion that police misreporting of belt use and injury severity is widespread.

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**Dr. Leonard Evans,  
General Motors Research  
Labs**

Dr. Leonard Evans, Senior Staff Research Scientist at General Motors Research Laboratories, recently evaluated restraint systems generally, and rear seat lap belts in particular.<sup>4</sup> He used a statistical procedure he recently developed called the double pair comparison method. (This procedure is described in app. I.) Because it examines only fatalities and nonfatalities in the same vehicle, Evans' approach reduces the problem caused by the relationship between belt use and accident severity.

Evans uses FARS data for 1975-84 to assess rear seat belt effectiveness on reducing fatalities. Because the information contained in FARS does not distinguish by type of restraint system employed, Evans must assume that all rear seat belted occupants are wearing lap belts. By confining his analysis to adults (16 years old or over), he eliminates cases where child seats were the restraint system. His assumption that all rear seat restraints are lap belts is plausible for two reasons: (1) child seats are excluded and (2) few cars are equipped with rear seat lap/shoulder belts.

Evans estimates that rear seat lap belts reduce fatalities by 18 percent. He finds that the probability that rear seat lap belts have a positive impact in reducing fatalities is almost 98 percent. However, when Evans examines only frontal accidents, the estimated benefit becomes negative, although as Evans notes the sample size is too small to conclude much more than that rear seat lap belts are probably less effective in frontal crashes than in crashes overall. Therefore, like Campbell, Evans finds that the available evidence shows that rear seat lap belts, on balance, are beneficial. Both Campbell and Evans find evidence to suggest that lap belts are less effective, and perhaps even negatively effective, in serious frontal accidents, the type that comprised the NTSB sample.

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**National Highway Traffic  
Safety Administration**

NHTSA also rejects the conclusions of the NTSB report as they pertain to the usefulness of police accident report data in deciding seat belt effectiveness. NHTSA officials point out that NTSB admits that it did not attempt to measure overall effectiveness, but rather examined the performance of lap belts under certain accident conditions. NHTSA officials believe that there are ample data showing that lap belts in the rear seat are effective, although they too agree that lap/shoulder belts are better and that lap belts can cause injury in some cases.

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<sup>4</sup>Leonard Evans, "Rear Compared to Front Seat Restraint System Effectiveness in Preventing Fatalities," *Restraint Technologies: Rear Seat Occupant Protection*, Society of Automotive Engineers (Detroit: Feb. 1987).

NHTSA officials, like B.J. Campbell, claim that the 26 NTSB accidents are very severe. The distribution of delta V for these 26 cases was very different from what NHTSA encountered for towaway crashes in the National Crash Severity Study (see table 3.1).

**Table 3.1: Frequency Distribution of Delta V in Towaway Crashes**

Figures in percent		
Delta V (mph)	NCSS	NTSB
1 - 10	49.6	6.7
11 - 20	40.3	13.3
21 - 30	7.5	43.3
31 - 40	1.7	33.3
41 - 50	0.6	3.3
Over 50	0.3	0.0
	100.0	100.0

Source: NHTSA.

NHTSA officials told us that NTSB is an agency that usually analyzes failures and serious crashes and therefore it is not surprising that the Board obtained such an unrepresentative sample.

NHTSA also defends the databases it uses to study restraint system effectiveness. The agency believes that, although some of the NTSB criticisms are valid, a chain of evidence from a number of databases developed over the past 10 years demonstrates the effectiveness of rear seat lap belts. NHTSA agrees that effectiveness estimates contain some bias because of misreporting, but previous investigations of this bias by HSRC have concluded that it is not fatal to the usefulness of the data.

**Evidence From the Restraint Systems Evaluation Program**

The Restraint Systems Evaluation Program was the first and only large, detailed database developed by NHTSA exclusively to evaluate occupant restraint system performance. Data were collected for RSEP in 1974 and 1975 for 1973-75 model year passenger cars. Accident investigation teams in five diverse and geographically representative areas of the country (Michigan, California, New York, Florida, and Texas) selected accidents for study through a probability sampling plan. More than 15,000 accidents were investigated and detailed data were collected on a number of variables, including injury type and severity using AIS codes. The investigators followed an elaborate procedure for determining

restraint use, including examining the belt system for evidence of loading; interviewing police, witnesses, and occupants; and studying occupant injury patterns. Like NTSB investigators, the RSEP investigators made a careful determination of belt use.

The RSEP data were examined by HSRC researchers. After controlling for confounding factors such as crash severity, car size, impact location, and occupant age, analyses determined that both lap and lap/shoulder belts were effective. Lap belts reduced moderate injuries (AIS 2) by 29 percent. Comparable analyses for lap/shoulder belts determined that they were 52 percent effective. For more serious injuries (AIS 3), lap belts were found to be 43 percent effective, while lap/shoulder belts were found to reduce serious injuries by 46 percent. All estimates were statistically significant.

The RSEP data have also been examined to determine the extent of police reporting bias. Belt use according to occupant testimony, police reports, and investigator analysis were compared. Analysis by G.Y.H. Chi,<sup>5</sup> formerly with HSRC, showed that police did underreport belt use generally, and more so for injured occupants, as NTSB has alleged. Still, for AIS 2 injuries, Chi found that lap belts were effective, although effectiveness estimates derived from police accident reports were much higher than those from investigator reports (see table 3.2). Chi's results suggest that although police reports may overstate belt use, they are not so biased so as to make a harmful system appear effective.

**Table 3.2: Effectiveness of Lap and Lap/Shoulder Belts in Reducing Serious Injuries According to Police and RSEP Investigator Reports**

Figures in percent		
	Investigator	Police
Lap belt effectiveness	23	34
Lap/shoulder belt effectiveness	53	55

Note: Differences between Chi and HSRC estimates result from the fact that Chi was able to include only three of the five states in his analysis.

Source: G.Y.H. Chi, The Effects of Belt Usage Misclassification Errors on Seat Belt Effectiveness Estimates, 1980.

NHTSA acknowledges, however, that there are reasons why the RSEP data cannot provide the final answer to rear seat lap belt effectiveness. First, the data are old. Today's cars are different and seat belts have changed

<sup>5</sup>G.Y.H. Chi, The Effects of Belt Usage Misclassification Errors on Seat Belt Effectiveness Estimates, HSRC (Chapel Hill: Feb. 1980).

over the past decade. Second, RSEP investigated only front seat passengers, so the lap-belted passengers in the data were in the front seat rather than the rear seat. With regard to the extent of seat belt use misreporting by the police, NHTSA believes that these limitations might affect the size of the effectiveness estimate, but not whether it is positive or negative.

### Evidence From the National Crash Severity Study and the National Accident Sampling System

Following RSEP, NHTSA began the National Crash Severity Study, which examined 12,000 towaway accidents between 1977 and 1979. Although it was not focused on restraint system effectiveness, NCSS recorded belt use from three sources: police accident reports, occupant interviews, and investigator determination. Analysis of the data showed that front seat belt effectiveness estimates were consistent with RSEP findings. There were few rear seat lap-belted cases in the NCSS file, but one examination of the data found that lap belts were equally effective, between 50 and 60 percent, for front and rear seat occupants.

The National Accident Sampling System succeeded NCSS in 1979. This is a broad sample of police accident reports designed to produce a statistically representative sample of the nation's accidents. While both NCSS and NASS used investigator determination of belt use, neither employed the protocols of RSEP and both relied more heavily on the police accident reports. Small sample sizes for specific population subgroups, such as injured rear seat occupants wearing lap belts, also limit the application of statistical analysis to NCSS and NASS data to estimate effectiveness. In addition, when there are only a few cases, it is not possible to control for confounding factors such as accident severity.

Despite these limitations, a March 1986 NHTSA analysis pooled the NCSS and NASS files to examine the question of rear seat lap belt effectiveness. Because there are relatively few injured rear seat belted occupants, even in the combined data sets, it is not possible to undertake rigorous statistical analysis. Nevertheless, a simple comparison of accident rates showed that rear seat lap belts were 39 percent effective in reducing fatalities and 57 percent effective in reducing serious injuries.

**Dr. Charles Kahane's  
Analysis of Fatal Accident  
Reporting System and  
Pennsylvania State  
Accident Data**

Dr. Charles Kahane of NHTSA recently estimated the fatality-and injury-reducing effectiveness of lap belts for rear seat passengers using data from the 1975-86 Fatal Accident Reporting System and 1982-85 Pennsylvania State accidents.<sup>6</sup> Like Evans, Kahane used the double pair comparison method to analyze the data (see app. I). Kahane's analysis of the FARS data differed from Evans' in that Kahane used only drivers as a control group. Kahane's analysis also differed from Evans' in that he included 1986 FARS cases, children between the ages of 5 and 15, occupants in the center rear seat, and passengers in vans and light trucks.

FARS contains nearly 500 records of fatally injured rear seat, lap-belted occupants. On the basis of the 1975-86 data, Kahane calculated that the reduction in fatalities for lap-belted, rear seat occupants compared with unbelted occupants is 17 percent. Kahane notes that lap belt use by rear seat passengers may have been underreported in the earlier years of FARS. He told us he believes that usage rates were so low that police may have ignored their use except when the occupant was killed in the crash. This type of underreporting would bias estimates against the restraint system because belt use would more likely be reported when the system failed. In fact, during the 1975-82 period, lap belt effectiveness was negative in 4 of the 8 years. However, effectiveness was consistently positive in the past 4 years, averaging 26 percent. Kahane believes that police today are more likely to record belt use in all types of crashes, and the more recent data are therefore more accurate.

Kahane estimated ranges of rear seat lap belt effectiveness from both 1975-86 and 1983-86 FARS data. For the 1975-86 data, he estimated that rear seat lap belts were between 3 and 31 percent effective in reducing fatalities. For the 1983-86 data, estimated effectiveness increased to between 15 and 37 percent. Kahane subdivided the data into frontal and nonfrontal crashes, and found that lap belt effectiveness is close to zero in frontal crashes when the experience of rear seat lap belt wearers is compared with that of nonwearers. As with the analyses of Campbell and Evans, this result is consistent with NTSB's finding for frontal accidents. The results appear in table 3.3.

<sup>6</sup>Charles Kahane, "Fatality and Injury Reducing Effectiveness of Lap Belts for Back Seat Occupants," Restraint Technologies: Rear Seat Occupant Protection, Society of Automotive Engineers (Detroit: Feb. 1987).

**Table 3.3: Fatality Reduction Through Employment of Rear Seat Lap Belts—Double Pair Comparison**

Type of accident	Data set	
	1975-86	1983-86
Frontal	- 8	+ 1
Nonfrontal	+34	+43

Source: Charles Kahane, "Fatality and Injury Reducing Effectiveness of Lap Belts for Back Seat Occupants." Restraint Technologies: Rear Seat Occupant Protection, 1987.

However, when compared with front seat drivers, both restrained and unrestrained rear seat passengers fare better. In fact, Kahane finds that the back seat is such a relatively benign environment in frontal crashes that an unrestrained, rear seat occupant is as safe or safer than a lap/shoulder-belted driver or lap-belted rear seat occupant. However, in nonfrontal crashes the unrestrained rear seat occupant is only 16 percent safer than the unrestrained driver and is at much greater risk than the restrained driver, according to Kahane's analysis. Approximately one-half of all fatal accidents are frontals. He finds that the lap belt is especially valuable in nonfrontal crashes because it can prevent occupant ejection. On the basis of 1983-86 data, he estimated that lap belts provided a 43 percent reduction in the likelihood of being fatally injured compared with being unrestrained in the rear seat in nonfrontal accidents.

Kahane also examined injury data from the Pennsylvania accident file for the 1982-85 period. Pennsylvania records contain over 2,000 cases in which occupants wearing lap belts in the rear seat were injured. Conventional analysis, that is, comparing injury rates of belted and unbelted occupants, yields an effectiveness estimate of 63 percent for serious injuries, 51 percent for moderate injuries, and 21 percent for injuries overall. On the basis of his own research experience, Kahane believes these estimates are too high. The double pair comparison method yields effectiveness estimates just over half as large as those from the conventional approach.

Kahane notes that NTSB was particularly concerned about lap belts increasing the risk of abdominal injury. He undertook a separate double pair comparison analysis of the Pennsylvania data for each of the major body regions. Since Pennsylvania does not code abdominal injuries separately, they are included under "torso." As indicated in table 3.4, the Pennsylvania data are consistent with NTSB's conclusion that lap belt-restrained occupants have an increased risk of abdominal injuries.

**Table 3.4: Effectiveness Estimates of Rear Seat Lap Belts Using Double Pair Comparison of 1982-85 Pennsylvania Accident Data**

Body region	Rear seat lap belt effectiveness		
	Serious	Moderate	Overall
Head	63	31	4
Torso	-86	-16	-21
Neck/back	49	39	16
Arm/leg	55	58	28

Source: Charles Kahane.

Kahane also finds that lap belts are more effective in reducing injury in nonfrontal than frontal crashes, except at the minor injury level. Kahane believes that lap belts are not as effective in frontal crashes because even unrestrained rear seat occupants have a lower injury risk than restrained drivers. However, the back seat offers no such advantage in nonfrontal crashes. These are the types of accidents in which rear seat lap belts may do the most good, and these types of accidents, which account for one-half of all fatal accidents, were not included in the NTSB study.

### Evidence From Canadian Experience

D. Dalmotas and J. Krzyzewski of Transport Canada (Canada's federal Department of Transportation) analyzed provincial accident data to assess the effectiveness of rear seat lap belts.<sup>7</sup> They used a variety of approaches ranging from direct comparison of injury and fatality rates for restrained and unrestrained occupants to Evans' double pair comparison approach. They found that both lap belts and lap/shoulder belts reduced the likelihood of serious or fatal injury. The likelihood of such injuries was found to be reduced by 40 to 55 percent for front seat occupants wearing lap/shoulder belts and by 20 to 50 percent for rear seat occupants wearing only lap belts. Lap/shoulder belts were found to be slightly more effective in frontal accidents than in nonfrontal while the reverse was true for rear seat lap belts. These findings were based on data from Ontario, the most populous province and one that has had a mandatory use law since 1976, and Alberta, which does not have a mandatory use law.

Although Dalmotas and Krzyzewski find the belt systems to be effective, they do find limitations in the available data, especially adequate size

<sup>7</sup>D. Dalmotas and J. Krzyzewski, "Restraint System Effectiveness as a Function of Seating Position," *Restraint Technologies: Rear Seat Occupant Protection*, Society of Automotive Engineers (Detroit: Feb. 1987).

samples. They are especially sensitive to the problem of bias due to police misreporting of belt use. They performed a sensitivity analysis that showed that if police overreport restraint use by survivors by 10 percent, a 20 percent difference in the effectiveness estimate could result. They believe that such a level of misreporting is entirely possible.

Dalmotas and Krzyzewski believe that the NTSB study is timely and that rear seat occupant protection for adults has been largely overlooked. They believe that the Canadian data they examined clearly indicate that increasing the wearing rate of rear lap belts will result in further reducing the number of occupants killed or injured annually in motor vehicle crashes. However, they also believe that the NTSB case studies show that further improvements in the design of rear seat occupant protection are required.

## Evidence From New York State

Frank Conley of the New York Department of Motor Vehicles examined New York State's police-reported accident data.<sup>8</sup> He made a straightforward comparison of the injury and fatality experiences of belted and unbelted occupants, which revealed that people fared better if they were restrained. Since 1982, New York State has required that children under 5 years be protected by a restraint, and has required other occupants, except for rear seat occupants 10 years and older, to buckle up since 1984. The state also requires that all accidents involving more than \$600 in damage be reported to the Division of Motor Vehicles. These provisions result in a large database with a fairly large number of cases in which restrained individuals are injured.

However, there are some obvious problems with the data. For example, the police-reported restraint usage is 80.1 percent, and this percentage is much higher than that recorded by belt use observers. Use by seating position raises even more questions about the accuracy of police reports. In New York almost 10 percent of rear seat passengers were recorded as wearing lap/shoulder belts, as were 22 percent of passengers riding in the middle front seat. These percentages do not correspond at all with the availability of such systems for these seating positions. These numbers, representing thousands of cases, suggest that problems of misreporting and miscoding are commonplace. These problems raise questions

<sup>8</sup>Frank Conley, "An Analysis of Safety Restraint Use and Effects in Passenger Vehicle Accidents in New York State," *Restraint Technologies: Rear Seat Occupant Protection*, Society of Automotive Engineers (Detroit: Feb. 1987).

about the accuracy of the data and, by implication, the validity of analysis based on them.

**Evidence From Michigan**

Ken Campbell of the Transportation Research Institute of the University of Michigan analyzed police-reported accident data from the state of Michigan to determine the effectiveness of lap belts for rear seat occupants. Michigan has had a mandatory use law since 1985. The unanalyzed data on rear seat belt use and injury suggest that lap belts are highly effective (see table 3.5).

**Table 3.5: 1985 Michigan Accidents—Rear Seat Occupants' Injury Severity by Belt Use**

Figures in percent			
Injury level	Belted	Unbelted	Belt effectiveness
Fatal	0.05	0.12	62
A	0.46	1.93	76
B	1.72	4.09	58
C	4.89	8.52	43
None	92.88	85.34	
<b>Total</b>	<b>100.00</b>	<b>100.00</b>	
Number of occupants	33,022	28,467	

Source: Ken Campbell.

However, when the data for the postmandatory use law period are examined separately, it is clear that police accident reports have substantially overreported belt use. Tables 3.6 and 3.7 contrast use rates recorded by observers in belt use surveys with those recorded by police in Michigan accidents.

**Table 3.6: Observed Belt Use of Rear Seat Occupants by Age in Michigan—Selected Months**

Age	Dec 84	Apr 85	July 85	Dec 85
Children, ages 4-15	28.0%	36.5%	50.3%	36.8%
Number	468	586	1,006	483
Adults, ages 16+	7.2%	9.7%	18.6%	6.9%
Number	423	532	688	429

Source: Ken Campbell.

**Table 3.7: Police-Reported Rear Seat Occupant Belt Use in 1985 Michigan Accidents by Age and Quarter**

Age	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec
Children, ages 4-15	24.6%	28.5%	58.0%	52.5%
Number	574	575	631	767
Adults, ages 16+	14.0%	17.3%	46.3%	43.1%
Number	965	1,034	1,065	1,185

Source: Ken Campbell.

Ken Campbell concludes that postmandatory use law data from police accident reports cannot be used to determine seat belt effectiveness without taking a time series approach, i.e., examining the change in injury experience over time after smoothing for other trends. He told us that he has chosen not to do this, but instead he plans to go back and examine experience prior to the passage of the mandatory use law. This work is still in progress.

Finally, Ken Campbell told us that he is more confident in police accident report data than is the NTSB. He believes that if miscoding or misreporting in the past were common, then reported belt use would have been much higher than observed rates. However, older data show a closer correspondence between actual observed rates and those reported by police in accidents. Therefore, he believes that the Board went too far when it concluded that the data could not be used to support lap belt effectiveness estimates because of misreporting problems.

## GAO Observations

Although some of the studies we examined agree with NTSB that there are problems, such as police misreporting of belt use, in the databases supported by NHTSA and others, they do not agree that the problems are so extensive as to make it impossible to undertake statistical analysis or to draw valid conclusions about the contribution of lap belts to rear seat occupant protection. The analyses consistently show that lap belts are a positive countermeasure against death and injury in motor vehicle accidents. The data do suggest that the belts are less effective in frontal collisions and when impact speeds are high. These are the types of accidents that made up the NTSB database.

The evidence from B.J. Campbell and NHTSA indicates that NTSB's sample of 26 accidents are unusually severe. For example, even if one accepts the Board's claim that many who receive minor injuries are often misreported as uninjured in police accident reports, the NTSB distribution remains very different from that found in larger databases such as

North Carolina's. Reclassifying Campbell's North Carolina cases that meet the NTSB reporting criteria into fatalities and nonfatalities still yields a distribution significantly different from NTSB's.

The evidence from several studies, employing different methods and data, indicates that lap belts are less effective in frontal, high-impact crashes—the type of crash that NTSB investigated—but are effective overall. Although the data these analysts used to estimate lap belt effectiveness do suffer from many of the drawbacks identified by NTSB, the analysts reach the consistent finding that lap belts are effective, although perhaps less so than originally believed.

Although prior studies have identified the problems of lap belt-induced injuries and exaggerated effectiveness estimates due to police misreporting, they are in general agreement that, on balance, a person in the rear seat is better off wearing a lap belt than riding unrestrained. NTSB's contention that none of these analyses are valid rests largely on its belief that the data contain a systematic bias—that the police tend to record those who are uninjured as belted and those who are injured as unbelted when, in fact the officer at the scene did not know whether or not a belt had been worn. This is one type of misreporting, but other types are also possible. For example, Kahane points out that police apparently underreported rear seat belt use in prior years, causing effectiveness to be understated.

NTSB dismisses the only previous attempt to measure reporting bias, the RSEP study, because it dealt with front seat occupants. However, NTSB has not explained why the focus on the front seat in RSEP should make a difference in the misreporting phenomenon, and the difference it might make is not apparent. Chi's analysis of the RSEP data concluded that although bias exists, police errors in the classification of belt use do not have a major impact on effectiveness estimates. Chi admits the data used were not fully representative, but it remains the most ambitious attempt to date to deal quantitatively with the problem.

# NTSB Response to the Critics

NTSB officials have responded to the critics of the lap belt study. They have defended their approach to the question and have rejected the notion that they examined only very serious accidents. NTSB staff have reiterated their concerns about the quality and usefulness of police accident report based data and believe that the recent studies suffer from most of the same problems as earlier analyses. Finally, they believe that they had a moral obligation to publish their findings and doubt that their study played any part in the outcome of the seat belt repeal referendum in Nebraska.

## The Board's Defense of Its Methodology

Board officials maintain, as said clearly in NTSB's report, that they never intended to and, in fact, did not perform a statistically reliable analysis of the effectiveness of rear seat lap belts and further, that they included the appropriate caveats in their study. They acknowledge that statistical reliability would have required a much larger and more fully representative sample. However, Board personnel in Washington and in the field reject the notion that they examined only very serious accidents. They point out that the average delta V in the studied accidents was 27 mph, below the NHTSA crash test standard for safety belt effectiveness of 30 mph. They point out that NHTSA crash tests are, in fact, performed at 35 mph.

The Board's staff also reject FaAA's allegation that criteria other than those stated were used for reporting accidents. While NTSB did not refute FaAA's specific criticisms of its sample, the Board claims that nothing in its notification criteria asked those reporting accidents to report only those in which injuries occurred or in which a belted person was injured. NTSB officials claim that no attempt was made to screen out cases where lap belts were effective. In fact, they note that in a number of situations in the cases they reviewed, an occupant was wearing a lap/shoulder belt and benefited from it. In response to the criticism by FaAA for omitting the outcome for occupants in noncase vehicles, these officials note that crucial sets of facts were not documented for most of the noncase vehicles. Thus, without information on occupant kinematics, occupant injuries, and other salient factors, they believe that a simple comparison of fatality rates would yield little insight into the efficacy of restraint systems.

## NTSB Views of Other Databases

With respect to the other databases, NTSB personnel believe that their criticisms are still valid. They maintain that police at the accident scene do not have the time, the training, or the inclination to assess and report

seat belt use accurately. They believe it is self-evident that data reliability is impaired if a state police accident report form lacks a space to record restraint use or the type of system available. Even when such a space is provided, the officer often miscodes belt use. For example, they note that there are reports of air bag systems in the rear seat when no such systems were available. They believe that police often code lap/shoulder belt use when only lap belts were available. The Board's researchers related to us a number of anecdotes about police misreporting based on their experience with this study and on their earlier experiences as accident investigators. However, they reject the FaAA suggestion that the cases they examined for their study be used to test the extent of police misreporting.

NTSB officials claim that they have too few cases to answer the question of lap belt effectiveness. They point out that they never claimed their sample to be a statistically valid representation of belt effectiveness. Furthermore, they claim that a variety of weaknesses exists in the available accident databases, other than simple police misreporting of belt usage, which limits their usefulness in estimating belt effectiveness. They claim that no one knows the error rates on police report forms and that errors in reporting the occurrence of injury, seating position, and the severity of injury are all factors that limit the usefulness of databases built on these reports.

NTSB staff emphasize that even those who have been critical of their report admit to the paucity of data supporting the estimates of rear seat lap belt effectiveness. They note that some studies overstate belt effectiveness because they did not correct for the correlation between belt use and accident severity. Other studies, while using methods that overcome this problem, often are plagued by small sample sizes. For example, NTSB staff noted that Evans' analysis of rear seat belt effectiveness in reducing fatalities yields widely different effectiveness estimates, depending on which seating position is used in the analysis.

Many of the drawbacks that limit the ability to analyze lap belts also affect the analysis of lap/shoulder belts. However, NTSB staff argue that there is a larger pool of data showing lap/shoulder belt effectiveness and there are logical reasons why lap/shoulder belts might be expected to be more effective. In an accident, the body of a belted person is propelled forward while being restrained by the belt. A lap belt concentrates the restraining forces on the abdomen, while lap/shoulder belts allow the forces to be distributed over a wider area and thereby reduce the pressure on any one area. In addition, the Board's investigation

found cases in which the lap belt caused serious injury, but found no cases of lap/shoulder belt-induced injuries.

### Problems With Federal Databases

The Board's staff believe that the FARS data, used by both Evans and Kahane, are unacceptable for estimating rear seat lap belt effectiveness for three reasons:

- The outcomes of occupants in fatal crashes cannot predict outcomes in nonfatal crashes.
- The rear seat occupant numbers are extremely small.
- FARS data are merely police-reported accident data and are not reliable in a number of crucial respects (discussed in ch. 2).

NHTSA also relies on evidence from NCSS and NASS databases to refute NTSB's findings. However, Board officials argue that their report raised a number of problems with NCSS and NASS databases which have not been addressed by NHTSA. NCSS data were not national estimates from a random sample and there may be large sampling errors. In any case, the Board staff believe that both NCSS and NASS contain too few rear seat lap belt cases to allow accurate assessment of their effectiveness.

### NTSB Response to Analyses Using State Data

At the heart of NTSB's critique of the reports based on state or provincial data is the fact that they are derived almost entirely from information in police accident reports. NTSB officials argue that the reliability of any effectiveness estimates using police accident report data depends on at least three factors:

- The police classification of the severity of the crash.
- The police classification of the severity of the injury.
- The police classification of the occupants' use or nonuse of the seat belts and, if used, the type of system used.

Although the Board's staff believe that the inability to (1) adequately control for crash severity and (2) accurately rate injury severity limit the ability to assess belt effectiveness, they believe that the second factor may be the most important.

## The Belt Use Reporting Issue

NTSB officials point to the studies using state accident data by Frank Conley and Ken Campbell as further proof of the futility of trying to work with police-reported accident data. They claim the obvious misreporting of the type of system employed that appeared in the New York and Michigan data makes it impossible to place any confidence in analysis using such police accident report-based data. NTSB staff also cite prior research, including that performed by B.J. Campbell and others at HSRC, that documents the problem of systematic reporting bias on the part of the police. Board officials claim that no examination has been made of the problem of bias in any representative sample of police-reported accidents. They claim that the oft-cited RSEP study was not representative because it was not a national sample and about 40 percent of the occupants actually were belted—a very high percentage for the mid-1970s. In addition the data are old and they relate only to front seat occupants.

NTSB staff argue that a bias as small as 5 percent can have a significant impact on effectiveness estimates. Using B.J. Campbell's North Carolina data, they reestimated seat belt effectiveness assuming that 5 percent of those reported unbelted were, in fact, belted. The result of this adjustment is to reduce the effectiveness of lap/shoulder belts from a range of 32 to 59 percent (depending on accident severity) to 3 to 29 percent. For lap belts, however, a 5 percent reporting bias makes the effectiveness estimates negative except for the least severe accidents. NTSB staff note that the estimates of lap belt effectiveness become highly negative, -51 and -58 percent, for TAD 6 and TAD 7 accidents. They do not allege that the bias is, in reality, 5 percent, but only that a bias this large would eliminate the estimated benefit of lap belts, but not of lap/shoulder belts, and that the bias could quite plausibly be five percent or more.

Finally, the Board staff answer Campbell's contention that "wrong way" cases are to be expected in accident analysis because of the complexity of individual accidents. They say that their assessment explains why the accident outcome for belted occupants went the "wrong way." Lap belts have been shown as a cause of death and injury.

## The Board's Justification for Publishing the Report

NTSB officials told us that they had a moral obligation to publish their findings. While it might be true that the highway research and the medical communities were aware of the problem of lap belt-induced injuries, they believe that highway police and emergency medical service personnel were not. They believe that they have provided an important service if their report has made the people who are the first at an accident scene aware of a previously little-known problem.

With respect to how the report was publicized, NTSB officials believe that the print media gave a reasonably accurate portrayal of the findings. The appropriate caveats were recorded and the coverage stressed the Board's call for lap/shoulder belts in the rear seat. Some TV coverage was less accurate and highlighted the Board's calling into question the effectiveness of lap belts. The Board could not withhold publication of the report, in any event, because it had been leaked to the press. The Board then held a press conference in an effort to make sure that its findings were not misunderstood.

In response to the criticisms that the report was badly timed and that it might have influenced the outcome of the seat belt repeal referenda in Massachusetts and Nebraska, NTSB staff point out that there is no evidence that the report was employed by opponents to the mandatory belt use laws in either of these two situations.

NTSB officials also note that some support has been voiced for their conclusion that lap/shoulder belts are more effective than lap belts. They believe that, in the long run, the report will have played a positive role in enhancing automobile occupant protection. They point out that the "big three" American car manufacturers have all announced plans to provide lap/shoulder belts in the rear outboard seating positions on some 1987 models and on all models by 1990. They do not believe this would have happened if the Board had not undertaken its investigation. In addition, NHTSA has published an advance notice of proposed rulemaking on the issue. This reversed a 1984 NHTSA decision denying a petition to hold hearings because the agency believed that the added benefits from requiring lap/shoulder belts in the rear outboard seating positions were minor.

## GAO Observations

NTSB believes that its case selection was unbiased and that its cases were not unduly severe. NTSB notes that NHTSA requires that a crash be survivable by belted occupants at delta V of 30 miles per hour, as evidence that the crashes in its sample with a mean delta V of 27 mph are not extreme. However, crashes at delta V slightly less than 30 mph, while survivable, are still severe. Moreover, NHTSA data show that relatively fewer than 3 percent of crashes experience delta V's of more than 30 mph, and nearly 90 percent are at 20 mph or less. On the basis of the studies prepared by B.J. Campbell and FaAA, we believe the evidence strongly suggests that the cases in the NTSB sample were very severe and not representative of the accident population described by the Board's selection criteria.

With regard to NTSB's criticisms of the other databases, it is true that not a great deal of research has been specifically aimed at rear seat lap belt effectiveness. However, research based on the data that do exist reached the same conclusion—that lap belts reduce the likelihood of death or serious injury for rear seat occupants. The RSEP data satisfy most of the Board's criteria for an adequate data base: belt use was accurately determined, the analysis was controlled for accident severity and other factors, injury data were coded accurately and precisely, the datafile was large, and the data collection procedures allowed for few or no missing cases. Although the data are old and refer only to the front seat, NTSB has not shown why these results would not be applicable to current vehicles and rear seat passengers. In the absence of convincing evidence to the contrary, we do not see the basis for rejecting the findings from the analysis of the RSEP study that police reporting bias exists but it is not so severe as to invalidate the conclusion that lap belts are effective.

Moreover, B.J. Campbell, in response to NTSB's claim that a 5 percent error can switch lap belt effectiveness estimates from positive to negative, makes such an adjustment to the RSEP data analyzed by Chi. Adjusting the RSEP data to account for a 5 percent error in police misreporting would reduce the effectiveness estimates from 40 percent to 25 percent, which would indicate a lower lap belt effectiveness rate than that identified through detailed investigator analysis. The results of his adjustment appear in table 4.1.

**Table 4.1: Belt Effectiveness in RSEP**

Figures in percent

	<b>Effectiveness estimate</b>
Police source	40.3
Investigator source	31.6
Police source adjusted for 5 percent reporting bias	24.9

Source: B. J. Campbell.

Finally, as FaAA notes, the Board's own sample fails to support its contention that the large databases are unusable due to police misreporting of belt usage and injury severity.

# GAO Observations and Conclusions

On the basis of our review of the NTSB report, other studies and analyses, and interviews with individuals expert in traffic safety research, we have developed observations and conclusions on the two basic questions posed to us by the Chairman: how NTSB developed the data on the 26 cases in its sample and whether its rejection of the databases underlying statistical analyses of rear seat lap belt effectiveness was justified.

## GAO Observations on the 26 Cases

The NTSB sample of 26 accidents was not a representative sample of highway accidents, but a statistically representative sample is not necessary to show that a problem exists. NTSB usually takes a case study, rather than a statistical, approach to analyzing accident causality or system performance. The sample of accidents NTSB examined was biased toward more severe types of accidents, and while the sample results triggered the Board's decision to look to other databases to judge overall rear seat lap belt effectiveness, it was not the Board's sole basis for questioning how the belts performed. Highway safety researchers already were well aware that lap belts sometimes can cause serious injuries and that lap/shoulder belts provide superior occupant protection.

However, even if NHTSA required all new cars to be equipped with lap/shoulder belts in the rear seat, more than 100 million cars currently on the road do not have these belts. The question NTSB has raised is whether NHTSA and other highway safety agencies should continue to advise rear seat occupants to wear lap belts when they are the only restraint system available. The Board says the data are insufficient for making such a recommendation. NHTSA and most other highway safety researchers do not agree. This then, not the adequacy of NTSB's evaluation of the 26 cases, is the key issue.

## GAO Observations on the Usability of the Databases

The point of controversy between NTSB and its critics is the matter of data accuracy. NTSB has concluded that prior highway safety research showing that rear seat occupants are, on balance, better off wearing lap belts than no belts at all, is not reliable because the data it was based on contain inaccuracies. NTSB offers a number of reasons why it believes the data underlying studies showing lap belts to be effective are flawed, including

- omitted or misclassified data in police accident reports,
- imprecise measures of crash severity,
- imprecise measures of injury severity, and
- inadequate sample sizes.

We do not believe that NTSB's concerns about the data provide a sufficient basis for dismissing either the results of other research in this area or the databases themselves. No database is perfect. The question an agency that intends to use data must address is whether the data are sufficiently accurate to yield valid findings about the thing being analyzed. Possible inaccuracies or limitations in the data should be evaluated to determine how likely it is that they would significantly affect any conclusions based on the data. NHTSA investigated the flaws in the data it uses to analyze seat belt effectiveness and concluded that the problems were not sufficient to invalidate the data for research. NTSB did no analysis of its own to demonstrate that NHTSA's findings about the usability of the data were incorrect.

Therefore, we find that while NTSB has highlighted some important limitations in widely used accident databases, it has not shown that these databases cannot be used to show that lap belts, on balance, protect rear seat passengers in automobile crashes. The presence of inaccuracies in the data is not a sufficient reason for dismissing the findings of all the research that has used that data.

Finally, NTSB's criticisms of the principal databases researchers used to analyze the performance of different types of safety systems have not been fully answered. While we believe that NTSB has not shown the data to be useless for analysis, there are, nonetheless, shortcomings in the quality of databases that rely on police accident reports. NHTSA is working on several programs that might improve the accuracy of police reporting and provide more current information on the relationship between police reports and investigator analysis of accidents.

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# Description of the Double Pairs Comparison Procedure

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The method focuses on two occupants, a “subject” occupant and an “other” occupant. The probabilities of a fatality to the subject occupant under two conditions—for example, restrained and unrestrained—are compared. The “other” occupant essentially serves a normalizing, or exposure estimating, role. The procedure uses two sets of fatal crashes. The first set consists of crashes involving cars containing a subject occupant of interest (such as a restrained right rear passenger) and an “other” occupant (such as an unrestrained driver), at least one of whom is killed. From the numbers of subject and other occupant fatalities, a subject/other fatality ratio is calculated (such as the restrained right rear passenger to unrestrained driver fatality ratio). From a second set of crashes involving cars where the subject occupant and the other occupant are unrestrained, another fatality ratio is calculated (such as the unrestrained right rear to unrestrained driver ratio). Dividing the first fatality ratio by the second yields the probability that a restrained right rear passenger is killed compared with the corresponding probability that an unrestrained right rear passenger is killed. This ratio is the effectiveness of the restraint system defined as the fraction (or percent) reduction in fatalities that would accrue to a currently unrestrained population if the population were to change to universal restraint use, all other factors remaining unchanged.

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