COMPARISON OF AUTOMATIC FRONT-SEAT OUTBOARD OCCUPANT RESTRAINT SYSTEM PERFORMANCE

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ABSTRACT

Federal motor vehicle safety standards required installation of passive restraints in passenger vehicles beginning with the 1987 model year. Manufacturers met standards by using either "automatic" seat-belt systems or airbags with active (manual) seat-belt sys-tems. Several different automatic designs were employed.

This paper addresses accident performance of various automatic seat-belt systems and discusses (1) factors that influence belted injury rates and (2) statistical procedures used to control for these factors. Different automatic systems are described and a list of passenger vehicles with different automatic systems is presented. State motor vehicle accident data were examined to assess the overall safety performance of automatic belts. Performance comparisons were made after controlling for factors that might influence injury rates, including (1) vehicular factors such as vehicle size and body style; (2) accident factors such as single- versus multiple-vehicle accident, rollover, and accident severity; and (3) driver-related factors such as driver age. Injury rates for belted and unbelted front-seat outboard occupants and the percentage reduction in injury for belted front-seat outboard occupants are reported as measures of overall belt effectiveness.

The analyses show no consistent significant difference in safety performance among various types of automatic restraint systems.

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DESCRIPTION OF AUTOMATIC RESTRAINT SYSTEMS

U.S. Federal Motor Vehicle Safety Standard (FMVSS) 208 specifies requirements for both active and passive occupant restraint systems in motor vehicles. When first effective on January 1, 1968, FMVSS-208 required manufacturers to place lap belts in each vehicle in all seating positions and upper torso (shoulder belt) restraints in the front outboard positions. In 1984, FMVSS-208 was amended to promulgate the use of passive occupant restraints at the front outboard seating positions. Manufacturers met this requirement by use of either "automatic" seat-belt systems or airbags with active (manual) seat-belt systems. Requirements for installation of passive occupant protection systems were phased in over the period 1987 to 1990 with the requirement that each manufacturer provide such systems in the following percentages of vehicles:

Model Year 1987 .... 10 percent
Model Year 1988 .... 25 percent
Model Year 1989 .... 40 percent
Model Year 1990 .... 100 percent

Manufacturers chose to meet the requirements of FMVSS-208 with various designs (Table 1). Inflatable airbags with manual seat belts were installed in the driver position or driver and front-seat passenger positions on several models, but the majority of the vehicles designed to meet the standard were equipped with automatic seat-belt systems.

Table 1 - Types of Passive Restraints Available in Model Years 1987-1989

1. Three-Point, Door-Mounted Detachable
2. Two-Point, Door-Mounted, Detachable, with Manual Lap Belt
3. Two-Point, Door-Mounted, Detachable, without Manual Lap Belt
4. Two-Point, Motorized, Detachable, with Manual Lap Belt
5. Two-Point, Motorized, Nondetachable, with Manual Lap Belt
6. Air Bag with Three-Point Manual Belt

Each restraint system is described below:

THREE-POINT, DOOR-MOUNTED SYSTEMS - These systems are similar in many ways to the manual, three-point Type II seat belts installed for many years in motor vehicles. Production installations of this configuration have separate emergency locking retractors for the lap belt and shoulder belt mounted near the rear edge of the door, and have a fixed-position inboard buckle. The buckle can be detached. When the door is opened, both the shoulder belt and the lap belt extend with the door, allowing the occupant to pass to or from the vehicle behind the extended lap and shoulder belts. When the door is closed, the retractors respool the belt webbing that was deployed when the door was open.

TWO-POINT, DOOR-MOUNTED SYSTEMS - These automatic seat belts consist of a shoulder belt with a fixed anchor attached outboard at the rear edge of the door, and an inboard-mounted emergency locking retractor. The shoulder belt extends from the retractor when the door is opened, allowing the occupant to pass to or from the vehicle behind the extended belt. When the door is closed, the retractor respools the webbing that was extended when the door was open. The two-point, door-mounted systems installed in 1987 to 1989 production vehicles have a buckle for emergency release at the attachment point on the door. Control of lower body movement in a frontal collision is provided by knee bolsters.

Some manufacturers also provided a manual lap belt. The lap belt emergency locking retractor can be mounted either outboard or inboard.

TWO-POINT, MOTORIZED SYSTEMS - In these systems, the outboard belt end is attached to a motorized carrier mounted in a track along the upper portion of the roof rail between the A and B pillars. The emergency locking retractor on the shoulder belt is mounted inboard. When the door is opened, the motorized track carries the outboard carrier forward to the A pillar. The belt is thus clear of the outboard edge of the seat to allow occupant passage from the vehicle. When the door is closed and the ignition turned on, the outboard carrier moves rearward along the motorized track to a position on the B pillar. A knee bolster is also employed with these systems to restrain lower body movement during frontal impacts. All production versions of this system in model years 1987 to 1989 also provided a manual lap belt with an inboard buckle and outboard retractor.

Emergency release from the two-point motorized systems in 1987 to 1989 model-year vehicles was provided in two different ways. Some designs provided an emergency release on the console-mounted retractors. Such systems permit the belt to fully unspool but are not detachable. Other designs provided an emergency release buckle at the outboard end on the motorized track.

VEHICLE CLASSIFICATION BY TYPE OF RESTRAINT

Candidate automatic belt-equipped vehicles were identified from surveys of passive systems published by the National Highway Transportation Safety Administration (NHTSA) (1987, 1988, 1989), the Insurance Institute for Highway Safety (1986, 1987, 1988), Automotive News (1988, 1989, 1990), the Fatal Accident Reporting System (FARS) manual (1989), and other papers and reports (e.g., Williams, et al., 1989). These references were considered secondary sources because they were not generated directly by the vehicle manufacturers. Primary sources of information such as manufacturers' MVMA specifications, owner's manuals, and service manuals were then used to confirm use of passive belt systems and to identify the type of passive system.

Primary sources revealed information concerning the number of attachments, locations of retractor and release mechanisms, motorized functions, and availability of manual lap belts. Vehicles equipped with airbags for front-seat occupants were also identified. Several vehicles were deleted from the candidate lists because no evidence of passive restraint availability was found, because there was insufficient information to characterize the vehicles with confidence, or because low sales volume for the model reduced its significance to the overall survey.

A subset of vehicle models was selected for accident data risk assessment. Included are automatic belt models manufactured by GM, Ford, Chrysler, Honda, Hyundai, Mazda, Mitsubishi, Nissan, Toyota, and Volkswagen. These models were selected for their significant U.S. sales volume. A listing of the selected models grouped according to restraint system is presented in Table 2.

Table 2 - Makes and Models Included in the Analysis, by Restraint Type

Make	Model
Three-Point, Door-Mounted, Detachable	
Buick	LeSabre
	Regal
	Somerset
	Skylark
	Electra/Park Avenue
Oldsmobile	Calais/Cutlass Calais
	Delta 88
	Cutlass Supreme
	98 Regency
Pontiac	Bonneville
	Grand Am
	Grand Prix
Chevrolet	Beretta
	Corsica
Honda	Accord
	Prelude
	Civic CRX
Two-Point, Motorized, Nondetachable with Manual Lap Belt	
Ford	Escort
	Tempo
	Lynx
	Topaz
Toyota	Camry
	Cressida
Two-Point, Motorized, Detachable with Manual Lap Belt	
Ford	Thunderbird
	Cougar
Mazda	626e
Mitsubishi	Mirage
	Colt
Dodge	Shadow
Plymouth	Sundance
Nissan	Maxima
	240SX
	Sentra
Two-Point, Door-Mounted, Detachable with Manual Lap Belt	
Dodge	Daytona
Chrysler	LeBaron Coupe
Hyundai	Excel (1989)
	Precis (1989)
Two-Point, Door-Mounted, Detachable without Manual Lap Belt	
Hyundai	Excel (1987-1988)
	Precis (1987-1988)
Volkswagen	Golf
	Jetta

DATA SOURCES USED

In order to assess injury risk associated with automatic belt systems, police-reported motor vehicle data from four states were used: Florida, New York, Maryland, and North Carolina. In addition, data from the Fatal Accident Reporting System (FARS) maintained by NHTSA were examined in order to identify driver-related factors that are distinctly different among the vehicles equipped with different types of restraint systems.

State databases that do not code vehicle identification number (VIN), restraint use, seat position, or injury severity were not considered in the study. Only states that record all occupants regardless of injury were considered for analysis. Data from all the states included in the study were examined for accuracy, completeness, and reliability of codes that identify injury severity, VIN, driver demographic information, accident severity, and restraint use. Collectively, the state databases included in the study provided information on approximately 250,000 motor vehicle occupants involved in real-world accidents from 1986 through 1991.

METHODOLOGY

Accident databases were interrogated in order to assess the overall injury risk and injury risk for belted and unbelted occupants for selected models equipped with automatic belt systems.

Several measures of restraint system performance were examined using the accident data. In particular, the following measures that directly relate to restraint system performance were examined:

1. Injury per accident-involved front-seat occupant, regardless of belt use.
2. Fatal/major injury per accident-involved belted front-seat outboard occupant.
3. Fatal/major injury per accident-involved unbelted front-seat outboard occupant.

In addition to the injury rates, the restraint use for these vehicles was examined.

Several accident-, vehicle-, and driver-related factors that influence injury experience of accident-involved occupants were examined, and the restraint system performance after removing the influence of these factors was determined using statistical techniques that are discussed below.

Rates of belt use for each type of design are presented in Table 3.

Table 3

Rates of Restraint Use by Restraint Type*
In Accident Years 1986-1991

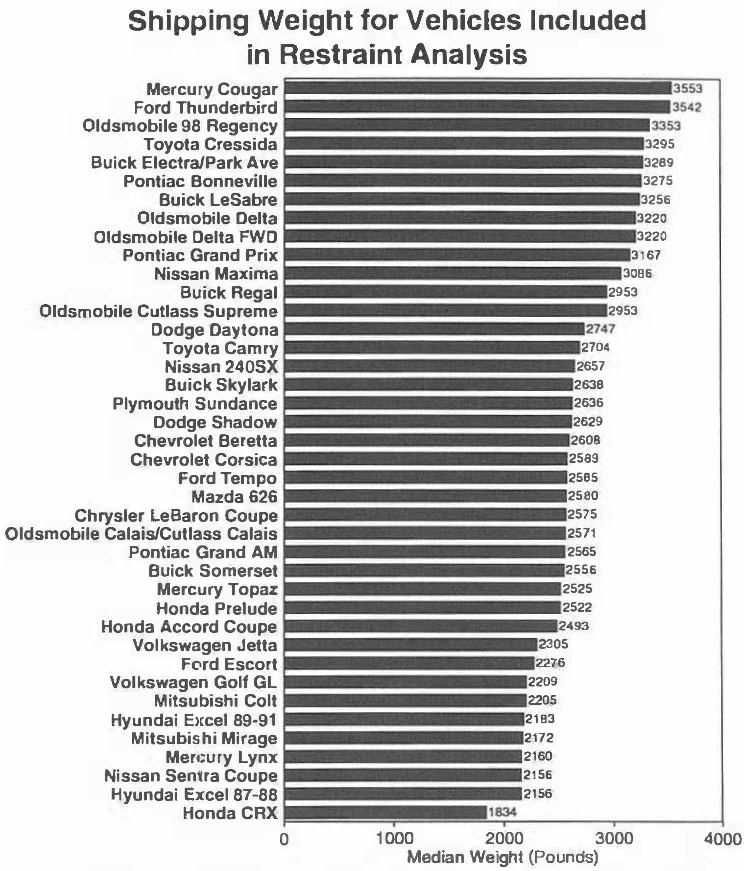
	Type 1	Type 2	Type 3	Type 4	Type 5
Florida					
used	86.46	86.14	85.73	89.80	91.85
not used	11.89	12.02	12.65	8.26	6.27
unknown	1.65	1.84	1.62	1.94	1.87
New York					
used	84.10	83.12	81.76	84.04	88.11
not used	6.76	7.27	7.43	6.14	3.73
unknown	9.13	9.61	10.80	9.81	8.16
Maryland					
used	82.23	82.41	82.80	87.48	87.85
not used	8.20	7.08	6.21	4.53	3.11
unknown	9.57	10.51	10.99	7.99	9.04
N.Car.					
used	92.24	93.14	94.45	95.01	95.34
not used	4.72	4.06	3.17	2.22	1.67
unknown	3.04	2.81	2.38	2.77	2.99

* Restraint types 1 through 5 are described at Table 1.

ADDITIONAL FACTORS CONSIDERED IN THE ANALYSIS

In order to evaluate the benefit associated with the various automatic belt designs, it was deemed necessary to control for certain factors that influence the injury experience of motor vehicle occupants. These include vehicle factors such as size and body type; the vehicles included in this study constitute a wide range of weights (Figure 1) and include both two-door and four-door models.

Figure 1



Model years included in the analysis are 1987-1989 except for the Hyundai Excel. Hyundai Excel includes Mitsubishi Precis.

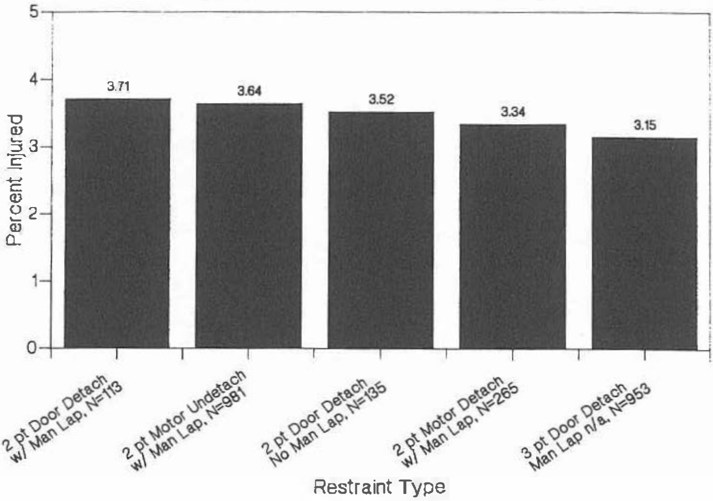
Accident factors such as single- versus multiple-vehicle accident, vehicle rollover, frontal impact, and crash severity were also found to be related to injury risk, as is the factor of driver age. The North Carolina database contains a direct measure of accident severity known as the TAD scale, and the Maryland database contains a code for the severity of accident damage. Both the TAD scale (National Safety Council, 1983) and the Maryland damage severity scale (Maryland, 1977) measure damage to the accident vehicle rather than the force of the collision. While these are good indicators of accident severity, they do not provide a direct measurement of the force of impact.

Controlling the analysis for these factors increases the precision of the evaluation and minimizes the potentially biasing effects of these factors. The confounding influence of these factors was removed prior to comparison of belted and unbelted injury rates, and the resultant figures formed the basis for the conclusions presented here. The North Carolina and Maryland analyses were controlled for accident severity in addition to the other factors.

Of course, potentially confounding factors that are not captured by the police-reported data were not controlled for in this procedure.

Figure 2

BELTED OCCUPANTS[1] WITH FATAL AND MAJOR INJURY[2] AS A PERCENT OF ALL BELTED OCCUPANTS[1] FLORIDA ACCIDENT DATA 1986-91



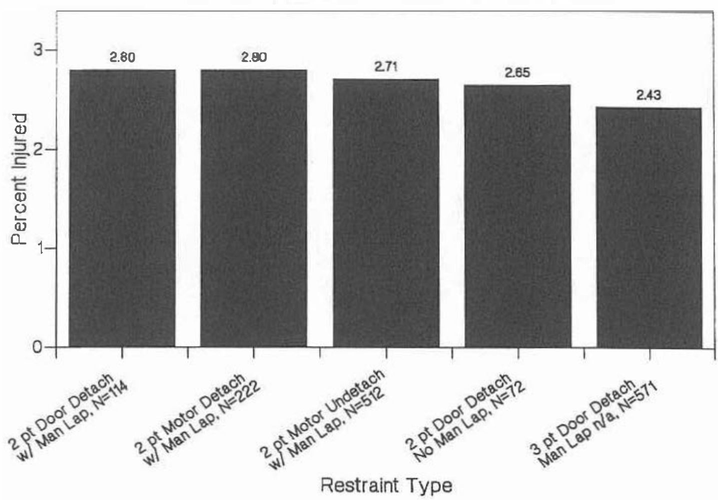
1. Front outboard occupants involved in motor vehicle accidents.
2. The injury rates are standardized by the following factors: Single vehicle accident, rollover, vehicle size, body style, and driver age.
N=number of injured occupants.

Statistical Analysis System (SAS) logistic regression was used to calculate the effect of restraint-system design on injury rates while simultaneously controlling for all of the factors listed above. This methodology provides a test of statistical significance of the differences among automatic restraint designs, while controlling for other factors. The method of directly standardized rates was used to calculate the rates of fatal or major injury displayed in Figures 2 through 7. Here the injury rates are calculated as they would have been if each of the five restraint systems were installed in a population with (1) the same mix of vehicle sizes and body styles, (2) the same relative frequency of single-vehicle and rollover accidents (and, in North Carolina and Maryland, damage severity), and (3) the same proportion of young drivers.

As seen in Figures 2 through 7, no consistent pattern of lower or higher injury rates is found in any one of the five automatic restraint designs.

Figure 3

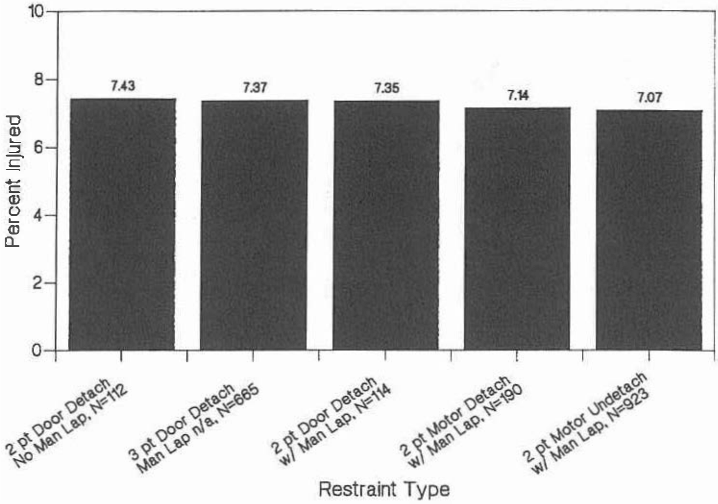
**BELTED OCCUPANTS[1] WITH FATAL AND MAJOR INJURY[2]
AS A PERCENT OF ALL BELTED OCCUPANTS[1]
NEW YORK ACCIDENT DATA 1988-91**



1. Front outboard occupants involved in motor vehicle accidents.
2. The injury rates are standardized by the following factors: Single vehicle accident, rollover, vehicle size, body style, and driver age.
N=number of injured occupants.

Figure 4

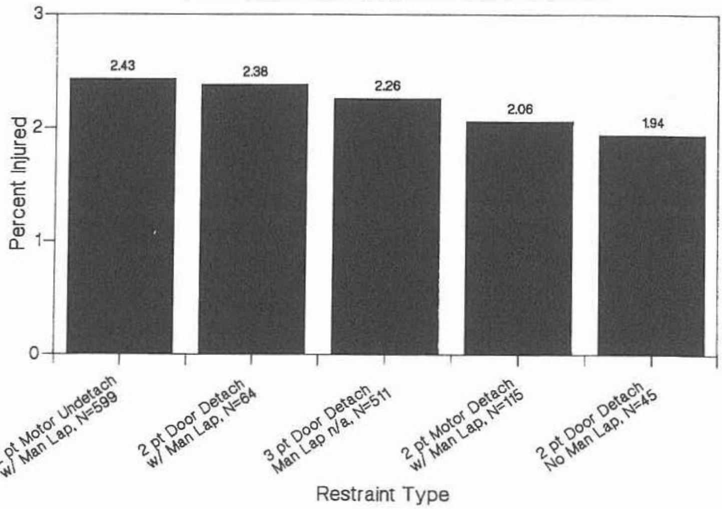
BELTED OCCUPANTS[1] WITH FATAL AND MAJOR INJURY[2]
AS A PERCENT OF ALL BELTED OCCUPANTS[1]
MARYLAND ACCIDENT DATA 1988-91



1. Front outboard occupants involved in motor vehicle accidents.
2. The injury rates are standardized by the following factors: Single vehicle accident, rollover, vehicle size, body style, damage severity, and driver age.
N=number of injured occupants.

Figure 5

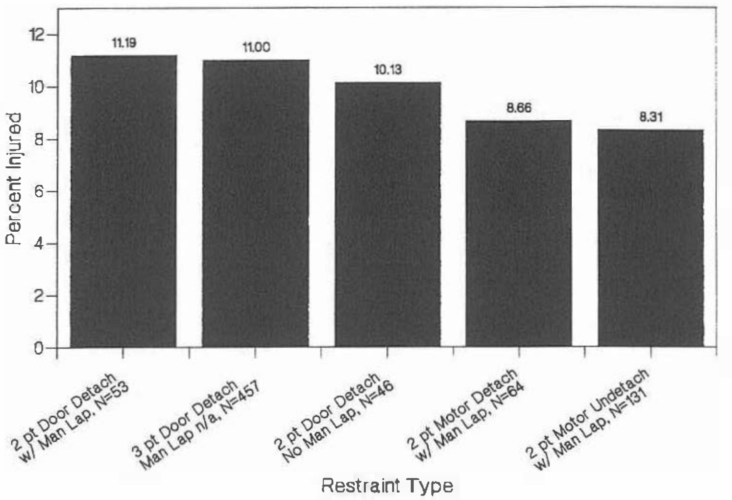
BELTED OCCUPANTS[1] WITH FATAL AND MAJOR INJURY[2]
AS A PERCENT OF ALL BELTED OCCUPANTS
NORTH CAROLINA ACCIDENT DATA 1988-91



1. Front outboard occupants involved in motor vehicle accidents.
2. The injury rates are standardized by the following factors: Single vehicle accident, rollover, vehicle size, body style, highest TAD, and driver age.
N=number of injured occupants.

Figure 6

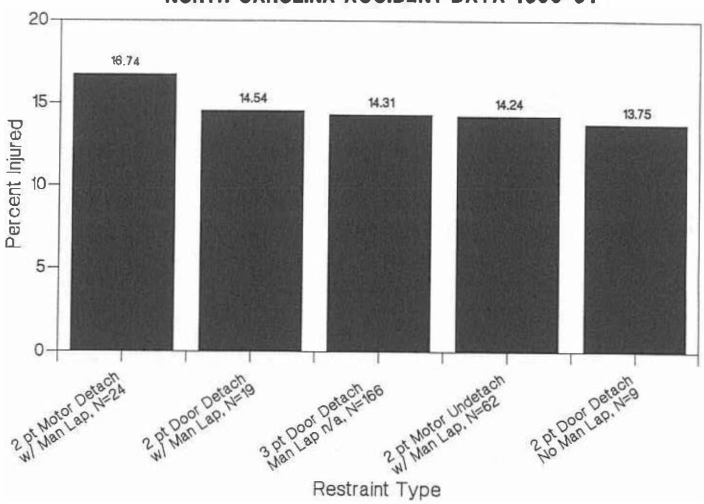
UNBELTED OCCUPANTS[1] WITH FATAL AND MAJOR INJURY[2]
AS A PERCENT OF ALL UNBELTED OCCUPANTS[1]
FLORIDA ACCIDENT DATA 1986-91



1. Front outboard occupants involved in motor vehicle accidents.
2. The injury rates are standardized by the following factors: Single vehicle accident, rollover, vehicle size, body style, and driver age.
N=number of injured occupants.

Figure 7

UNBELTED OCCUPANTS[1] WITH FATAL AND MAJOR INJURY[2]
AS A PERCENT OF ALL UNBELTED OCCUPANTS[1]
NORTH CAROLINA ACCIDENT DATA 1986-91



1. Front outboard occupants involved in motor vehicle accidents.
2. The injury rates are standardized by the following factors: Single vehicle accident, rollover, vehicle size, body style, highest TAD, and driver age.
N=number of injured occupants.

DISCUSSION OF RESULTS

Figures 2 through 5 present the rates of fatal or major injury to belted front-seat occupants as a percentage of all belted front-seat occupants for the states of Florida, New York, North Carolina, and Maryland. These rates resulted from removing the effect of confounding factors that could influence the rates of injury to accident-involved occupants.

Figures 6 and 7 present unbelted occupants with fatal or major injury as a percentage of all unbelted front-seat occupants. This measure is indicative of crashworthiness of the vehicle compartment. It is influenced by false reporting of belt use in accident-involved vehicles; police-reported data on belt use may suffer from overreporting of belt use by uninjured occupants, which in turn could bias unbelted injury rates. Fleischer (1972) and Kahane (1974) found belt use to be lower in lower-speed accidents. If this still holds true since the advent of mandatory-use laws, it implies that the observed higher injury rate for unbelted occupants as compared to belted occupants is understated due to differences in crash severity.

Multiple logistic regression was used to test the statistical significance of differences in injury rate among the five belt designs. An analysis of covariance design was used to determine whether there is any significant variation in injury risk attributable to seat-belt design, while controlling for the covariates listed previously. Separate analyses were performed in each state (1) for belted occupants, (2) for unbelted occupants, and (3) for all occupants. Table 4 presents these results.

Table 4
Results of Tests of Statistical Significance of Differences in Injury Rates among Five Types of Automatic Restraints

State	Belted occupants	Unbelted occupants	All occupants
Florida	Belt type "main effect" indicates some statistically significant effect of belt design, but no consistent pattern of superiority for any one design.	Belt type "main effect" indicates some statistically significant effect of belt design, but no consistent pattern of superiority for any one design.	NS*
Maryland	NS	NS	NS
New York	NS	NS	NS
North Carolina	NS	NS	NS

SUMMARY AND CONCLUSIONS

The overall performance of automatic belt systems installed in 1987 through 1989 model-year vehicles was evaluated by examining the motor vehicle accident databases of four U.S. states. The data from these states support injury analysis for front-seat outboard occupants, belted occupants, and unbelted occupants. The data also permit accurate identification of vehicles equipped with automatic belts. Based on the accident data interrogated, the following conclusions were derived:

1. No single automatic restraint system consistently performs much better or worse than the other designs that were introduced in 1987 to 1989 model-year vehicles. Overall effectiveness has two components: (1) the effectiveness of restraints in preventing injury and (2) the likelihood that occupants will wear

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* No significant difference

the restraints. The injury rate for all occupants regardless of belt use measures the combined impact of both components. There were no significant differences among belt types in any of the four states for the measure.

2. The performance of these systems is even more similar after controlling for vehicle-, accident-, and driver-related factors that affect vehicle safety and use of restraints.

3. No statistically significant differences in belt performance were found in three of the four states studied. The significant differences found in the Florida analysis are not consistently associated with any one type of automatic restraint system.

4. The study included vehicles from a wide range of vehicle weight classes, and multiple logistic regression procedures cannot control for vehicle size completely. Consequently, additional research is warranted in order to evaluate the peformance of different types of automatic restraints within each vehicle size category.

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Discussion of Streff and Padmanaban/Ray papers

SOCRATES, AN ELEPHANT, AND OCCUPANT RESTRAINTS

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ABSTRACT

The key question for occupant restraint systems is which systems provide the greatest reduction in morbidity and mortality when examined over comparable wide ranges of vehicle and crash configurations and occupant use patterns. Neither the Streff paper nor that by Padmanaban and Ray totally answers this question. The Streff paper considers only two systems in a single vehicle make and type. The paper by Padmanaban and Ray substantially fails to define the basic question in sufficiently useful form for administrative decision making.

I first heard about occupant restraints in 1956 as a medical student when one of my professors of surgery spoke about the recently published research of the Cornell Automotive Crash Injury Research project, and their observation that, among persons in injury producing crashes, those who wore seatbelts were less likely to be ejected and killed than were unbelted occupants. Two years later, when my wife and I bought our first car, I purchased and personally installed two belts.

In 1963, when even seatbelt anchors were not yet provided in automobiles, a collegue and I in the Atlanta Regional Office of the U.S. Public Health Service carried out and evaluated a program to convince people to purchase seatbelts. (Waller and Conte, 1963) We arranged with a couple of local service stations to install the belts at a reasonable price.

Now, over three decades later, the issue no longer is whether we can convince people even to have restraint systems in their vehicles. The questions now are how we can best get them to use those more comprehensive systems that are standard equipment in all vehicles and, once used, which of several systems provide the greatest degree of injury reduction. The papers by Streff and by Padmanaban and Ray explore the question of which systems work best, and appear to have come to different conclusions. One says that all systems studied had basically the same injury reducing capacity. (Padmanaban and Ray, 1994) The other says that one system was better than another. (Streff, 1994)

BASIC EPIDEMIOLOGICAL QUESTIONS

The background I bring to this discussion is that of an epidemiologist. There are two components to my field. One reminds me of the Socratic method. The answers one gets in doing research depend first on what questions one asks and how they are asked. In examining these two papers I will try to determine what questions were asked by the authors and whether these questions were consistent with the conclusions.

The second component is best described by the story of the blind men examining the elephant. Once the question is posed, it is necessary to choose and apply the proper techniques to answer it. On being asked to describe the elephant, each of the blind men, of course, chose a different nonrandom sample of the whole animal, and all used only sense of touch for their examination. It was hardly surprising, therefore, that they came up with different observations and conclusions. So the second part of my examination is whether the authors of the two papers used similar methods, or differed sufficiently to affect their results.

At the risk of being presumptuous, I would like to start the process by posing the question as I think it should be asked. The ultimate goal of restraint systems is to achieve the greatest reduction of morbidity and mortality over the range of vehicle and crash configurations, given the fact that some systems are completely active, requiring occupants to take the initiative to buckle up on each occasion, some are partially passive, restraining occupants to some extent whether they wish it or not but offering them the option of adding additional restraint, and some are entirely passive. The legal context also is important, since the existance and types of mandatory restraint use laws can affect the application of systems that require active participation by the occupant. The question, therefore, is "which system or systems provide the greatest reduction in morbidity and mortality when examined over comparable wide ranges of vehicle and crash configurations and occupant use patterns?"

APPLICATION

Fredrick Streff has asked, if we offer occupants a state-of-the-art (i.e., three point) lap-shoulder system, but leave them the option to use it or not, will they be any better off than if we force them to use what may be a less effective (i.e., two point) passive shoulder system coupled with the option voluntarily to improve that system by using a manual seatbelt? He concludes that forcing more people to use what may be a less effective system results in significantly fewer serious or fatal injuries than does offering them the best, but with no guarantee that it will be used.

He has controlled for variations in vehicle size, weight, and occupant characteristics by limiting his analysis to a single vehicle make and model, whose characteristics changed little, except for the type of occupant restraint, during the years under study. In addition he has taken into consideration crash characteristics and temporal factors involving mandatory use laws and changes in attitudes and voluntary use patterns in doing his analysis.

What has he left out of his study? He does present data from other researchers indicating the frequency of use of the manual lap belt in combined automated/ manual systems. The pattern of nonuse of the lap belt component ranges widely in those studies, from over 70% in one study to as little as 30% in one of his own.

But we do not know in this sample how often the two point motorized shoulder belt/manual lap belt system is used as a two point system, and how often as a three point one. Thus we know what systems we are theoretically comparing, but we really don't know what systems we are actually comparing in this study, even if we assume that problems in police reporting of injury and use patterns are minimal or, at least, randomly distributed.

In summary, Streff does at least control for vehicle and crash characteristics, although he never really examines a range of vehicle characteristics, as do Padmanahan and Ray. While he defines the two systems he is comparing, he does not do so with complete clarity. Nonetheless, even during years when mandatory use laws were being applied, the field effectiveness of the partially passive system appears to exceed that of the manual system.

This brings us to the contribution by Padmanaban and Ray. I have grouped the several systems they have examined into three categories: no restraint system used, potentially removable restraint system used, and nonremovable restraint system used. Their conclusion is that, after controlling for vehicle, occupant, and crash characteristics, the variations studied within the latter two categories all are comparable, and all are significantly better than no restraint at all.

Or, is that what they have shown? I'm afraid not. The design of their study limits the analysis to occupants who at least in part made use of their restraint systems. We do not know for any of the systems how often they were bypassed completely or partially. The missing information for each system is: a) how often was it used completely, partially, or not at all, and b) putting all of the above use patterns together, and multiplying each use pattern by its respective serious and fatal injury rate, what is the net use frequency/ inherent injury reduction capability figure - or field effectiveness - for comparable vehicle and crash configurations? I suspect that Padmanaban and Ray have access to such information, at least with respect to complete bypassing of restraints, and I hope they will carry out at least that analysis.

Reinfurt reports that in surveys by the University of North Carolina complete nonuse of passive systems ranges from 6% to 10%, but he has no data - nor is he aware of any - concerning method of restraint bypass, such as disconnecting a system that was designed to be disconnected versus doing so to a system for which theoretically this action could not be taken. (personal communication) I am curious to know who is likely to dismantle a system or to use only a partial system.

Enough information already exists to suggest that heavy users of alcohol would be likely candidates for both patterns of misuse. (Preusser, Williams, Lund, 1986; Vegega and Klein, 1991) It is known that alcohol users have worse outcomes in crashes, at least in part because they more often fail to buckle up. (Andersen et al., 1990) We need to know more about their behaviors and crash outcomes when exposed to various restraint systems. Data from a survey by Reinfurt et al indicates that younger drivers are less likely than older drivers to make complete use of passive shoulder belt/ manual lap belt systems. (Reinfurt et al., 1991)

CONCLUSIONS

Where does all this leave us with respect to the underlying question that I started with about the value of various restraint systems as used in the real world, especially one in which many nations and virtually all states in the U.S. have mandatory use laws? In my opinion, Streff comes reasonably close to answering the question, although for only two of several possible systems. I do suspect that the differences between individual semipassive and passive systems will turn out to be rather minor, as the Padmanaban and Ray paper suggests. But we really won't know until the question is asked in the proper way, and the appropriate methods are used to put it to the test.

The questions in both papers and in my discussion are important in order to improve upon what already is a successful countermeasure against unnecessary death and injury. But, in the broader historical context, all these are simply details compared with my initial experiences with occupant restraints over three decades ago.

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