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THE UNIVERSITY OF NORTH CAROLINA HIGHWAY SAFETY RESEARCH CENTER

ANALYSIS OF OCCUPANT RESTRAINT ISSUES FROM STATE ACCIDENT DATA

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16. Abstract

Using police-reported crash data from a variety of states, this three-year project (1987-1990) dealt with a series of occupant restraint questions defined by NHTSA, plus other topical issues that emerged, such as the use of automatic restraints in the population. Data for the analysis were derived from a multi-year 18-state data base that resides at NHTSA, plus data from the State of North Carolina. A confounding factor in the analysis was the worse than expected quality of the reported belt use data in accidents contained in the individual state data bases, a problem sometimes referred to as the "lie factor" in police-reported belt use. Because of motorists falsely claiming belt use with the passage of mandatory belt use laws, some of the originally planned analyses were substituted for analyses where belt use status was not required.

Topics covered in this report include injuries to restrained and unrestrained occupants, the effect of a state seat belt law on use, the effect of a mandatory belt law on injury and fatality reduction using time series analysis of Ohio and Louisiana injury data, ejection trends in Maryland before and after the mandatory belt law, results of an on-road survey of automatic seat belt use and misuse in North Carolina, and an investigation of the double pair method of Evans (1986) for examining seat belt effectiveness.

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TECHNICAL SUMMARY

Background and Objectives

In the United States over the last two and a half decades, much has been accomplished in terms of occupant injury reduction due to changes in the vehicle, improvements in roadway crashworthiness, and to some extent, modification of the driver's behavior. It is somewhat paradoxical that this decrease in injuries has occurred without the widespread national use of occupant restraints, even though restraints have existed in a great majority of our vehicles for nearly two decades. Thus, the potential for additional safety enhancements seems highly promising if an increase in occupant restraint use is realized.

This report is the product of a three-year project (May 1, 1987 - September 30, 1990) that has focused on questions pertaining to occupant restraints. Using police-reported crash data from a variety of states, the project was primarily concerned with answering a series of occupant restraint questions, plus other topical issues that emerged in regard to restraints. Below are the five questions that were listed in the original solicitation that were candidates for analysis:

1. How effective are restraints?
2. How are restrained people injured?
3. How can restraints be improved?
4. Who is using restraints?
5. How does a State law affect use of restraints?

Method

Data for the analysis were derived from a multi-year 18-state data base that resides sat NHTSA. North Carolina is not included in the NHTSA data base; nevertheless, these data were available for use in this project.

A confounding factor in the analysis was the worse than expected quality of the reported belt use data in accidents contained in the individual state data bases, a problem sometimes referred to as the "lie factor" in police-reported belt use. Because of motorists falsely claiming belt use with the passage of mandatory belt use laws, some of the originally planned analyses were substituted for analyses where new and reliable data were collected.

Results

Injuries to Restrained and Unrestrained Occupants. To examine injuries to restrained and unrestrained occupants, data from 1984-1986 for New Jersey, whose belt law and enforcement became effective March 1985, were contrasted to similar data for Pennsylvania, a proximate state without a belt law in 1984-1986. In general, covered occupants in New Jersey tended to experience less A+K injuries, bleeding injuries, concussions, fractures/broken bones, head, and face injuries. The New Jersey covered occupants experienced more neck, chest/abdomen and complaint of pain injuries. These findings generally held across a variety of accident types.

Indiana injury data from 1985-1988 were similarly examined (belt law effective July 1987). Like New Jersey, head and face injuries tended to decline over time, and neck and chest/abdomen/pelvis injuries tended to increase. This tendency was present for the different crash types examined. However, most of these changes appeared to be long term and not directly associated with the seat belt law.

To further address the question of how restrained people are injured, pre-law 1984 accident data for New Jersey and Pennsylvania were used in order to minimize the bias in police-reported use rates found after the introduction of a belt law. Not surprisingly, when seat belts were used the odds of sustaining a major injury or being killed were about half as much as when belts were not used. The percentage of head and face injuries was clearly smaller when belts were used, while a slightly larger percentage of belted occupants sustained chest/abdomen injuries than unbelted occupants.

Effects of State Law on Belt Use. Assessing the effect of belt use changes in accident data is not as straightforward now that the "lie factor" is an issue. Unfortunately, the police officer often relies on the response given by the accident victim, rather than looking for additional evidence of belt use.

This analysis was primarily concerned with comparing accident versus population-at-risk belt usage from North Carolina data. Results show that effects of the "lie factor" are prevalent throughout the crash data, including: (1) crashes investigated by the Highway Patrol (as well as all other crashes), (2) crashes distributed by race and sex groups, and (3) fatal crashes. Thus, analyses involving changes in mortality and morbidity arising from seat belt laws need to be designed so that reported belt use in the crash is ignored (e.g., using time series to examine long term injury patterns).

Time Series Analysis of Ohio and Louisiana Injury Data. Accident victims were classified as either "covered occupants" or "not covered others" and structural time series models of the form used by Harry and Durbin (1986) in their evaluation of seat belt legislation in Great Britain were used to analyze these data series covering 1982-1987.

In Ohio the belt use rate rose from about 15 percent pre-law to about 47 percent just after enforcement. However, there was no evidence of a reduction in motor vehicle related injuries at any severity level as a result of the seat belt law. In Louisiana the belt use rate rose from about 12 percent pre-law to about 36 percent post-law. Statistically significant decreases were shown for both the percent killed and percent killed or seriously injured series for "covered occupants." No significant intervention effects were found for the "not covered" series, nor for two series focusing on ejection.

Effectiveness of a Belt Law in Reducing Ejection. Due to overreporting of belt use in accidents, the alternative indirect approach of examining ejection trends was used with Maryland data as a measure of effectiveness of the belt law, since the ejection rate should decrease as reported and observed belt use increases.

Besides examining ejection rates in injury related crashes, other variables receiving close scrutiny included overturns, fixed-object crashes, and vehicle wheelbase. As population belt use increased in Maryland during the study period, ejection rates for both drivers and right front passengers decreased, and the largest decreases were obtained after passage of the belt law. The driver ejection rate in overturn crashes was similar. Regardless of wheelbase greater than or equal to 102 inches, the ejection rates decreased during the study period. Ejections in fixed-object crashes showed no clear trend.

Usage Patterns and Misuse Rates of Automatic Seat Belts by System Type. Since relatively little is known about the use and misuse of automatic seat belts, observational data were gathered as part of North Carolina's on-going statewide seat belt survey. Over 4,000 observations were obtained during three sampling periods. License plate and vehicle description data were used to obtain the vehicle identification number (VIN), from which belt system type was obtained.

Shoulder belt usage rates for all systems (automatic belts 79.6 percent, air bags 73.9 percent, manual belts 76.3 percent) considerably exceeded the statewide average of approximately 60 percent largely because these vehicles are nearly all new model cars. Within the automatic belt group, usage was highest (94.2 percent) for the motorized automatic shoulder/manual lap belt system, intermediate (83.8%) for the non-motorized system with automatic shoulder belts, and lowest (76.9%) for the non-motorized automatic shoulder/automatic lap belt system. The results seen in North Carolina are quite consistent with the 19-city U.S. DOT survey rates of 97.2 percent, 81.3 percent, and 76.9 percent, respectively.

In regard to misuse, only 30 percent of the drivers having a motorized shoulder belt were also using the available manual lap belt. The three-point non-motorized automatic belt systems were defeated nearly 25 percent of the time. Further, drivers under age 25 had lower use rates than other age groups except for the case of manual belts. Males and females used automatic belts with about the same frequency. Correct use rates for non-white drivers were lower than for their white counterparts.

Double Pair Versus Traditional Belt Effectiveness Estimates. The double pair comparison procedure was utilized by Evans (1986) to determine how occupant characteristics affect fatality risks in traffic crashes. This method, which originally used data from the Fatal Accident Reporting System (FARS), compares pairs of occupants in the same vehicle. By utilizing the fatality risk of an "other" occupant in the same vehicle, the procedure controls for many vehicle and roadway factors.

The analysis in this report, which uses the reliable seat belt data from NCSS, estimates seat belt effectiveness for the driver and right front passenger in reducing moderate, serious, and severe injuries (AIS $\geq$ 2, AIS $\geq$ 3, and AIS $\geq$ 4, respectively). The procedure yields estimates of 36 to 66 percent effectiveness over these categories.

The findings by this technique are compared to traditional estimates controlling for crash severity (Partyka, 1988). The results of the double pair analysis are generally higher than the traditional approximations with regard to seat belt effectiveness. Further, adjusting for damage type typically produces the lowest estimates of belt effectiveness.

CHAPTER 1. INTRODUCTION

Overview

This report is the product of a three-year project that has focused on questions pertaining to occupant restraints. The project officially began on May 1, 1987, and ended on September 30, 1990. Interim reports describing the first and second years of effort are contained under separate cover (Hunter, Reinfurt and Hirsch, 1988, and Hunter, Reinfurt, Stewart and St. Cyr, 1989).

The project was primarily concerned with answering a series of occupant restraint questions, using police-reported crash data from a variety of states, plus other topical issues that emerged in regard to restraints, such as the use of automatic seat belts in the population. Shown below are the five questions that were listed in the original solicitation that were candidates for analysis:

1. How effective are restraints?
2. How are restrained people injured?
3. How can restraints be improved?
4. Who is using restraints?
5. How does a State law affect use of restraints?

Data for the analysis were derived from a multi-year 18-state data base that resides at NHTSA. The process of acquiring the data was begun some years ago by other NHTSA staff, although up to now only limited use has been made of the data. North Carolina is not included in the NHTSA data base; nevertheless, these data were available for use in this project.

Background

In the last two and a half decades, the motor vehicle death rate in the U.S. has been cut in half -- from 5.63 deaths per hundred million vehicle miles in 1964 to 2.46 in 1988 (Accident Facts, 1989 Edition). Our death rate is the lowest in the world, and we have achieved this superior safety record without addressing the occupant restraint issue to a significant degree until the mid 80's.

Much has been accomplished in terms of occupant injury reduction due to changes in the vehicle, improvements in roadway crashworthiness, and to some extent, modification of the driver's behavior. It is somewhat paradoxical that this decrease in injuries has occurred without the widespread national use of occupant restraints, even though restraints have existed in a great majority of our vehicles for nearly two decades. Thus, the potential for additional safety enhancements seems highly promising if an increase in occupant restraint use is realized.

There are several factors now in place that may aid the process of having more motor vehicle drivers and passengers using their available restraints. First, Federal Motor Vehicle Safety Standard (FMVSS) 208 had a major revision in 1984 that spelled out a schedule of increases in the availability of automatic restraints and/or air bags in newly manufactured passenger cars. The schedule called for passive restraints (i.e., automatic belts or bags) to be available in 10 percent of the model year 1987 cars, in 25 percent of the cars in model year 1988, in 40 percent of the cars in model year 1989, and in all of the 1990 model year cars, unless two-thirds of the U.S. population was covered by mandatory belt laws meeting certain criteria established by the U.S. DOT. Second, mandatory laws were passed in a number of states, with well over two-thirds of the U.S. population being covered, but the above mentioned schedule imposed by FMVSS 208 was not rescinded as many of the laws did not meet the DOT criteria. And thirdly, the automotive manufacturers started developing new automatic belt designs that would be expected to lead to increased restraint use.

Given the present situation, there continue to be identifiable restraint-related research needs, including:

1. How the increased number of mandatory belt laws affect restraint use,

2. The need for information on population subgroups continuing to ride unrestrained, and

3. The need for more information concerning the injury-related effectiveness of the various restraint designs now being marketed.

The current version of FMVSS 208 plus the enactment to date of 38 safety belt laws is an historically important set of interventions on behalf of highway safety, notwithstanding the fact that belt laws have been rescinded in Massachusetts, Nebraska, and Oregon. The monitoring of this process is therefore of utmost importance. It is essential for NHTSA and the national research community to be able to quantify the degree of success of safety belt laws as well as safety belt designs, not only to optimize the effects of the laws, but also to optimize planning for (1) future occupant restraint systems, (2) further improvements in vehicle interior design, and (3) considerations of crashworthiness designed in highway appurtenances and other life saving treatments.

Data Acquisition and Management

During the course of the project, the following states' crash data tapes (in SAS format) were received from NHTSA by the Highway Safety Research Center (HSRC):

State	Years Available
Indiana	1984-1988
Kansas	1984-1986
Louisiana	1982-1987
Maryland	1984-1986
Michigan	1982-1985
New Jersey	1984-1986
Ohio	1982-1987
Pennsylvania	1984-1986
Texas	1984-1986
Washington	1982-1986

After tape copies were made, 20 to 30 individual records from each tape were printed to verify that the tapes contained usable data. Relevant fields were examined to ensure that data values were what would be expected based on the state code books. Frequency counts on many relevant fields were also made.

In general, each state's data are different enough that standardization across states is not usually possible, making it necessary to carry out analyses within states. Very similar variables across states, such as dates, position in vehicle, or injury type, could be standardized across states to an extent by naming and formatting conventions. However, most other attempts to force data sets from different states into rigid formats would not have been useful -- a lesson learned in a previous NHTSA project entitled, "Trend Analysis: State and National Accident Summary Files" (Reinfurt, Rodgman and Stutts, 1982).

Project Limitations

Analysis questions were formulated by HSRC and NHTSA staff on a year-to-year basis. During the first year of the project, emphasis was directed toward the following two questions:

- How are restrained people injured?
- How does a State law affect use of restraints?

After examining these issues, it was apparent that some of the original proposed project activity could not be explored with much chance of success. The confounding factor was the worse-than-expected quality of the reported belt use data in accidents contained in the individual state data bases, a problem sometimes referred to as the "lie factor" in police-reported belt use. Even before the project began, it was clear from North Carolina data that the officer-reported belt use status was much less reliable than it was prior to the law. More than ever, motorists falsely claimed belt usage because "it is the Law."

As an example, North Carolina is generally considered to have good traffic records data. Even with good reporting agencies, the North Carolina data in Table 1.1 show huge differences between population belt use data and the reported belt use for drivers in crashes after the initiation of a belt law. And contrary to numerous previous studies, belt use in crashes was higher than in the driving population throughout the citation phase.

At the project outset, it was believed that adjustments to the post-law crash data might be made based on pre-law outcomes. However, adjusting for the "lie factor" in police-reported belt use did not prove to be feasible. Thus, instead of closely following the original set of questions, HSRC and NHTSA staff had to find alternative ways of seeking answers to restraint questions when reliable belt data by age, sex, seating position, and other variables was not available.

Report Composition

What follows are chapters pertaining to the variety of restraint questions that were pursued. Topics covered include injuries to restrained and unrestrained occupants (Chapter 2), the effect of a state seat belt law on belt use (Chapter 3), the effect of a belt law on injury and fatality reduction using time series analyses of Ohio and Louisiana injury data (Chapter 4), ejection trends in Maryland before and after the mandatory belt law intended to

Table 1.1. Percent driver belt use reported in crashes and in the population-at-risk in North Carolina.

Belt Law Period	Time Period		Driver Belt Use % In Crashes	Driver Belt Use % In the Population-at-risk
Pre-law	September	1985	31	26
	Oct. - Nov.	1985	68	47
Warning Ticket Phase	January	1986		44
	June	1986		45
	October	1986		45
	December	1986*	62	
$25 Citation Phase	January	1987		78
	June	1987		67
	October	1987		65
	December	1987*	89	
	January	1988		62
	June	1988		65
	December	1988*	88	
	January	1989		60
	June	1989		61
	December	1989*	89	
	January	1990		58

*The data reported for December in 1986-1989 actually cover all reportable crashes in the State for the particular year.

reflect changes in belt use in the post-law period (Chapter 5), results of a survey of automatic seat belt use and misuse in North Carolina (Chapter 6), and an investigation of the double pair method of Evans (1986) for examining seat belt effectiveness (Chapter 7).

CHAPTER 2. HOW ARE RESTRAINED PEOPLE INJURED?

New Jersey - Pennsylvania Comparisons

To answer a question like this, data beyond the normal police-reported KABCO (K=killed, A=major injury, B=moderate injury, C=complaint of pain, O=no injury) coding scheme used by most states are needed. Two states in the system having supplemental injury data are New Jersey and Pennsylvania. Both of these states routinely collect type and location of the most severe injury sustained in a motor vehicle accident. Common codes for injury type include amputation, bleeding, concussion, broken bones, burns, contusions/bruises/abrasions, etc. Location codes include body areas such as head, face, neck, chest, arms, legs, entire body, etc.

Besides having comparable injury codes, another advantage to using these two states is that for the period of analysis, New Jersey had enacted a seat belt use law (SBUL) whereas Pennsylvania had not. New Jersey's SBUL became effective March 1, 1985, while Pennsylvania's SBUL did not become effective until November 23, 1987. The years of data included in the present analysis were 1984-1986 for both New Jersey and Pennsylvania.

Seat belt use in the driving population within each state for the period under consideration is certainly an important variable, but only limited population belt use data are available. One source of belt use data is a report by Campbell, Stewart, and Campbell (1988) that examines the belt law experience in the United States for 1985-1987. Direct observation survey data reported for New Jersey ("overall percent use") are the following:

Date	Belt Use Rate	Comments
February 1985	18%	Pre-law
July 1985	42%	Law and enforcement became effective March 1985
July 1986	35%	
January 1987	35%	
August 1987	41%	

Thus, after the law and enforcement became effective in March of 1985, the belt use rate more than doubled.

Pennsylvania had no statewide observation scheme in place for the period covered by this analysis; a sampling scheme is now being implemented to help in evaluating their belt law. Belt use in accidents was about nine percent in 1984 and 32-33 percent in 1986.

New Jersey and Pennsylvania are proximate and comparable in other respects as well. They are both heavily populated states -- Pennsylvania with a population of 11.8 million, the fourth most populous state, and New Jersey at 7.6 million, the ninth most populous. On a square mile basis, New Jersey is the most densely populated of all states, but Pennsylvania has the eighth highest population residing in metro areas. A few additional comparisons: Pennsylvania has 7.9 million licensed drivers compared to New Jersey's 5.8, and 7.2 million registered vehicles (cars, trucks, and buses) to 4.9 in New Jersey. In both states motor vehicle related deaths per 100,000 population are relatively low -- 15.0 for Pennsylvania (41st highest in the nation) and 13.1 for New Jersey (46th highest) (all data from Statistical Abstracts of the United States, 1987, U.S. Department of Commerce).

In addition to these similarities, there are clear differences between the two states. Most obvious is Pennsylvania's greater land mass and more extensive rural land use. Whereas 93 percent of Pennsylvania's land use is classified as rural, only 75 percent of New Jersey's is so classified. Pennsylvania also has a much more extensive system of rural (non-Federal aid) roadways -- 87,000 miles versus only 11,500 miles for New Jersey.

Some of the analytical focus of Question 2 concerns changes in injury patterns as related to belt use. In this regard, much of what follows disregards the belt use in the crash as reported by the investigating officer primarily because there is a known and sizable bias in this variable with the passage of SBUL's. As we analyzed the data, we examined various distributions containing an indication of belt status, but mainly to be sure that the trends were in the right direction -- that is, that restrained occupants showed a less severe injury pattern -- as was indeed the case.

The analyses also pay particular attention to occupants in vehicles covered by the SBUL as well as to those not covered by the SBUL who serve as comparison groups. Since the New Jersey law pertains to front seat occupants of passenger vehicles, these were designated as "covered," with rear seat occupants as well as occupants of non-covered vehicles (vehicles other than passenger cars, station wagons, and vans) being designated as "not covered." Similar comparisons were performed with Pennsylvania front-seat occupants (the Pennsylvania data used being pre-law).

To try to ensure more uniformity in regard to type of restraint used, children under five years of age were deleted from the analyses. This should eliminate the vast majority of occupants in child restraint devices.

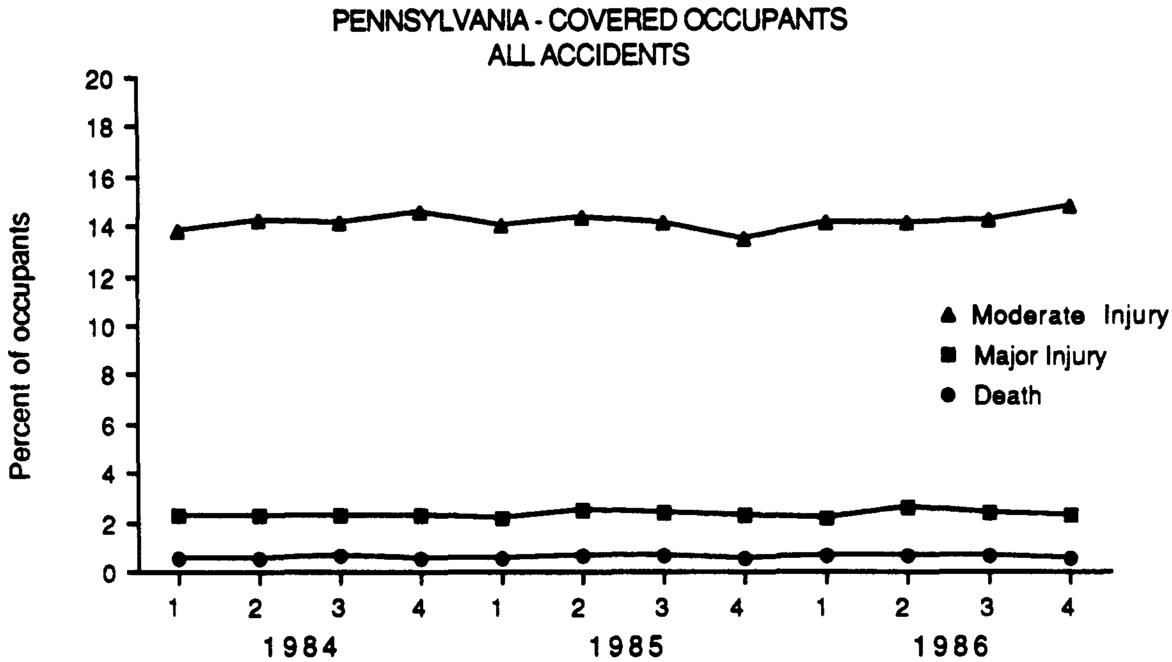
One final strategy was to attempt to delete older vehicles (say, 1973 and earlier) from consideration, so that lap and shoulder restraint systems would generally be the three-point type. However, it was determined that while New Jersey routinely collects model year information for each accident-involved vehicle, this information is not processed for analysis. Thus, the data could not be subsetted in this manner. For uniformity, the model year filter was not applied to the Pennsylvania data.

Trends Across Time

What follows are comparisons of the New Jersey and Pennsylvania data, concentrating on covered occupant injury patterns for various types of crashes. We first examine injury patterns in all crashes and then follow with examinations of injury patterns for specific crash types (e.g., rollovers, head-on crashes, etc.). It should be noted that different reporting thresholds are in effect for the two states. Both states require crashes to be reported in case of injury. In regard to property damage, New Jersey has a minimum of $500 to any one party, while Pennsylvania requires property damage of an amount sufficient to prevent the vehicle from being driven away. Thus, one would expect the Pennsylvania criteria to result in a higher average crash severity.

KABCO - Like Results. Figure 2.1 shows KABCO-like results for the covered occupants in the two states for all crashes. New Jersey injury codes are standard -- killed, incapacitated, moderate injury, complaint of pain, and uninjured. The Pennsylvania injury codes substitute the category "minor injury" for "complaint of pain," so that the scale is killed, major injury, moderate injury, minor injury, and no injury. Examining the injury data for the two states, it would appear that the definitions of fatal, major, and moderate injuries are reasonably consistent. Plotting the percentages of fatal injuries, major injuries, and moderate injuries by quarters across several years shows (as expected) little, if any, change in the Pennsylvania data

a)



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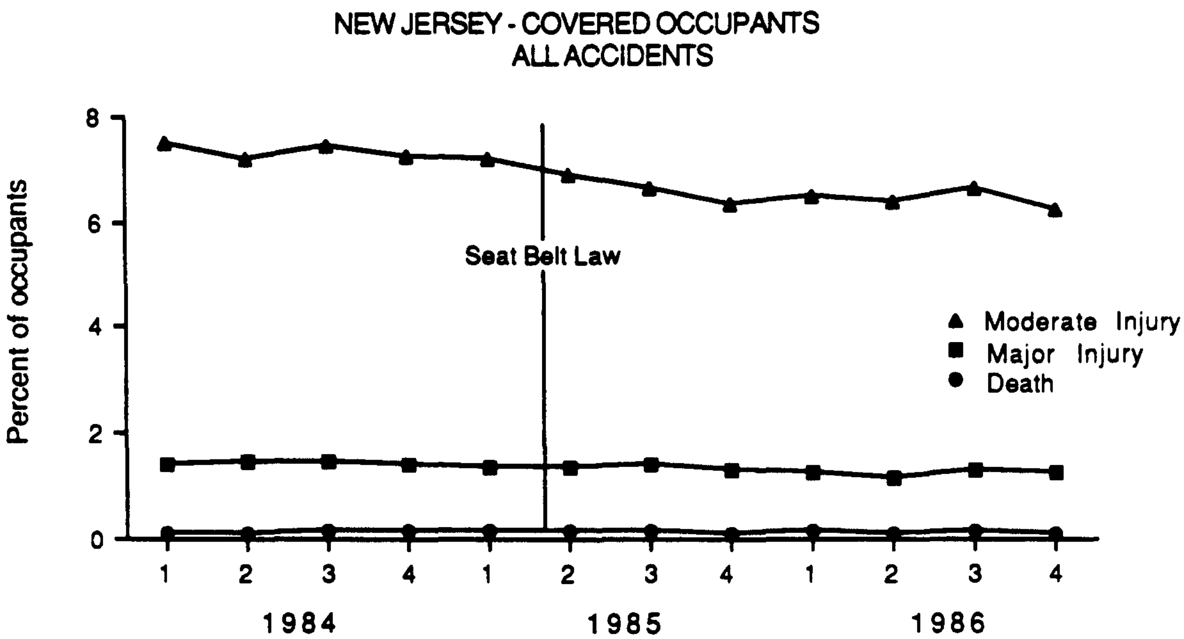


Figure 2.1. Pe[illegible]nt of occupants in all accidents with moderate, major or fatal inju[illegible]s across time periods (PA and NJ data).

(Figure 2.1a). The moderate injuries show a slight downward trend in New Jersey after the SBUL became effective during the first quarter of 1985, although this trend actually started prior to the law's onset and leveled off during 1986. The percentages of fatal and major injuries in New Jersey appear unchanged across all time periods (Figure 2.1b).

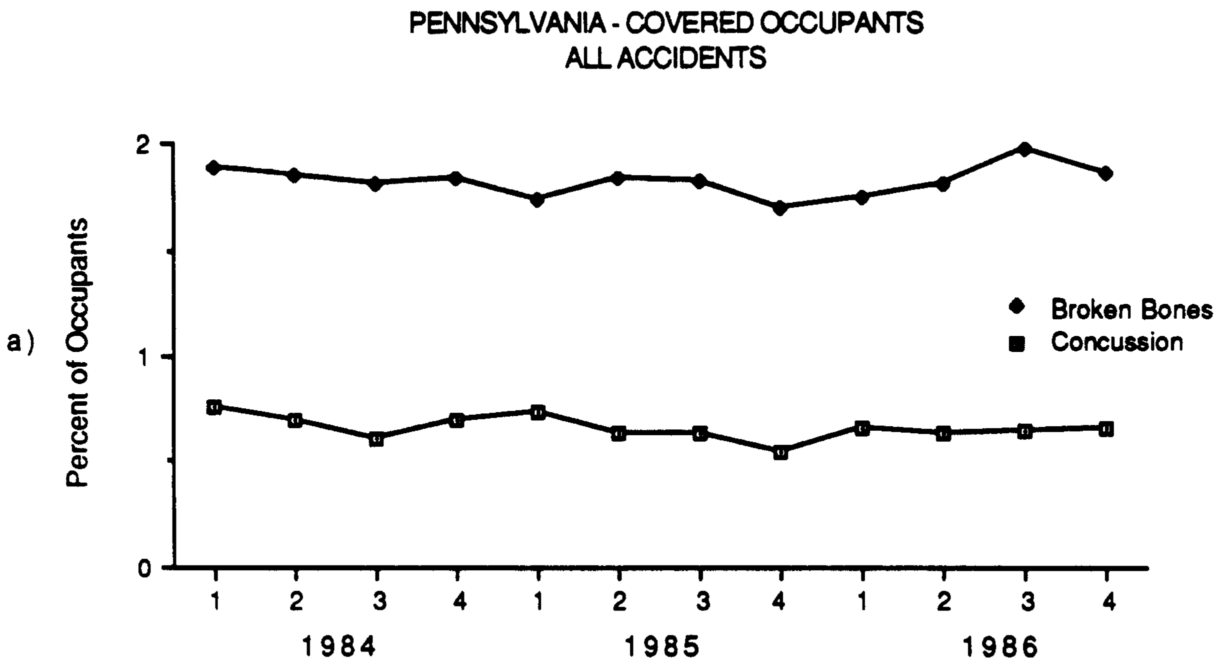
The differences in the magnitudes of the percentage values for the two states (with Pennsylvania being consistently higher) most likely relates to the accident reporting threshold. For further detail, see the Appendix A tables which contain both frequencies and percentages from which the figures in the text were derived.

Injury Type. Figure 2.2 concerns certain common injury types for covered occupants for all crashes. The injury types reported here (and at other places in the text) are ones in which there were sufficient cell sizes to make comparisons, as well as representing injury types where a belt law might be expected to show some effect. Although the percentages of concussions and broken bones are relatively small in Pennsylvania (1-2 percent), the trends across time are basically flat. In New Jersey, both fractures/dislocations and concussions are generally less frequent after the SBUL (although again small in magnitude). The percentage of internal injuries (not available for Pennsylvania) appears, if anything, somewhat higher after passage of the SBUL.

Figure 2.3 shows bleeding injuries and complaint of pain injuries for the covered occupants in all accidents. While the percentages of bleeding occupants are relatively unchanged in both states, the complaint of pain percentages have gradually risen in both states, although in NJ this trend appears to have leveled off.

Body part injuries in all accidents are portrayed in Figure 2.4. For Pennsylvania, all plots are relatively flat. In New Jersey, the percentage of head injuries to covered occupants appears to have decreased since the SBUL, while the percentage of neck injuries appears to have increased. Injuries to the face also appear to have decreased slightly.

Injury Percentage Reductions. The plots across time in Figures 2.1-2.4 generally did not provide a clear indication of injury changes. To examine the changes in further detail, specific comparisons were made for both states across comparable time periods, namely April - December 1984 (pre-law for New Jersey) versus April - December 1985 (post-law for New Jersey). To attempt to



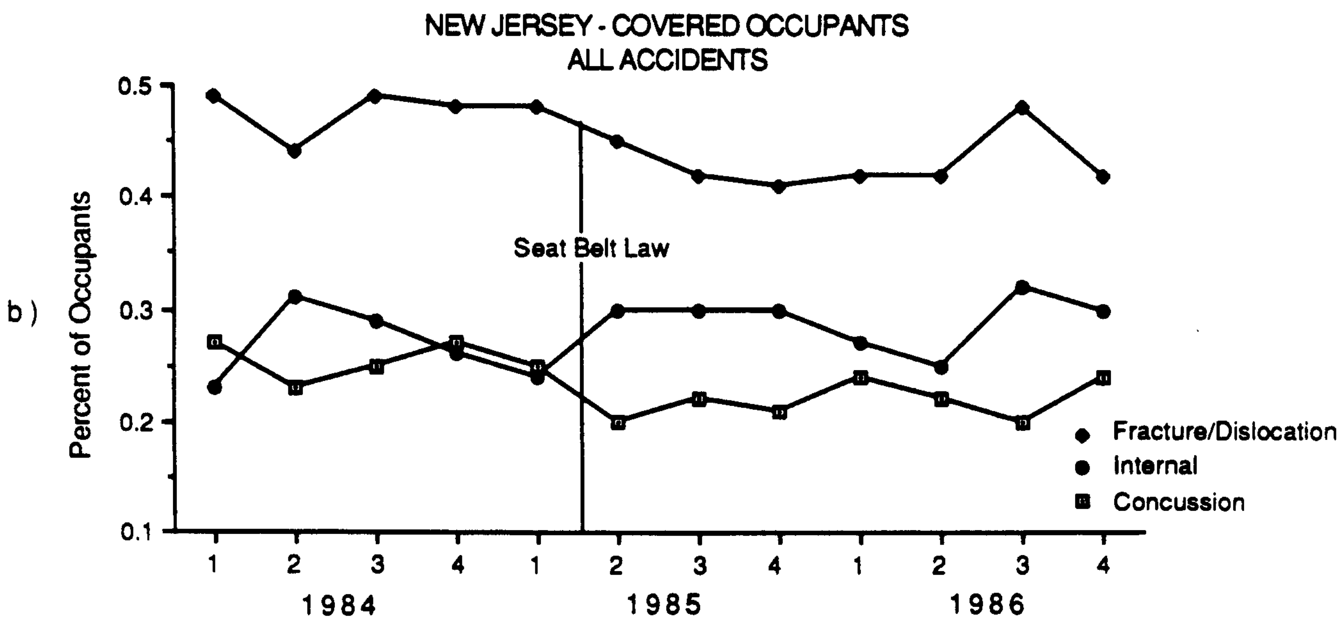
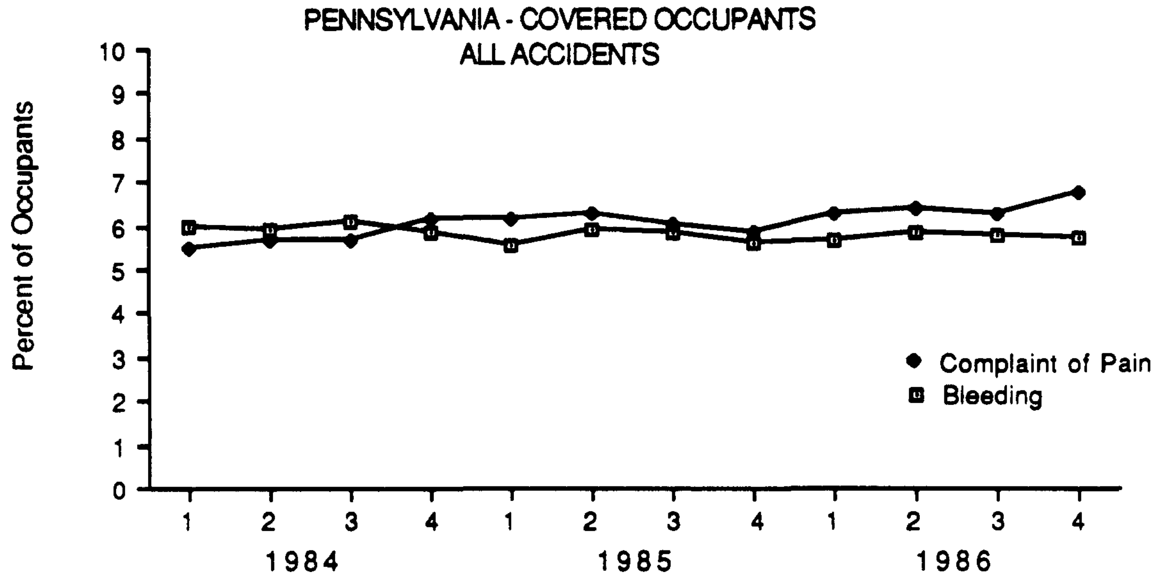


Figure 2.2. Percent of occupants in all accidents with certain injury types across time periods (PA and NJ data).

a)



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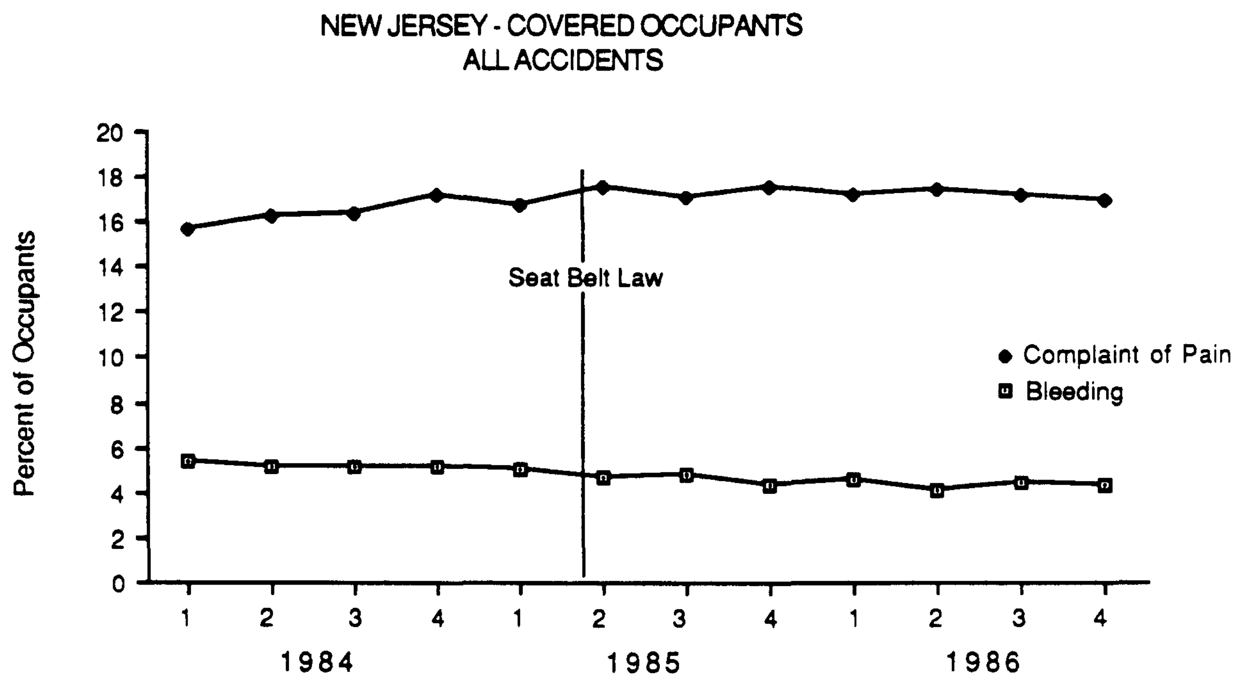
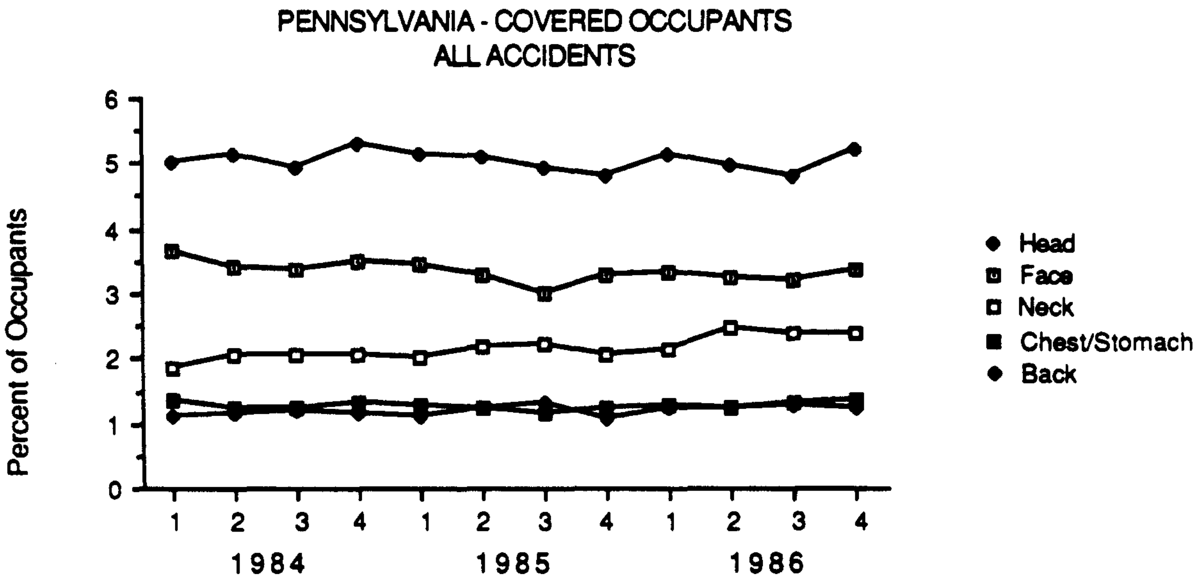


Figure 2.3. Percent of occupants in all accidents with bleeding or complaint of pain injuries across time periods (PA and NJ data).

a)



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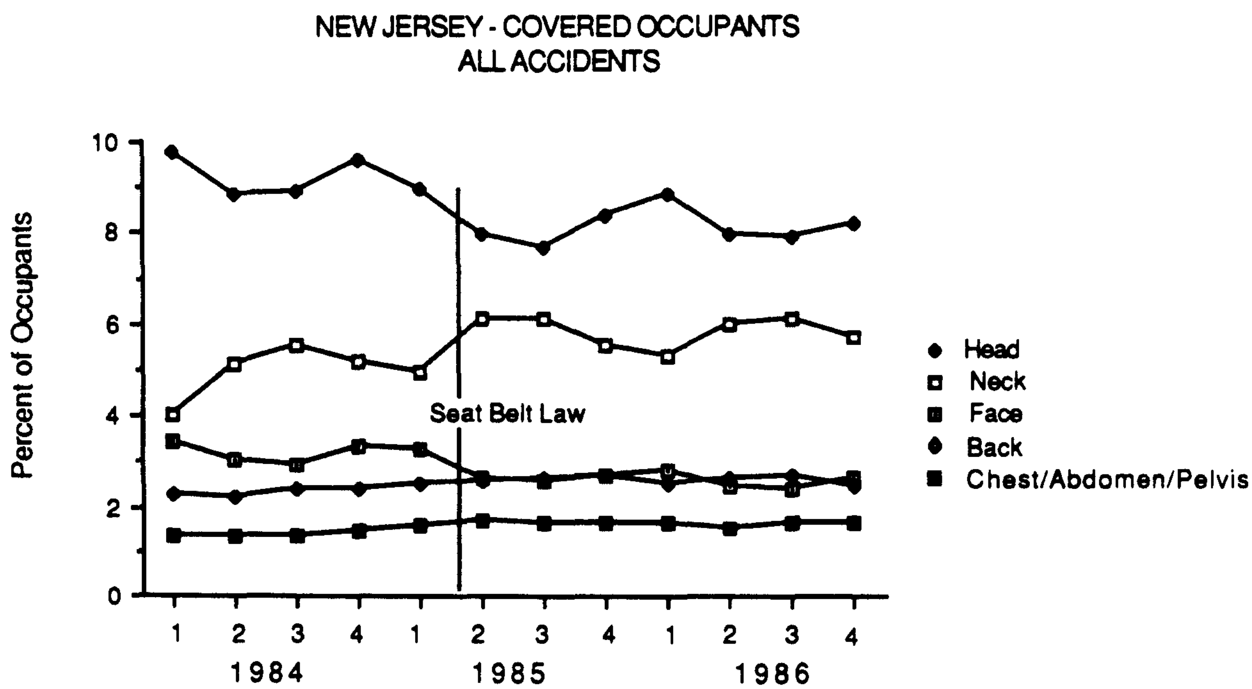


Figure 2.4. Percent of occupants in vehicle accidents with certain injury locations across time periods (PA and NJ data).

quantify the respective changes, one can compare the respective percentage reductions, namely, for New Jersey

$$\frac{(\%\ A+K\ pre) - (\%\ A+K\ post)}{\%\ A+K\ pre} \times 100$$

$$= \frac{1.58 - 1.48}{1.58} \times 100$$

$$= 6.3\%$$

and similarly for Pennsylvania, a 2.3 percent reduction where no belt law was in effect (see Table 2.1).

To examine shifts in nature of injury (Figures 2.2 and 2.3 along with Tables A.2 and A.3) as well as body region of injury (Figure 2.4 and Tables A.4 and A.5), one can again look at percentage reductions across time periods between the two states. Table 2.1 presents the results for those injury types and/or body regions with reasonable sample sizes.

Table 2.1. Percentage reduction for injury level, nature of injury, and body region when comparing April - December 1984 versus April - December 1985 for New Jersey and Pennsylvania.

	Percentage Reduction	
Criterion	NJ (Belt Law 3/85)	PA (No Belt Law)
Injury Level:		
A+K	6.3	2.3
Any Injury	1.1	1.2
Nature of Injury:		
Bleeding	9.7	1.7
Concussion	16.7	9.1
Fracture/Broken Bones	8.3	1.9
Complaint of Pain	-5.8	-4.7
Body Region:		
Head	11.0	2.8
Face	6.2	5.6
Neck	-13.2	-5.3
Chest/Abdomen	-22.9	1.6
Arms	-3.7	5.2
Legs	1.5	-1.3

As one might hypothesize, the percentage reduction in bleeding, concussion and/or fracture/broken bones is in the right direction and greater in the belt law state of New Jersey. It is also reasonable that the complaint of pain "reduction" is actually an increase (note the use of the negative sign), since belt effectiveness would likely result in some minor and moderate injuries shifting into the complaint of pain category.

With respect to body region, the New Jersey percentage reductions are greatest for the head and face and, in the opposite direction (i.e., increases), for neck and chest/abdomen. There is a mixed message for the extremities. Other than for the extremities, these overall results (New Jersey and Pennsylvania) are reasonably consistent with the literature with respect to relative changes in location of injury resulting from increasing belt usage.

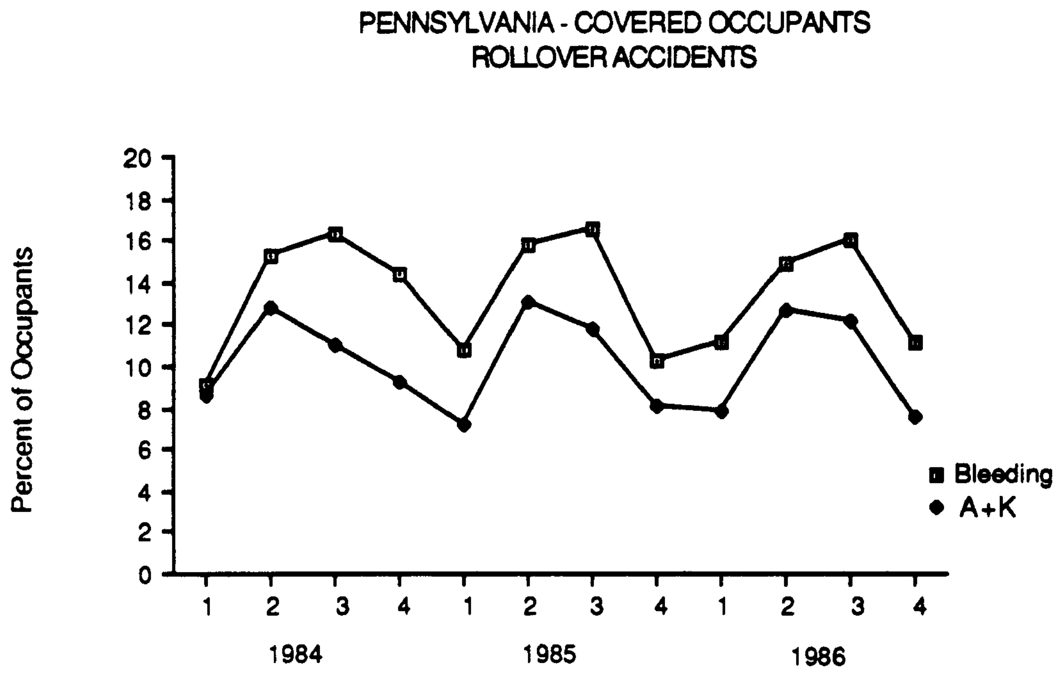
A Comparison of Rollover and Non-Rollover Accidents. Figures 2.5-2.11 pertain to comparisons of covered occupants in rollover and non-rollover crashes. Figure 2.5 shows the percentages of A+K (serious and fatal) as well as bleeding injuries in rollover crashes. The Pennsylvania data are remarkably similar, although more variable, and likewise seem to follow a seasonal trend across the three years. The A+K plot for New Jersey shows a downward trend following the enactment of the seat belt law, but increasing slightly during 1986. The percentage of bleeding accidents shows no clear trends over time. As would be expected from the reporting criteria, the percentages of these more serious A+K accidents are somewhat greater in Pennsylvania.

Figure 2.6 is a companion plot for Figure 2.5 and concerns the percentages of A+K and bleeding injuries in non-rollover crashes. While the Pennsylvania plots are again reasonably flat, the percentage of bleeding injuries in non-rollover crashes appears to be declining after the SBUL in New Jersey.

Figure 2.7 portrays the percentage of uninjured covered occupants for both rollover and non-rollover crashes in the two states. In Pennsylvania, the percentage of uninjured occupants in non-rollover crashes remains "constant" at around 82 percent, as compared to a "constant" value of about 73 percent for New Jersey. For the rollover crashes, the percentage of uninjured occupants in Pennsylvania fluctuates between roughly 55 and 70 percent. In New Jersey, the fluctuation is between 40 and 55 percent, with no clear trend.

The final rollover/non-rollover plots pertain to the body part injured (Figures 2.8-2.11). Figures 2.8 and 2.9 show the rollover crash injuries. Except for mild fluctuations within the head injury plot, the Pennsylvania data

a)



b)

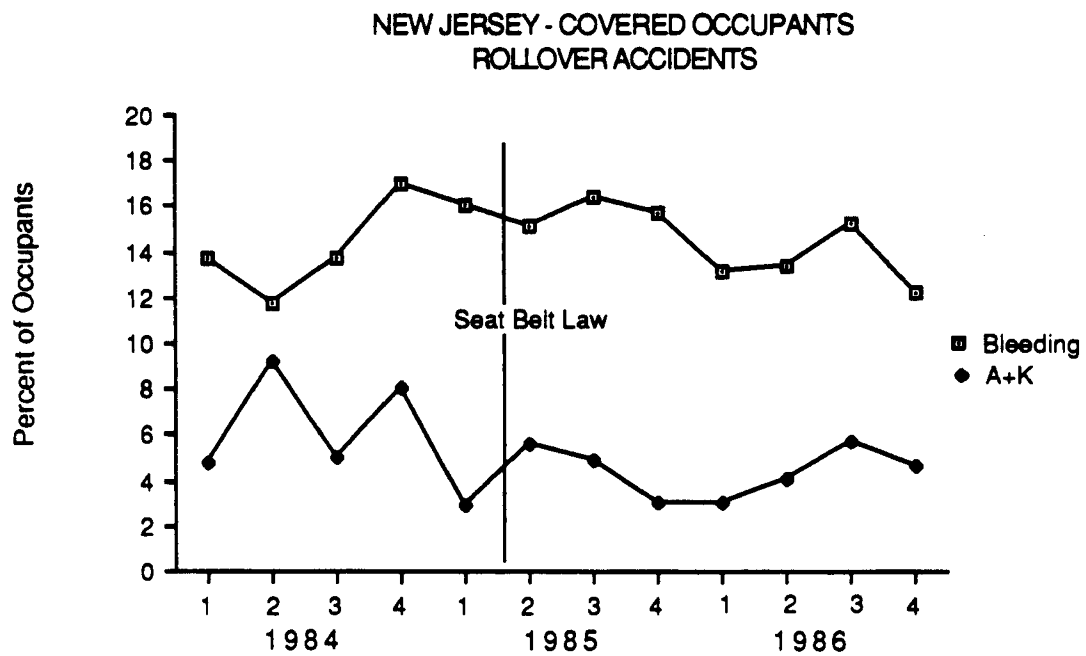
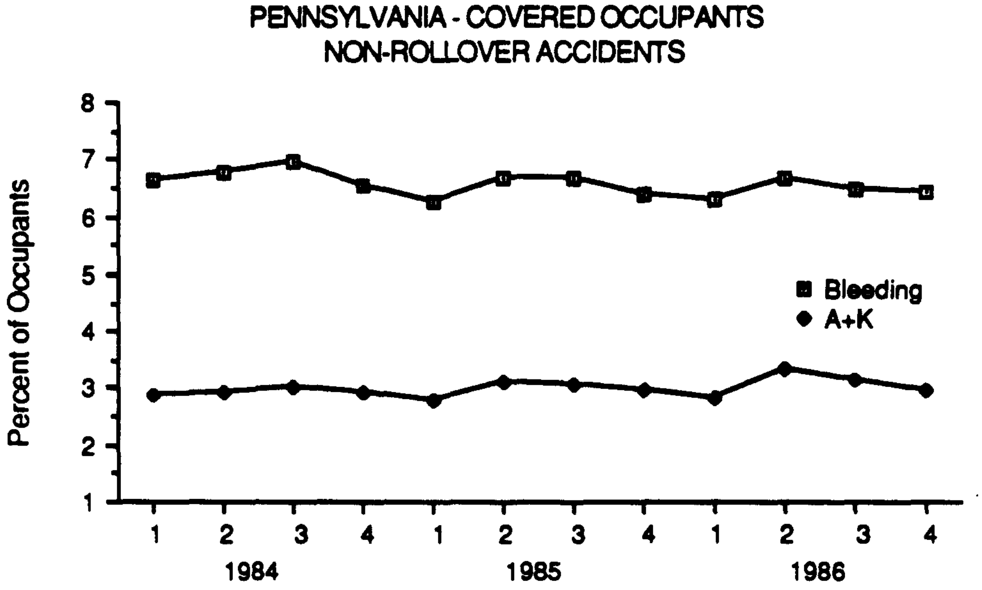


Figure 2.5. Percent of occupants in rollover accidents with bleeding or serious (A+K) injuries across time (PA and NJ data).

a)



b)

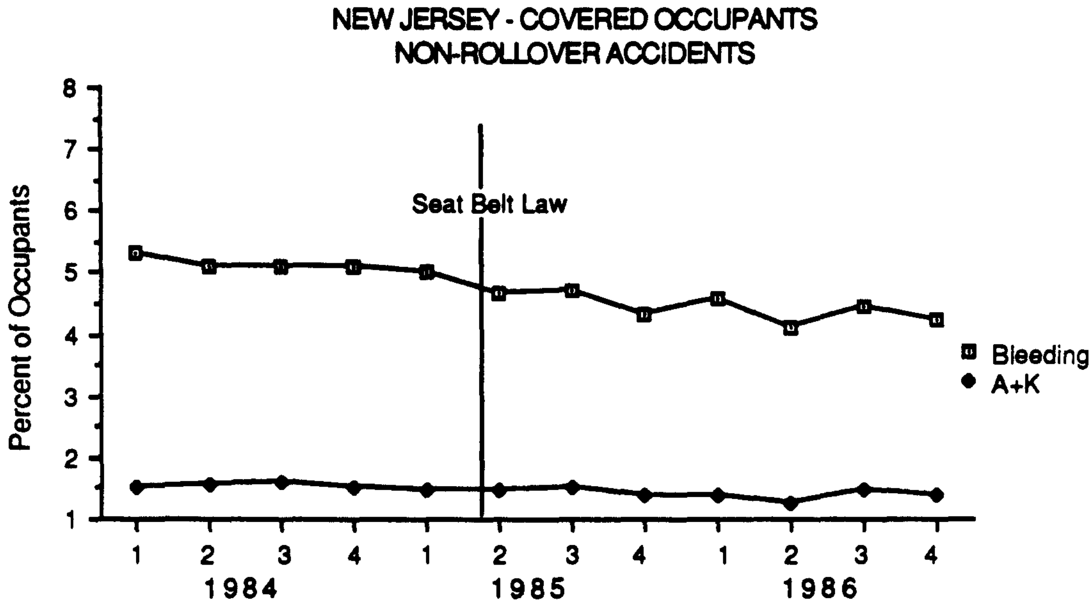
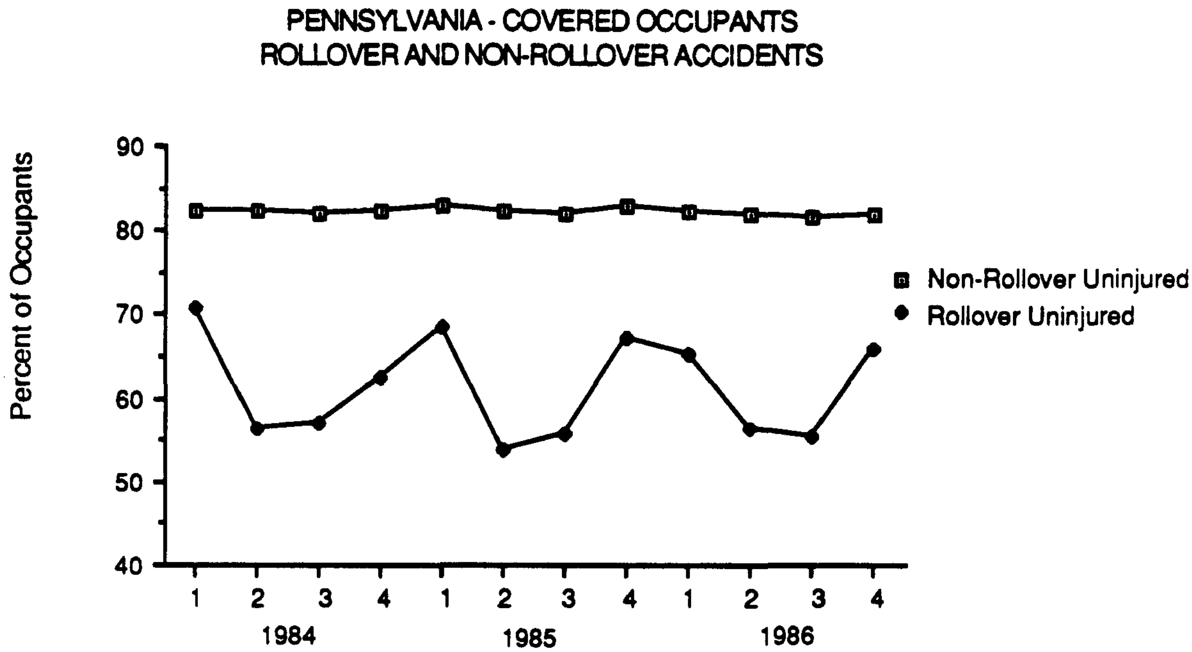


Figure 2.6. Percent of occupants in non-rollover accidents with bleeding or serious (A+K) injuries across time periods (PA and NJ data).

a)



b)

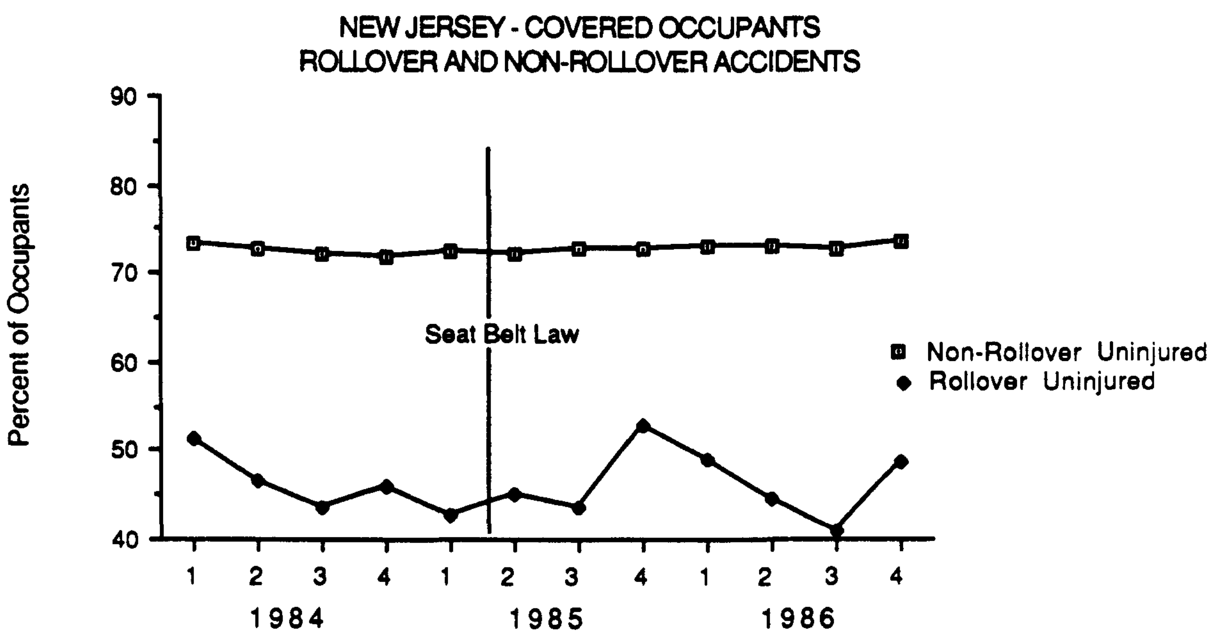
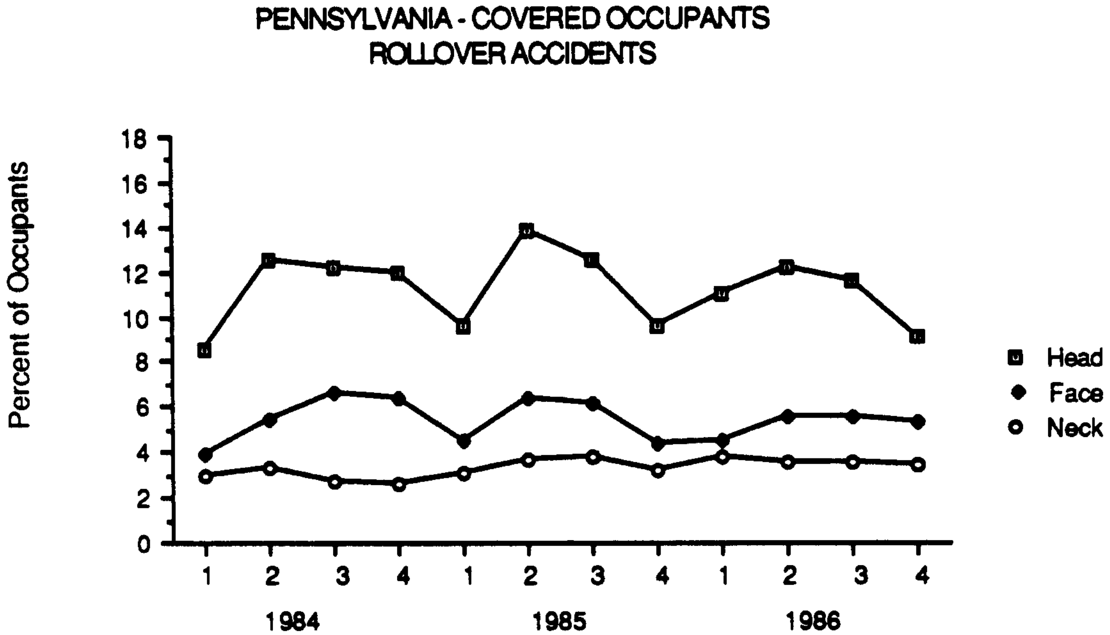


Figure 2.7. Percent of uninjured occupants in rollover and non-rollover accidents across time periods (PA and NJ data).

a)



b)

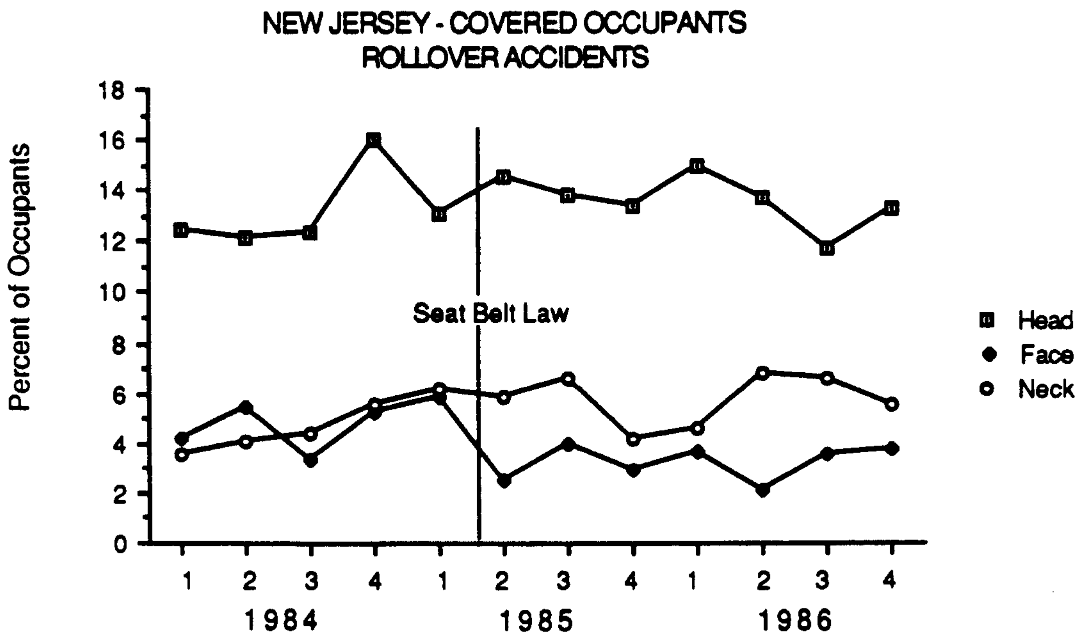
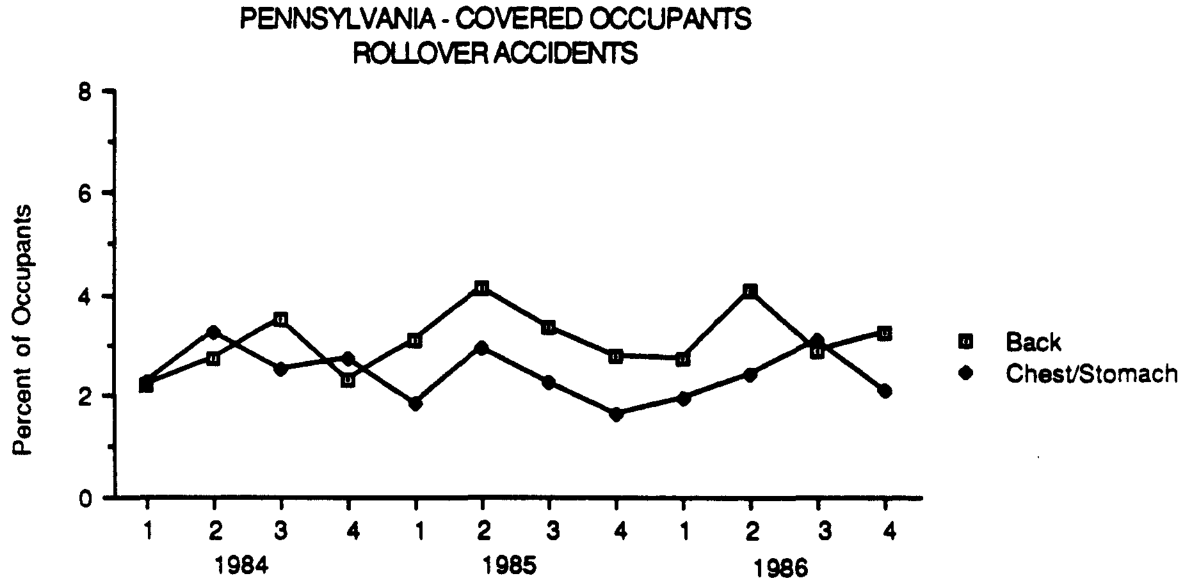


Figure 2.8. Percent of occupants in rollover accidents with certain injury locations across time periods (PA and NJ data).

a)



b)

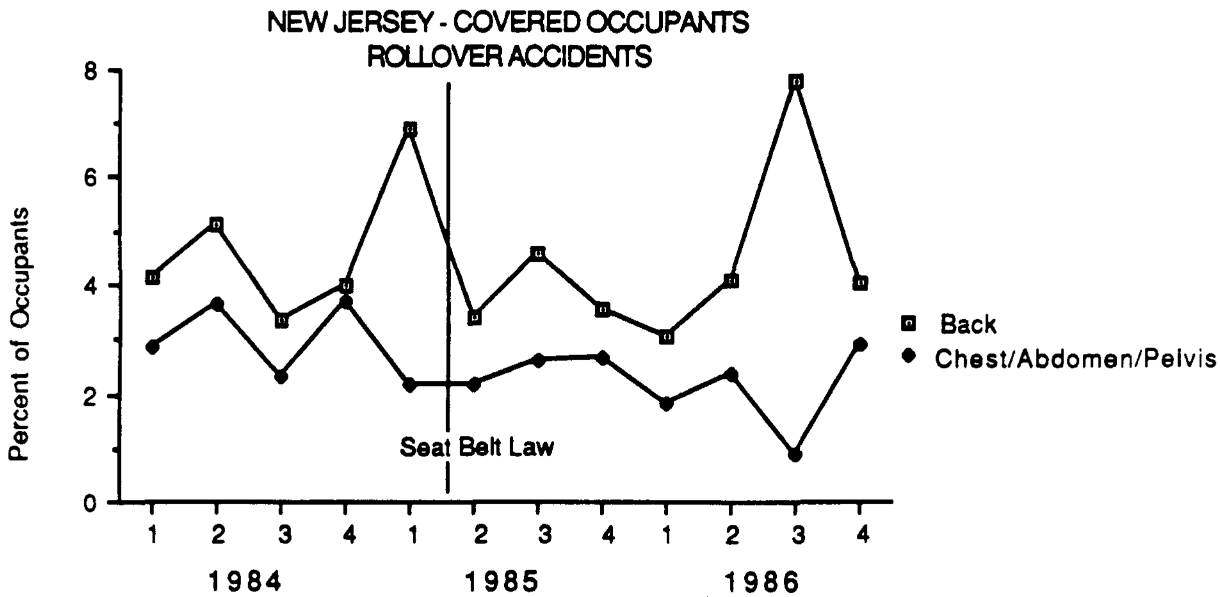


Figure 2.9. Percent of occupants in rollover accidents with certain injury locations across time periods (PA and NJ data).

are relatively constant over time. In New Jersey, the trends are far from clear, with only the percentage of occupants with face injuries in rollover crashes appearing to decrease slightly after the SBUL.

Figures 2.10 and 2.11 are the companions to Figures 2.8 and 2.9 and concern non-rollover crashes. Once again, the Pennsylvania data are relatively constant, while the New Jersey head, neck and face plots show slight variability (Figure 2.10). The percentages of New Jersey head and face injuries appear to be decreasing over time, while neck, back and chest/abdomen/pelvis injuries appear to be slightly increasing.

A Comparison of Head-On and Non-Head-On Accidents. The next crash types analyzed were head-ons versus non-head-ons. Head-on is defined as frontal, corner-to-corner damage. The figures follow the same scheme as before and concern only covered occupants. Figure 2.12 shows the percentage of occupants in head-on crashes with A+K and/or bleeding injuries. In Pennsylvania, the A+K plot appears to have a slight upward trend, while the bleeding injury plot appears relatively flat. The same general tendency was present in the New Jersey data, although the data are more variable.

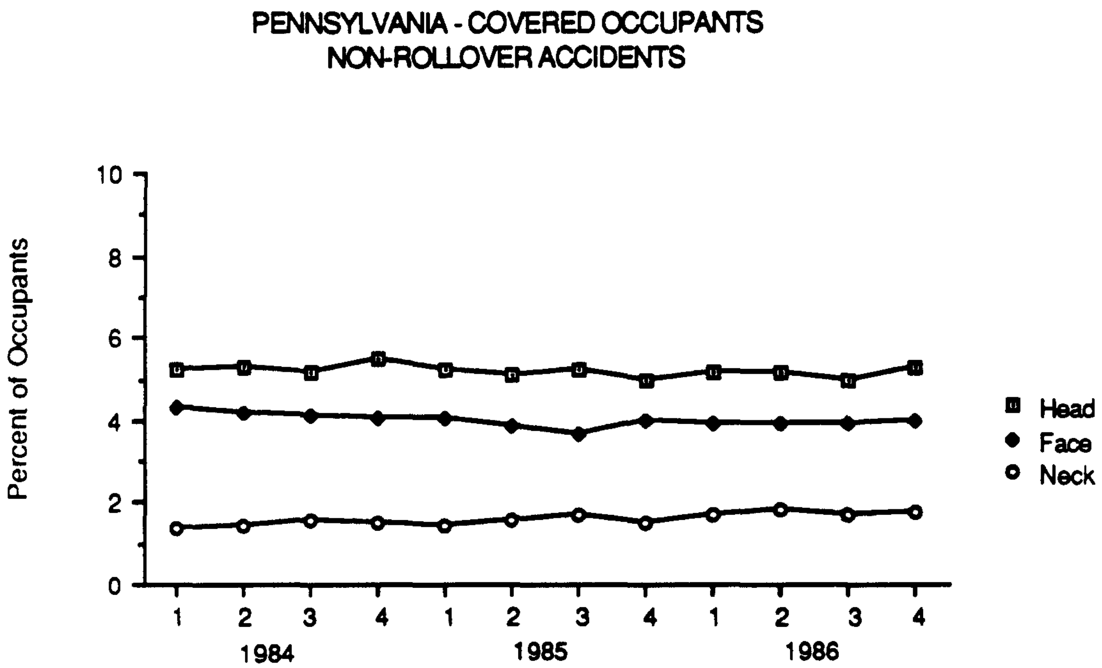
Figure 2.13 is the companion plot for Figure 2.12 and pertains to the non-head-on crashes. About the only change is a slight downward trend for the bleeding injuries plot for New Jersey.

Figure 2.14 shows the percentage of uninjured occupants for both head-on and non-head-on crashes in the two states. Both the Pennsylvania and New Jersey data look quite constant over time.

The final graphs in this series (Figures 2.15-2.18) concern the body part injured in head-on and non-head-on crashes. For Pennsylvania head-on crashes, the only plot with any apparent slope is that for head injuries, where the trend is slightly upward (Figure 2.15a). Neck injuries may also be increasing but the trend is even less pronounced than for head injuries. The same tendency for neck injuries is present for the New Jersey data (Figure 2.15b), while the head injuries appear relatively constant over time. For New Jersey, chest/abdomen/pelvis injuries are increasing over time (Figure 2.16).

For the non-head-on crashes (Figures 2.17 and 2.18), the Pennsylvania plots are all relatively flat. For New Jersey, the head injuries appear to decline slightly over time, while the neck, back and chest/abdomen/pelvis injuries appear to increase (Figures 2.17b and 2.18b).

a)



b)

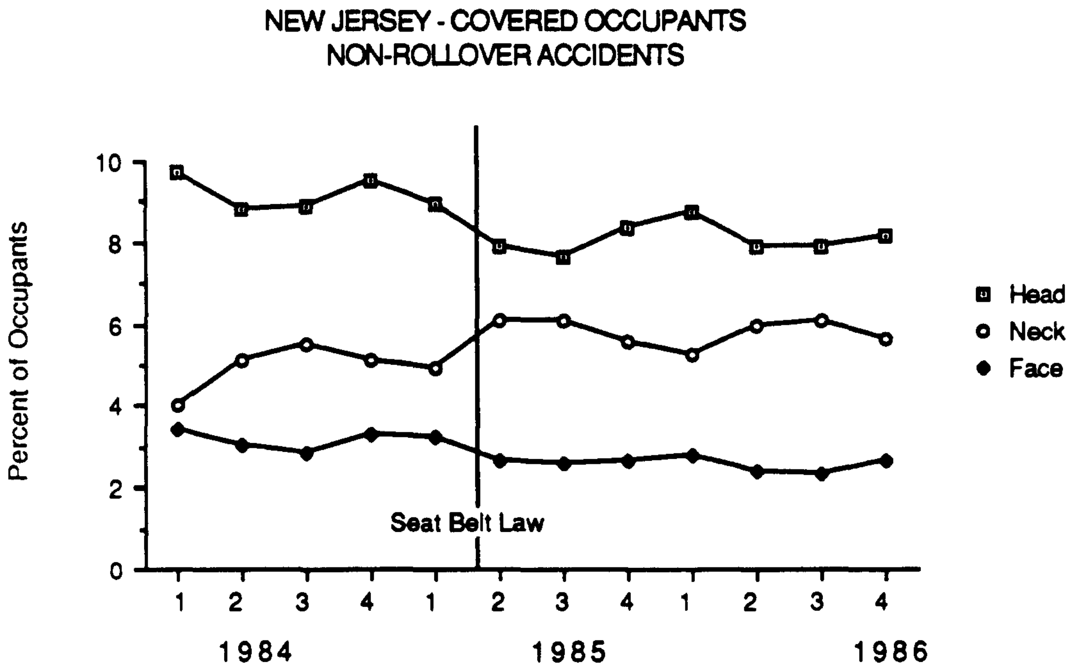
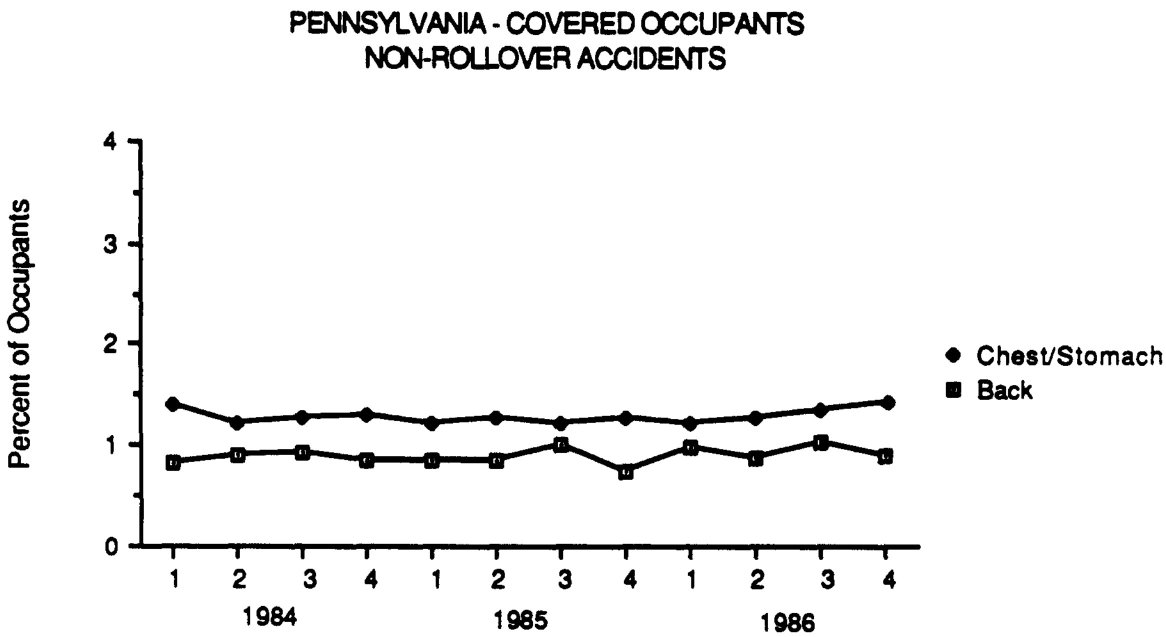


Figure 2.10. Percent of occupants in non-rollover accidents with certain injury locations across time periods (PA and NJ data).

a)



b)

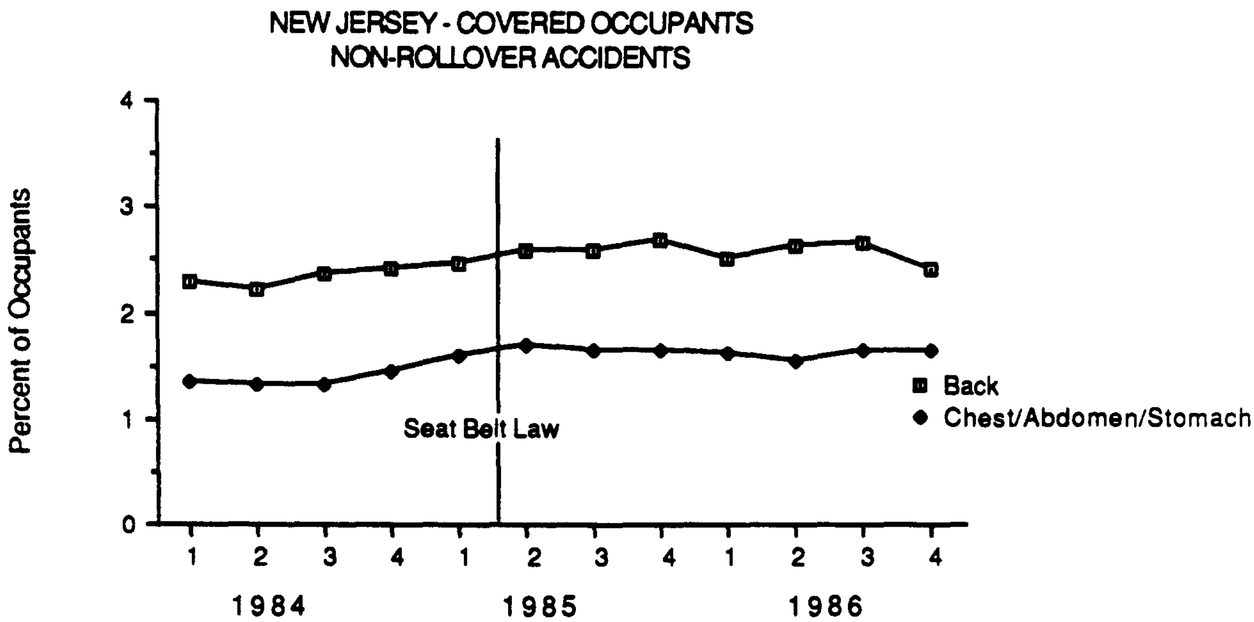
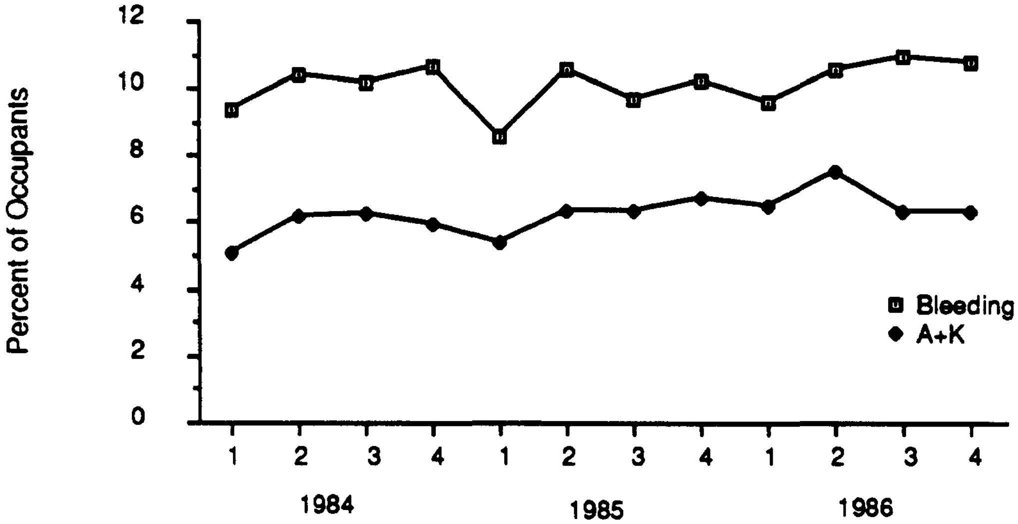


Figure 2.11. Percent of occupants in non-rollover accidents with certain injury locations across time periods (PA and NJ data).

PENNSYLVANIA - COVERED OCCUPANTS
HEAD-ON ACCIDENTS

a)



NEW JERSEY - COVERED OCCUPANTS
HEAD-ON ACCIDENTS

b)

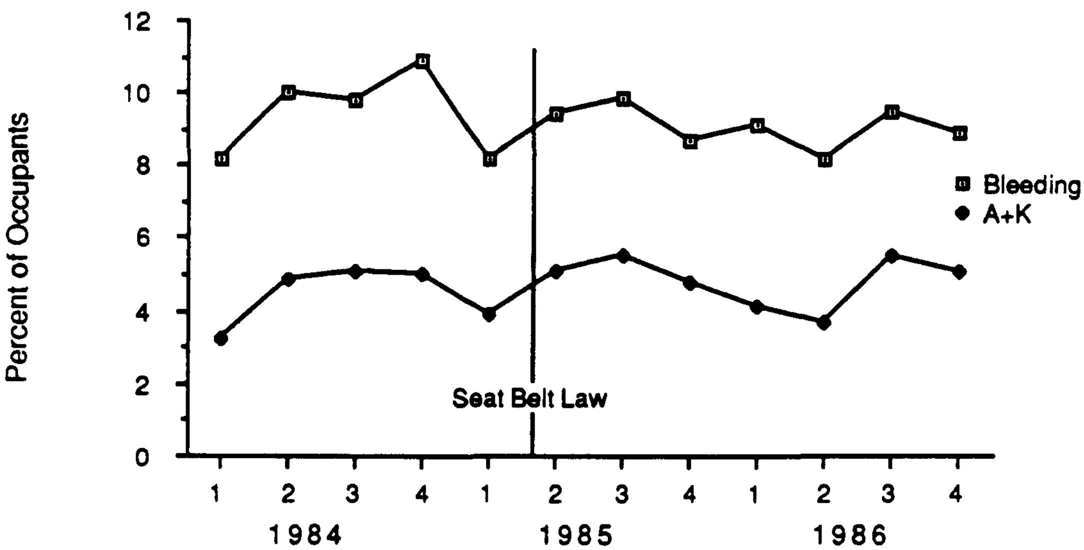
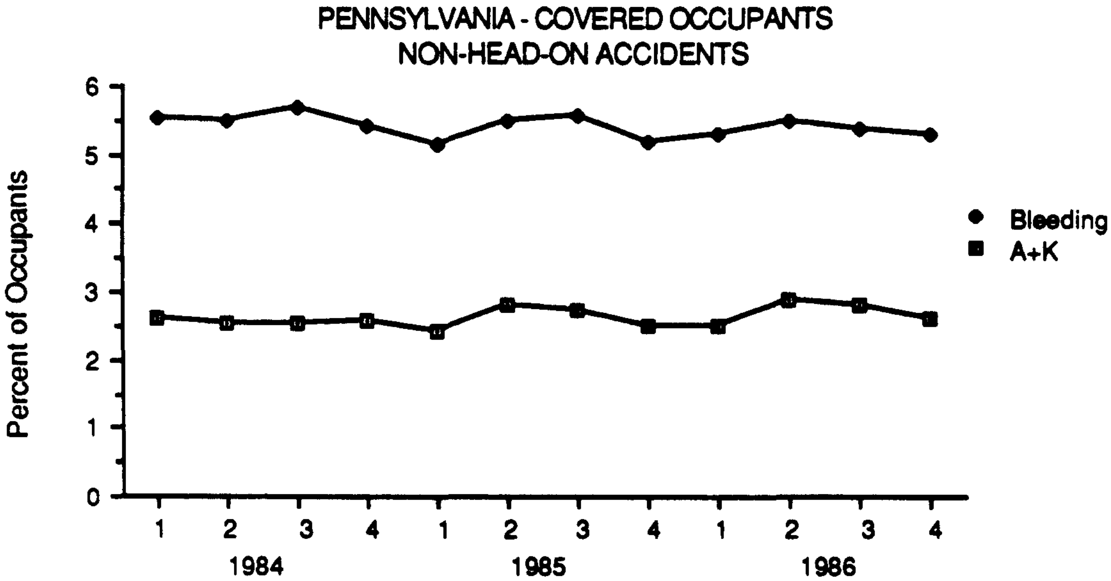


Figure 2.12. Percent of occupants in head-on accidents with bleeding or serious (A+K) injuries across time periods (PA and NJ data).

a)



b)

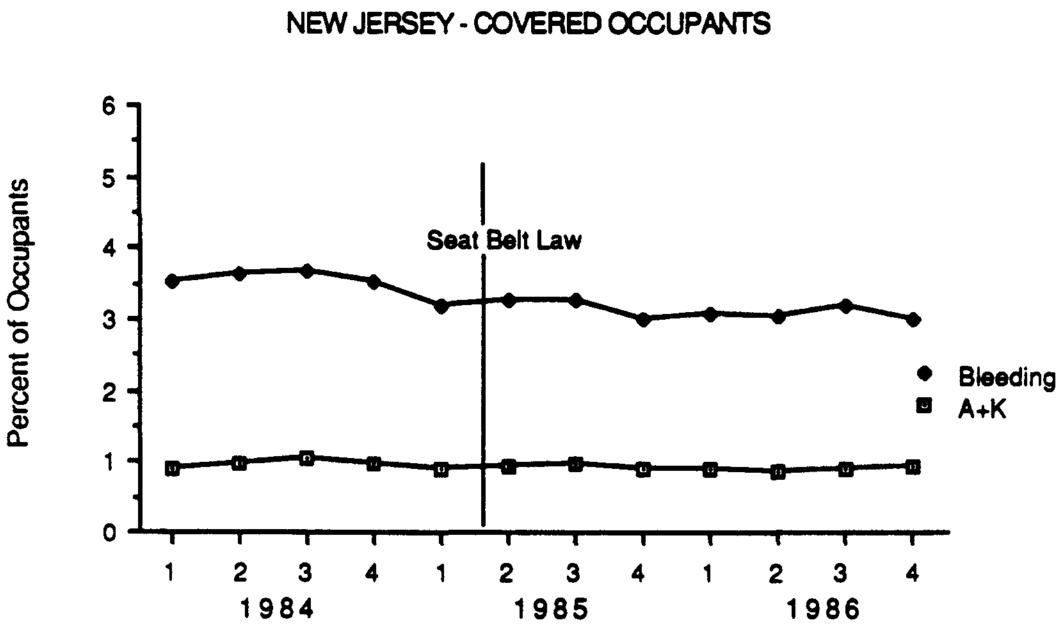
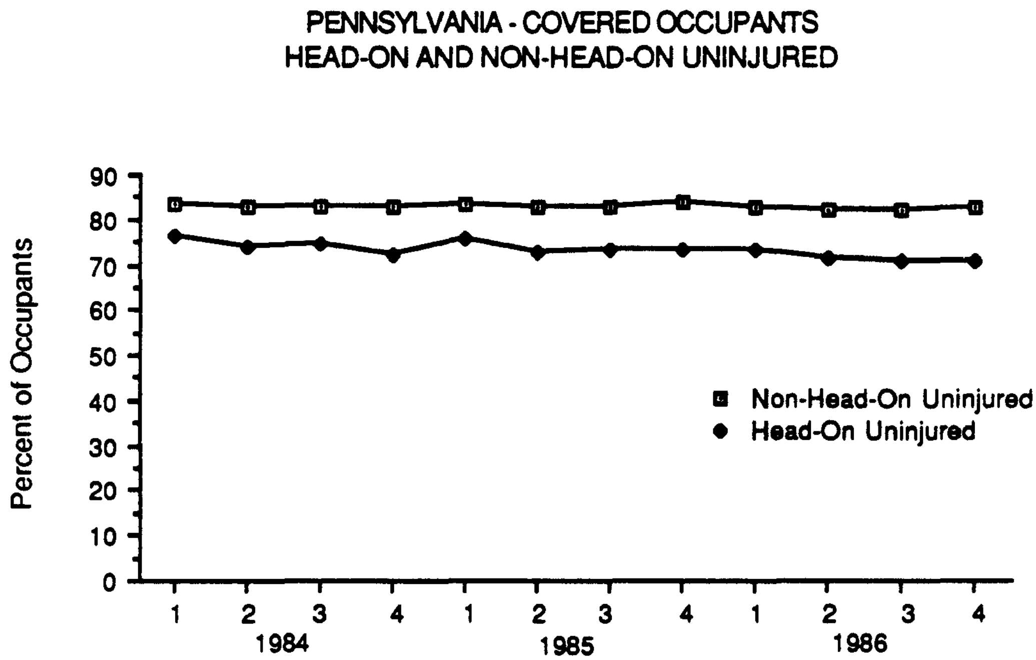


Figure 2.13. Percent of occupants in non-head-on accidents with bleeding or serious (A+K) injuries across time periods (PA and NJ data).

a)



b)

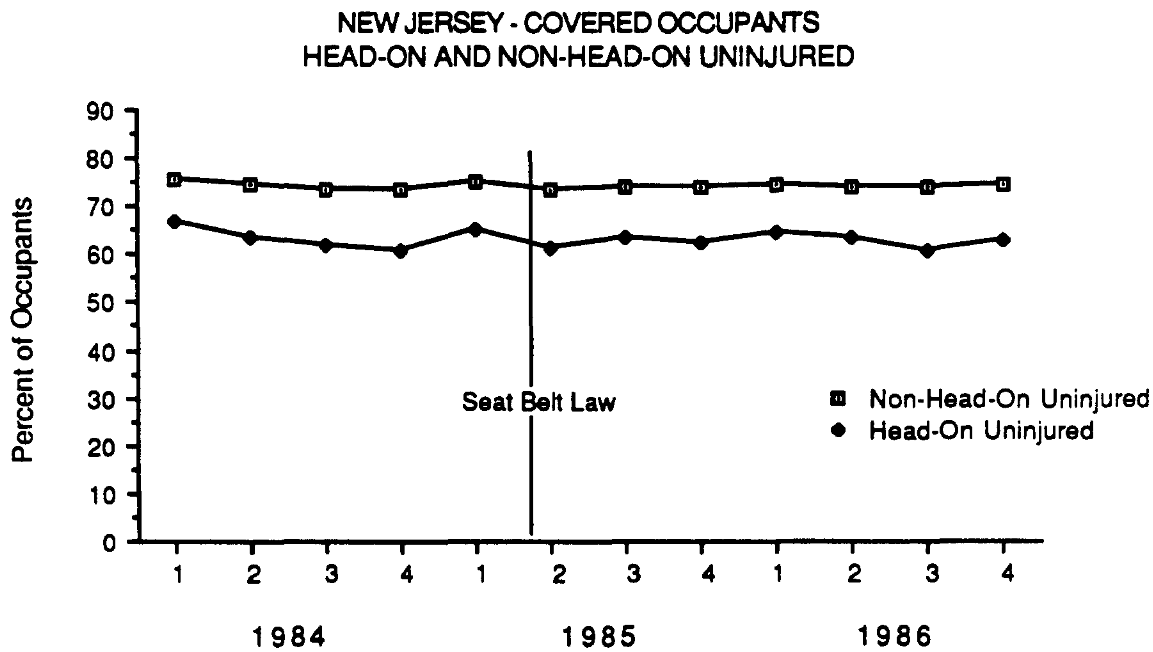
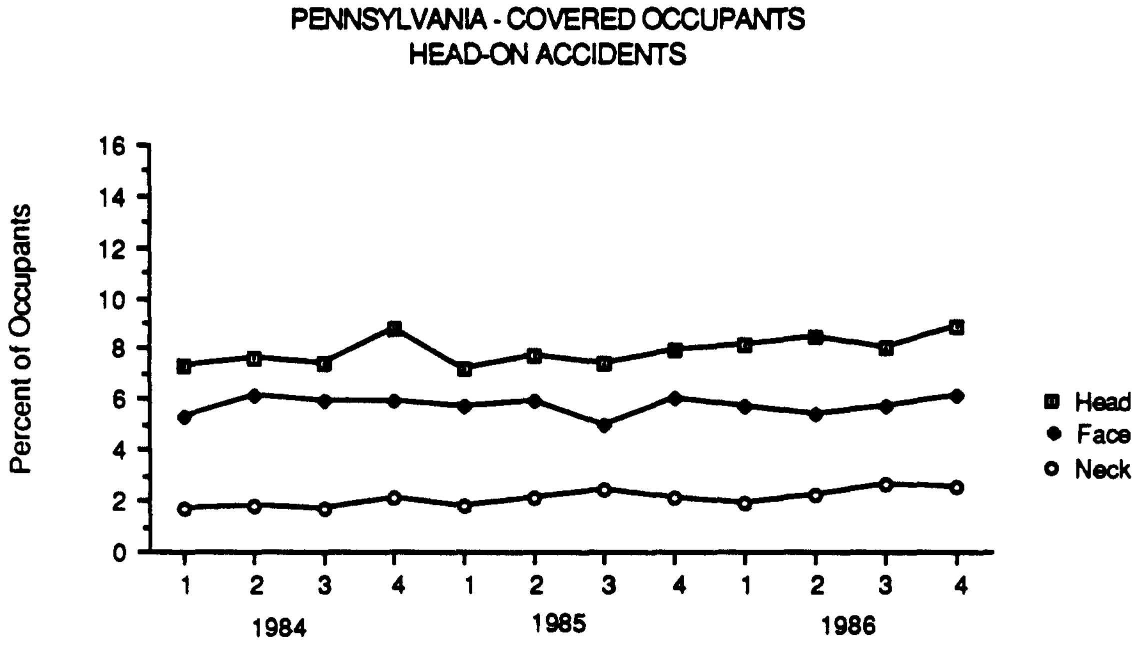


Figure 2.14. Percent of uninjured occupants in head-on and non-head-on accidents across time periods (PA and NJ data).

a)



b)

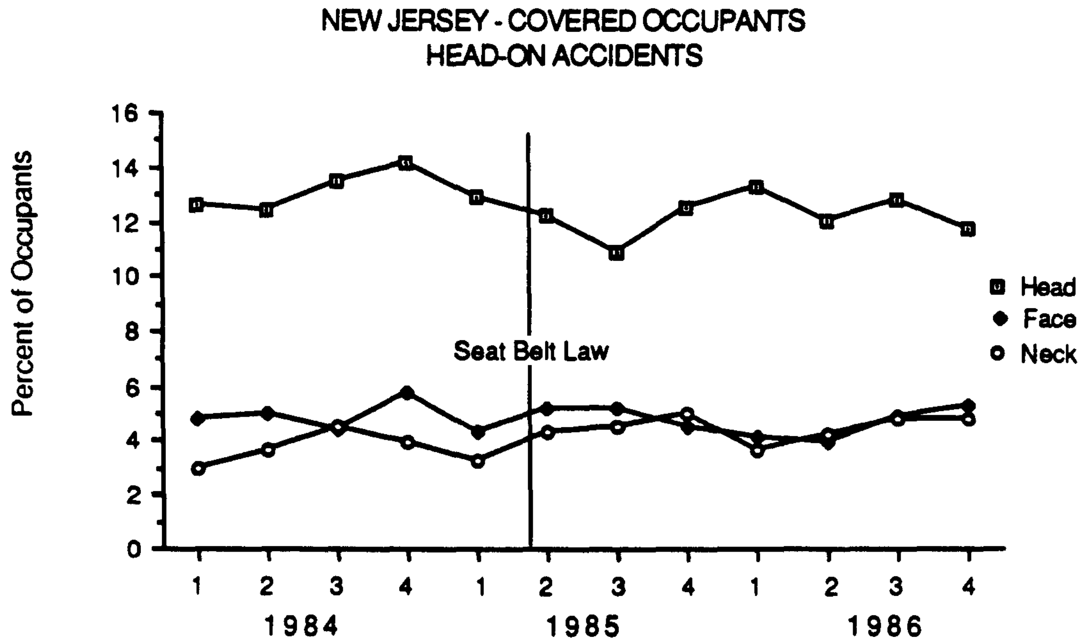
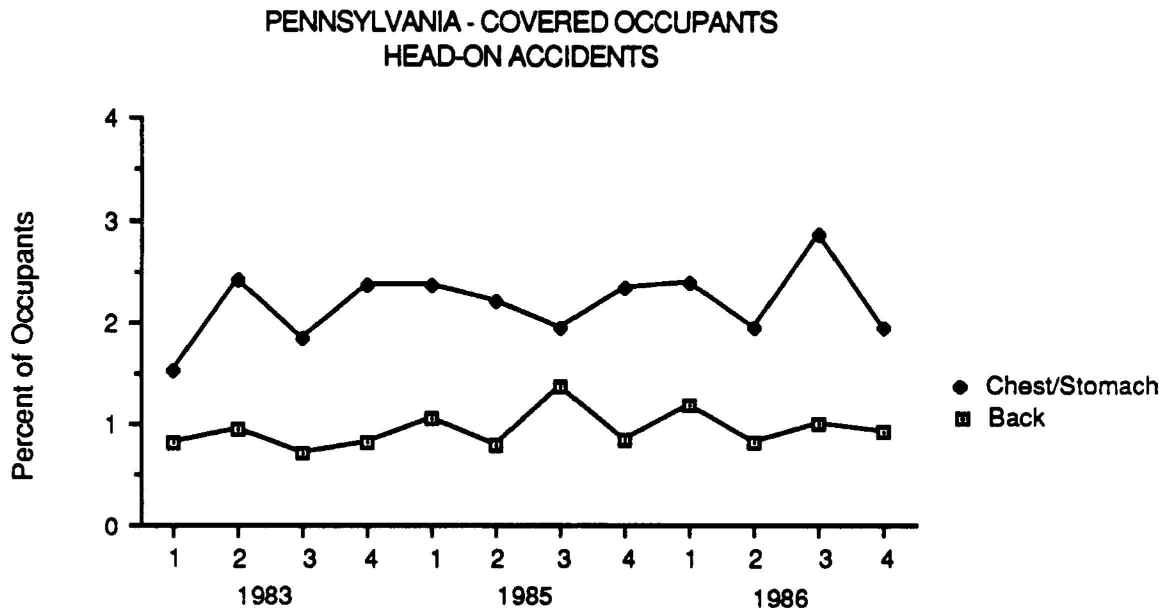


Figure 2.15. Percent of occupants in head-on accidents with certain injury locations across time periods (PA and NJ data).

a)



b)

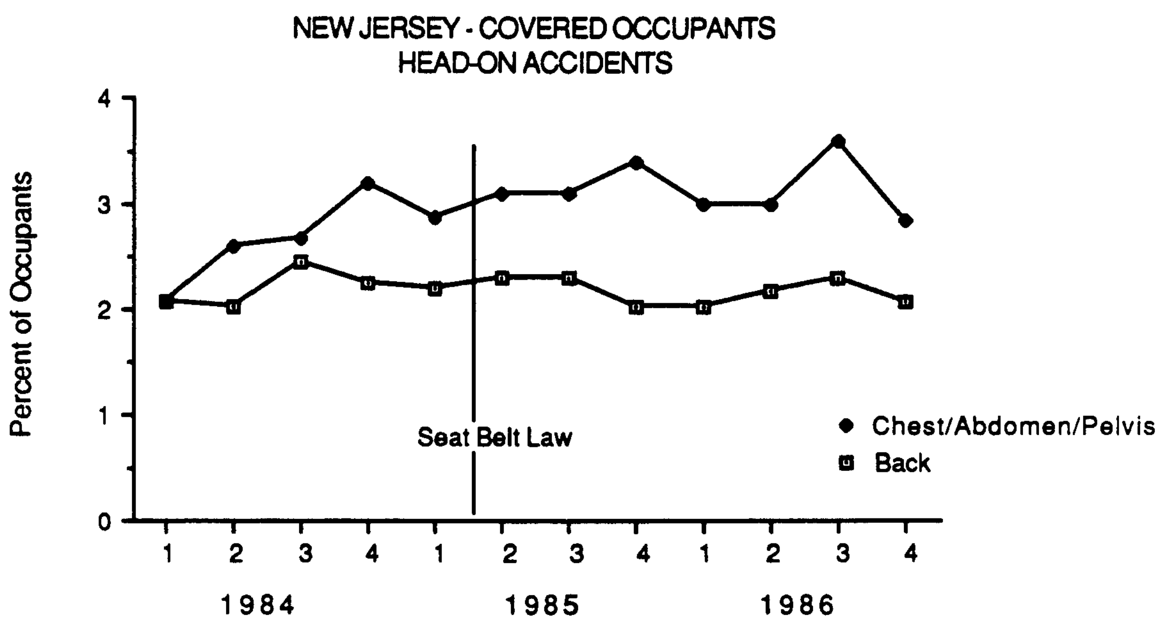
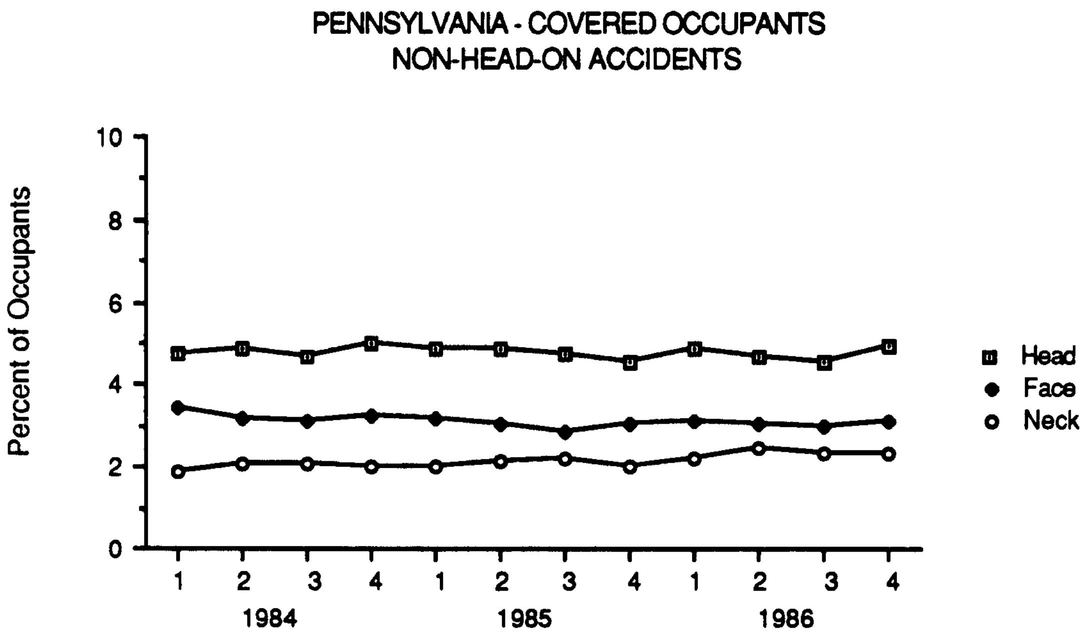


Figure 2.16. Percent of occupants in head-on accidents with certain injury locations across time periods (PA and NJ data).

a)



b)

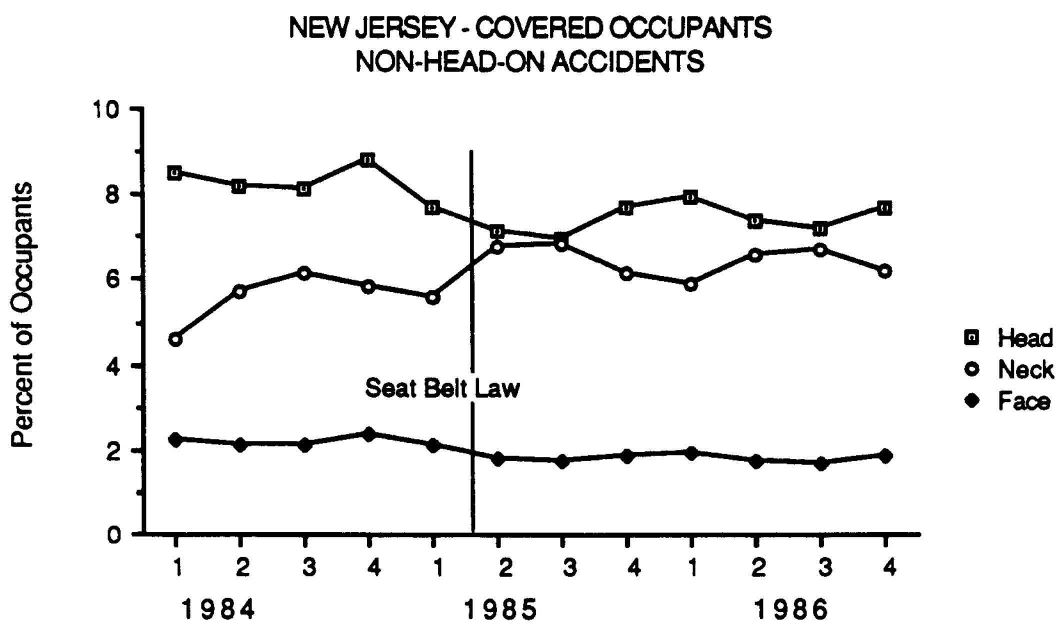
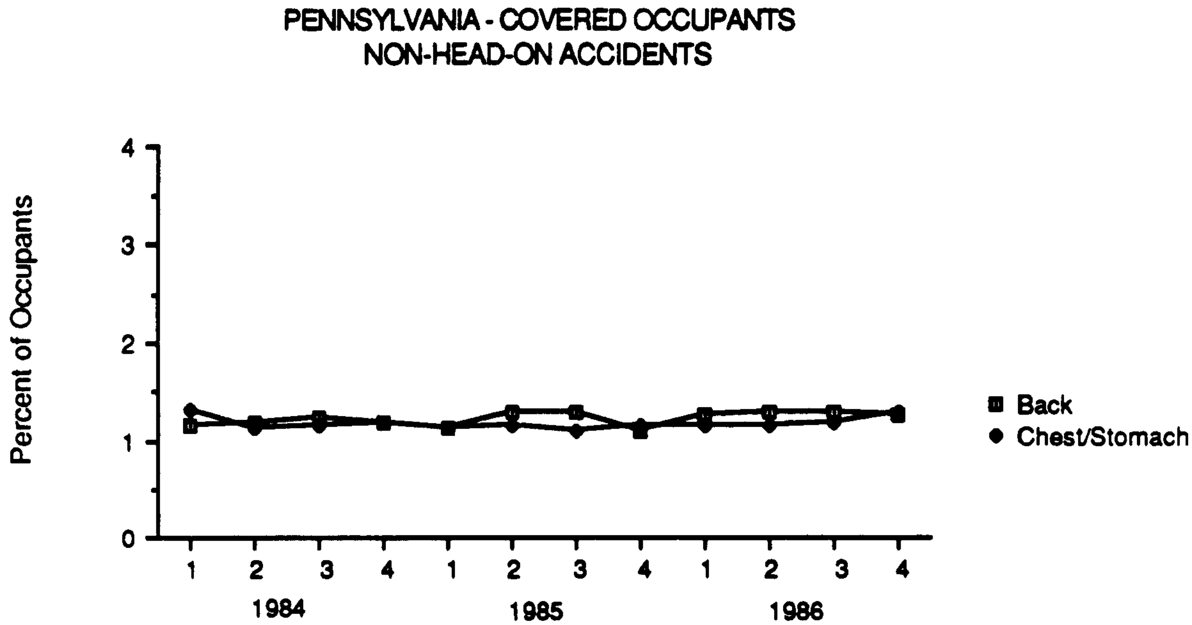


Figure 2.17. Percent of occupants in non-head-on accidents with certain injury locations across time periods (PA and NJ data).

a)



b)

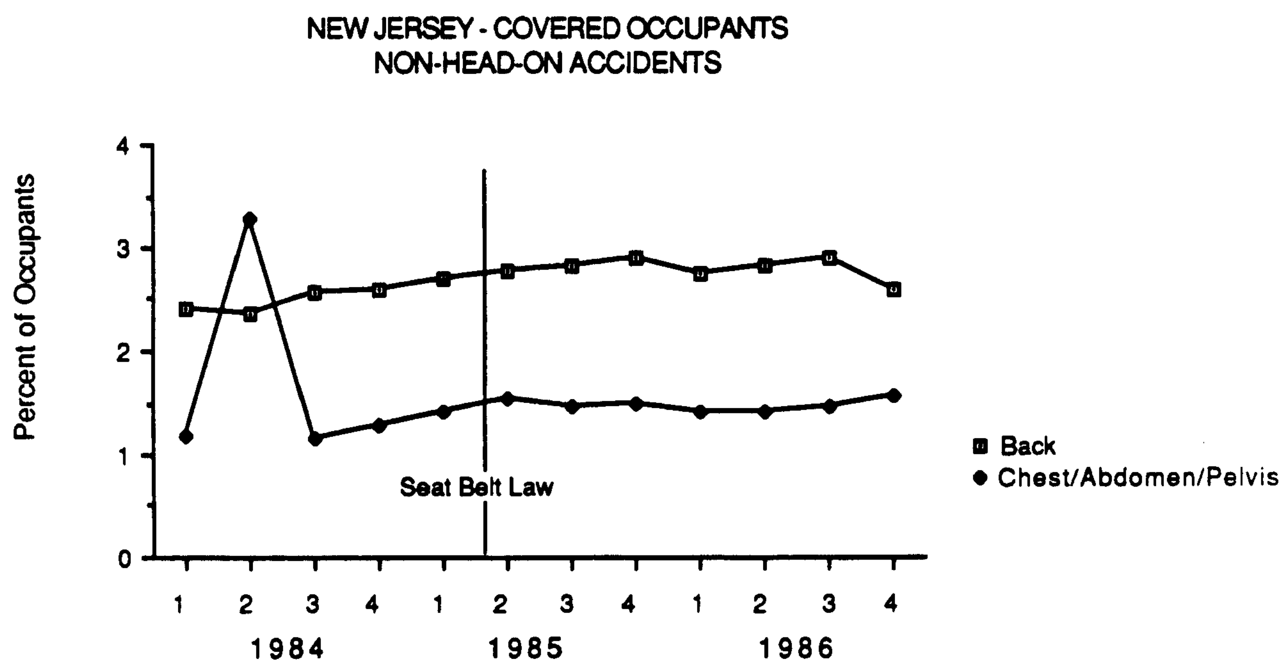


Figure 2.18. Percent of occupants in non-head-on accidents with certain injury locations across time periods (PA and NJ data).

A Comparison of Single-Vehicle and Multi-Vehicle Accidents. The last iteration in this series deals with single-vehicle and multi-vehicle accidents. In Figure 2.19, the Pennsylvania single-vehicle A+K and bleeding injuries appear to cycle across time in a manner similar to that for rollover accidents (Figure 2.5), while the single-vehicle bleeding accidents in New Jersey appear to be declining over time. The same type of pattern holds for the multi-vehicle crashes (Figure 2.20), except that the Pennsylvania cycling trend has disappeared.

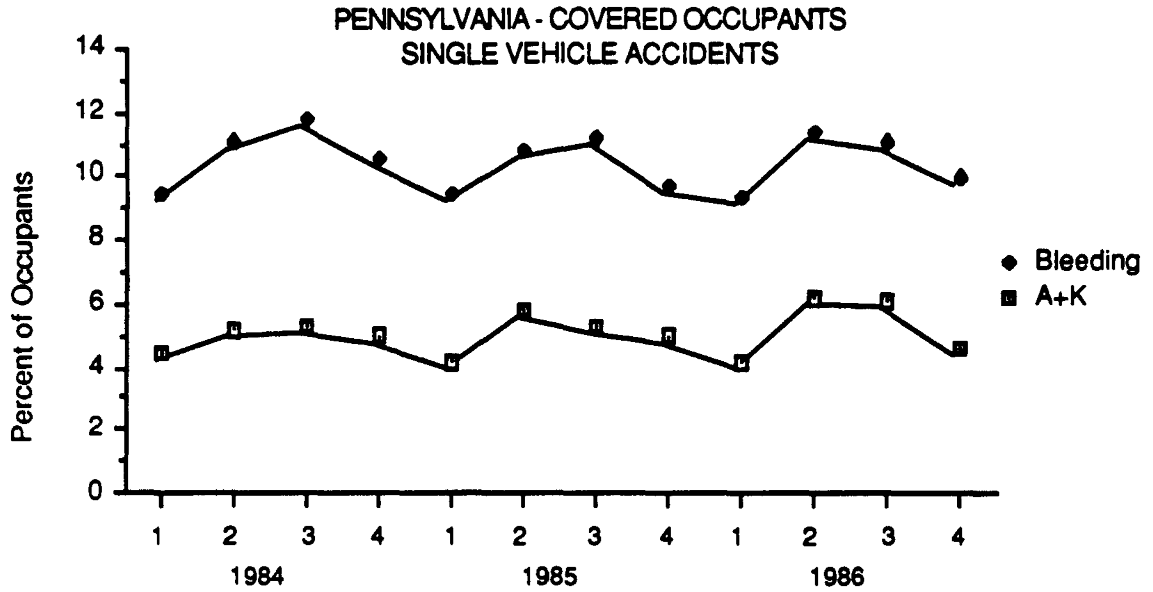
Figure 2.21 concerns the single and multi-vehicle crashes with uninjured occupants. While the Pennsylvania data seem to lack direction, the percentage of uninjured occupants in single vehicle crashes have been increasing after the SBUL in New Jersey.

Single-vehicle body part injuries are covered in Figures 2.22 and 2.23, and the percentage of head injuries appears to decline in New Jersey (Figure 2.22b). Face injuries also appear to decline slightly, while neck injuries show a slight increase. The Pennsylvania plots are all relatively flat.

Finally, Figures 2.24 and 2.25 concern body part injuries for multi-vehicle crashes. For New Jersey (Figure 2.24b), the plot is very similar to the head-on crashes shown earlier in Figure 2.17, where the head injuries appear to be declining over time and the neck injuries increasing. In addition, it appears from Figure 2.25b that both back and chest/abdomen/pelvis injuries are increasing across time in New Jersey multi-vehicle accidents.

Real or Reporting Changes. Since it is possible that any of the trends observed in either the New Jersey or Pennsylvania data could reflect changes in data collection procedures rather than actual changes in accidents and/or injuries, an attempt was made to contact appropriate personnel in both states to ascertain that this was not the case and that any observed trends were in fact genuine. The New Jersey contact in their highway safety office's seat belt section indicated that their office only looked at changes in numbers of injuries and fatalities as a result of the law, and not changes in injury locations, etc. Nevertheless, he was unaware of any event over the past several years that might have affected this coding. He noted that with passage of the New Jersey belt law there had been an increased emphasis placed on the officers to fill out accident report forms completely, but no changes in how they were to fill out the form. For coding information such as location of

a)



b)

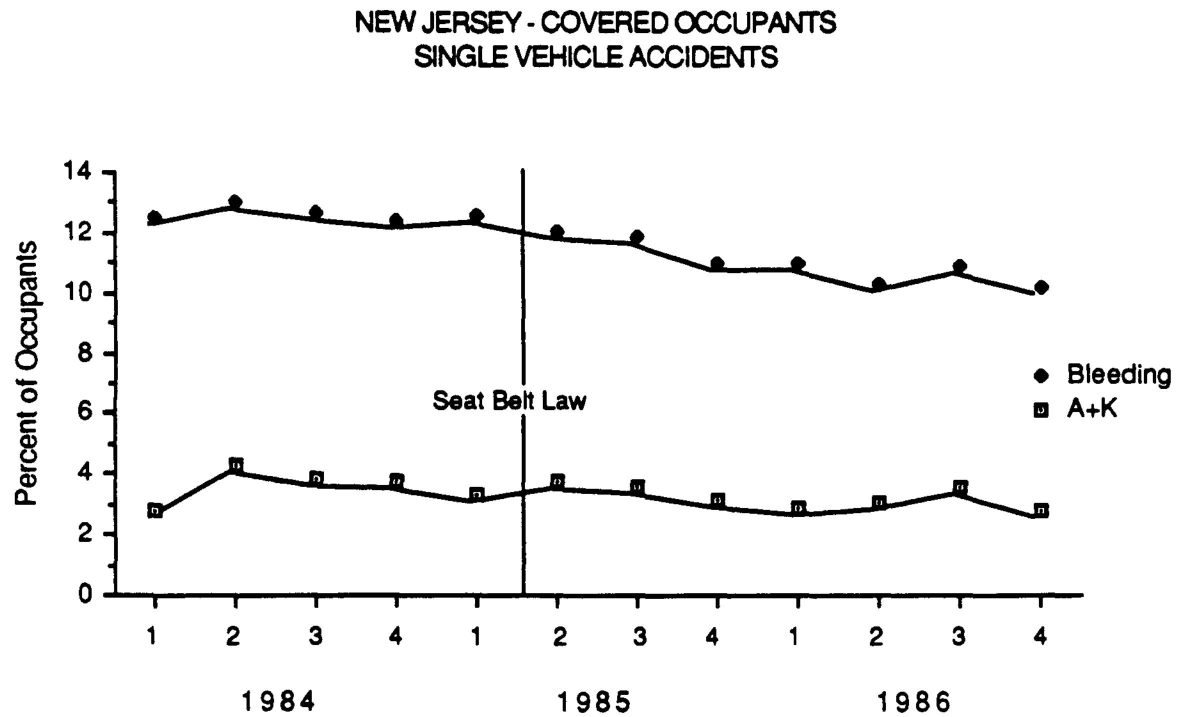
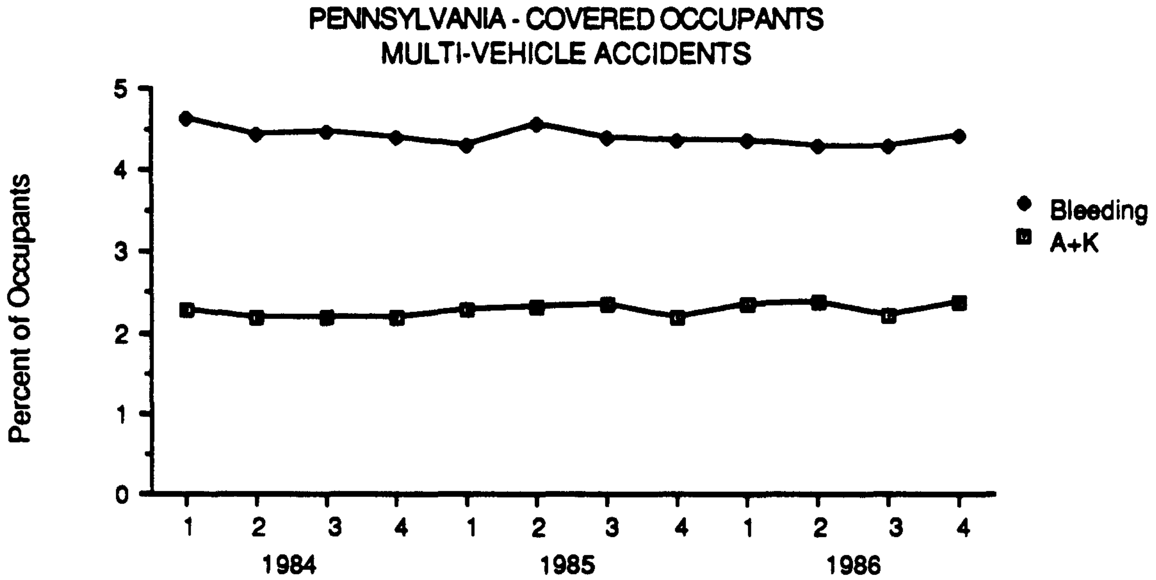


Figure 2.19. Percent of occupants in single vehicle accidents with bleeding and serious (A+K) injuries across time periods (PA and NJ data).

a)



b)

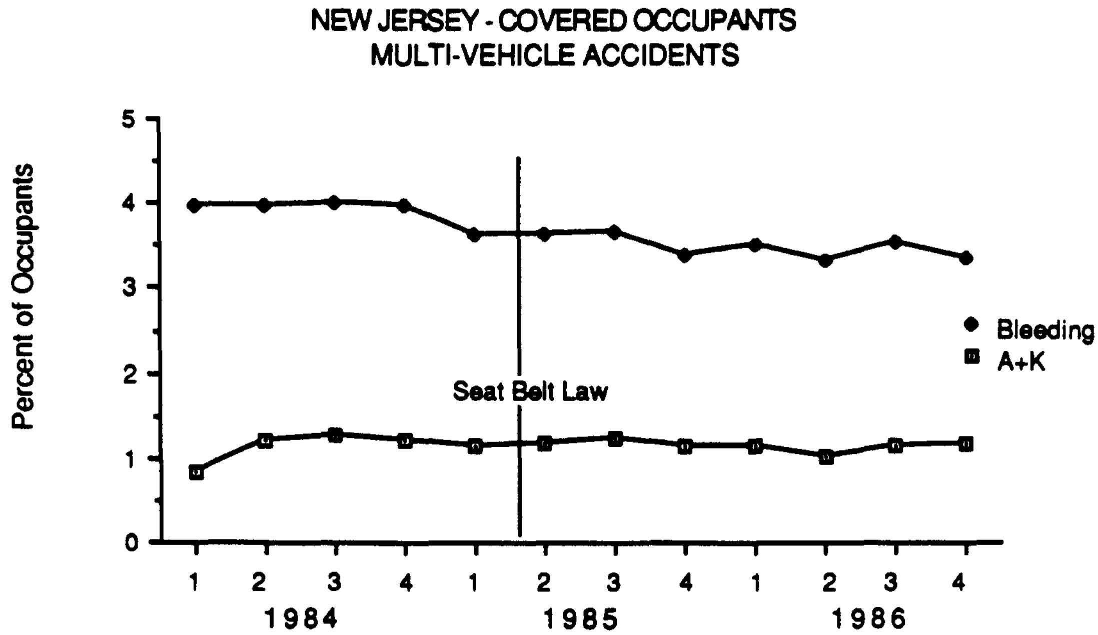
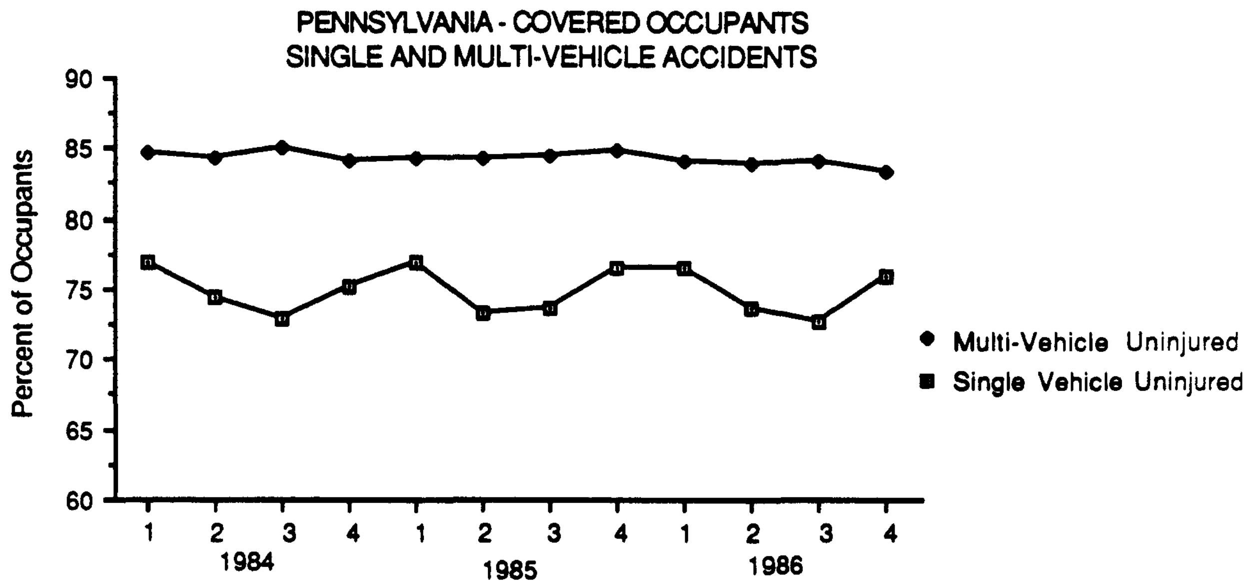


Figure 2.20. Percent of occupants in multi-vehicle accidents with bleeding or serious (A+K) injuries across time periods (PA and NJ data).

a)



b)

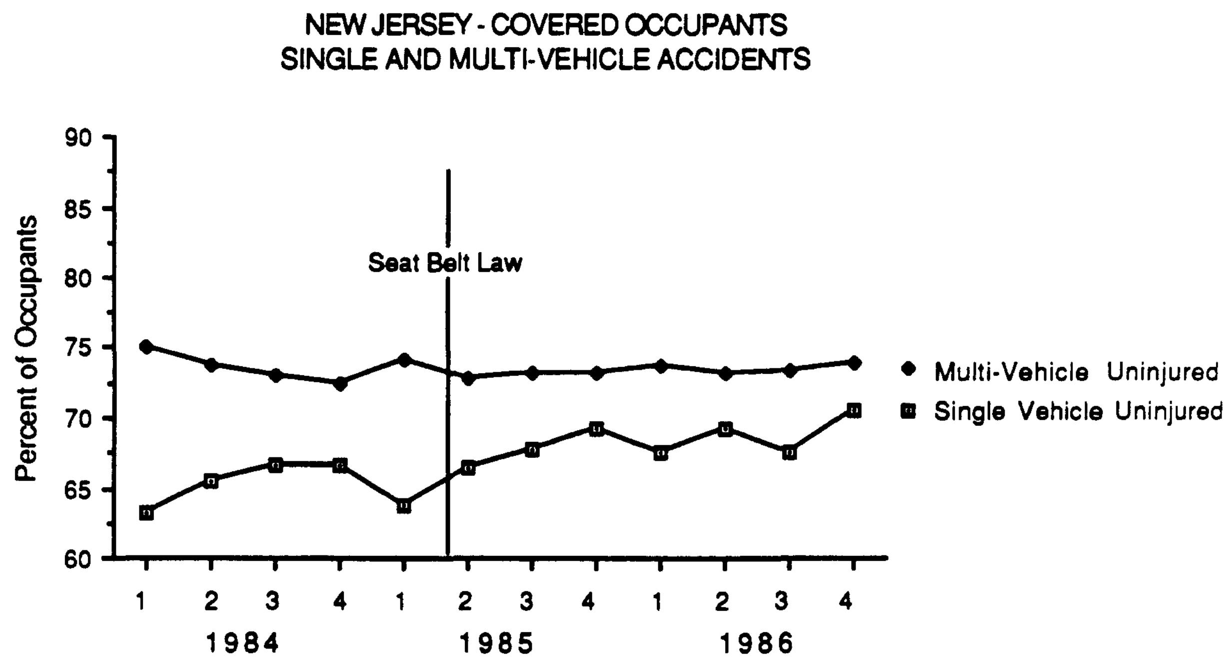
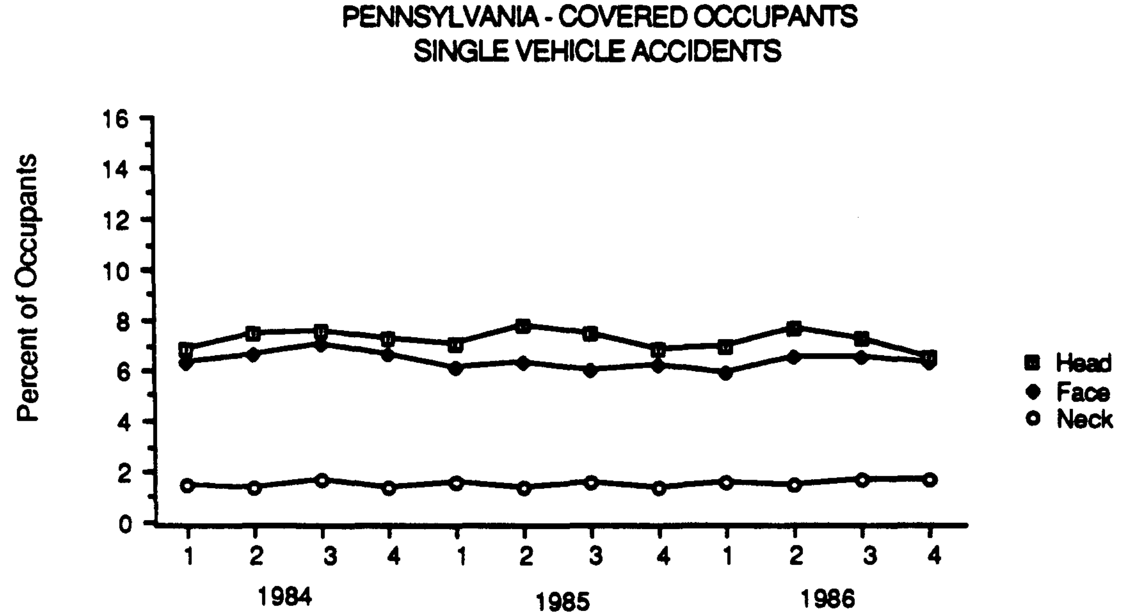


Figure 2.21. Percent of uninjured occupants in single and multi-vehicle accidents across time periods (PA and NJ data).

a)



b)

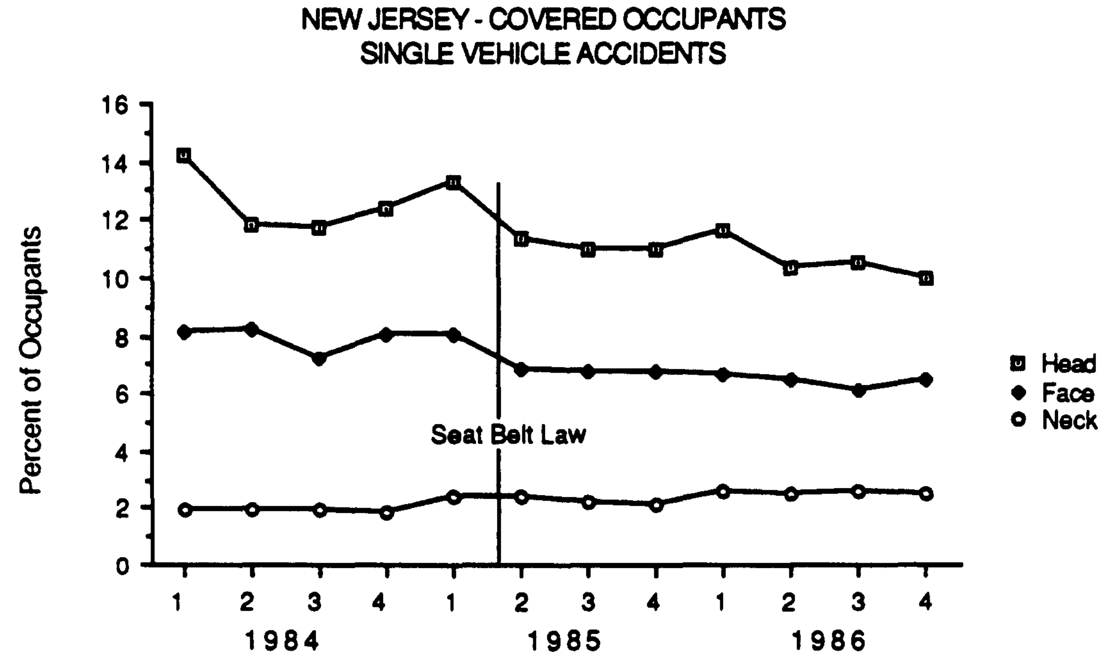
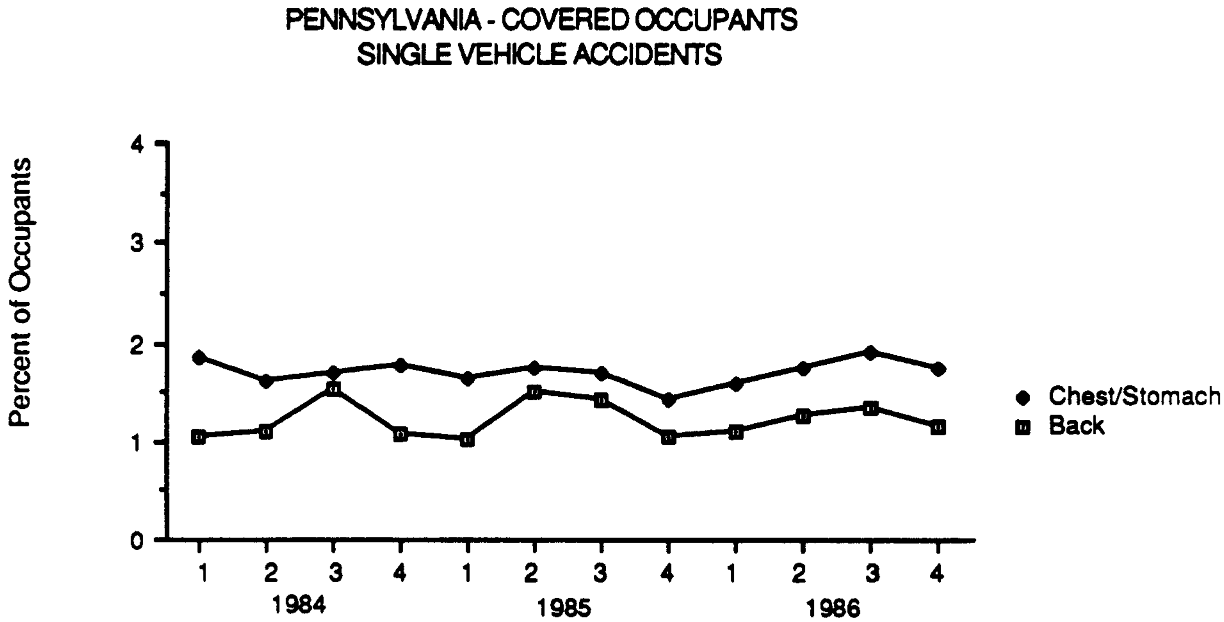


Figure 2.22. Percent of occupants in single vehicle accidents with certain injury locations across time periods (PA and NJ data).

a)



b)

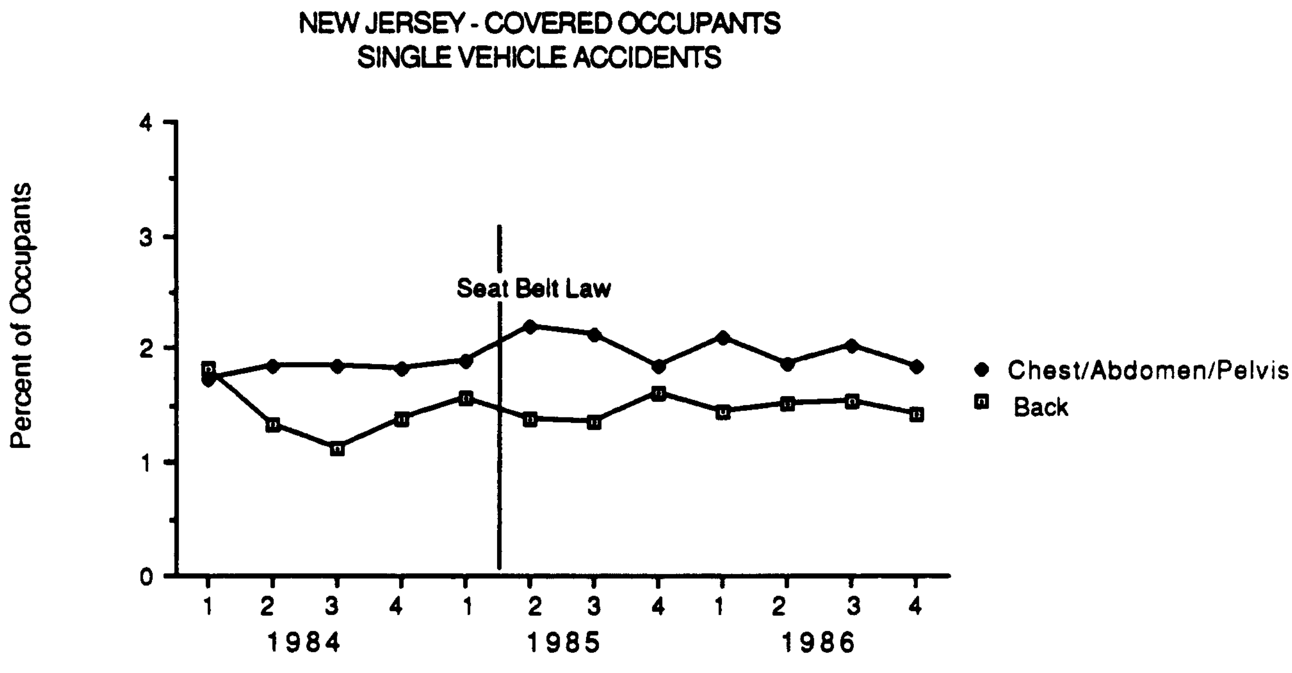
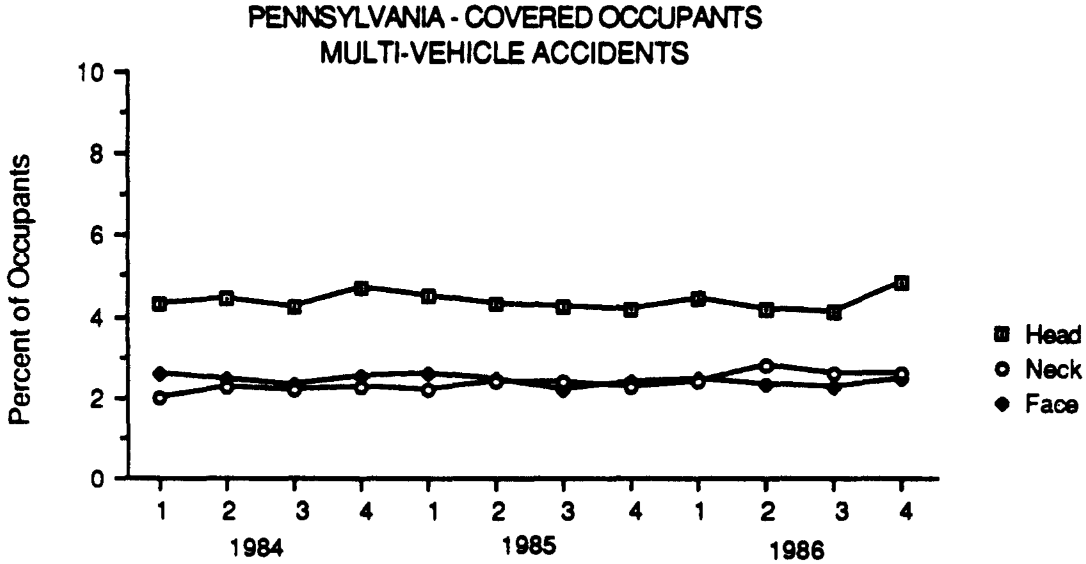


Figure 2.23. Percent of occupants in single vehicle accidents with certain injury locations across time periods (PA and NJ data).

a)



b)

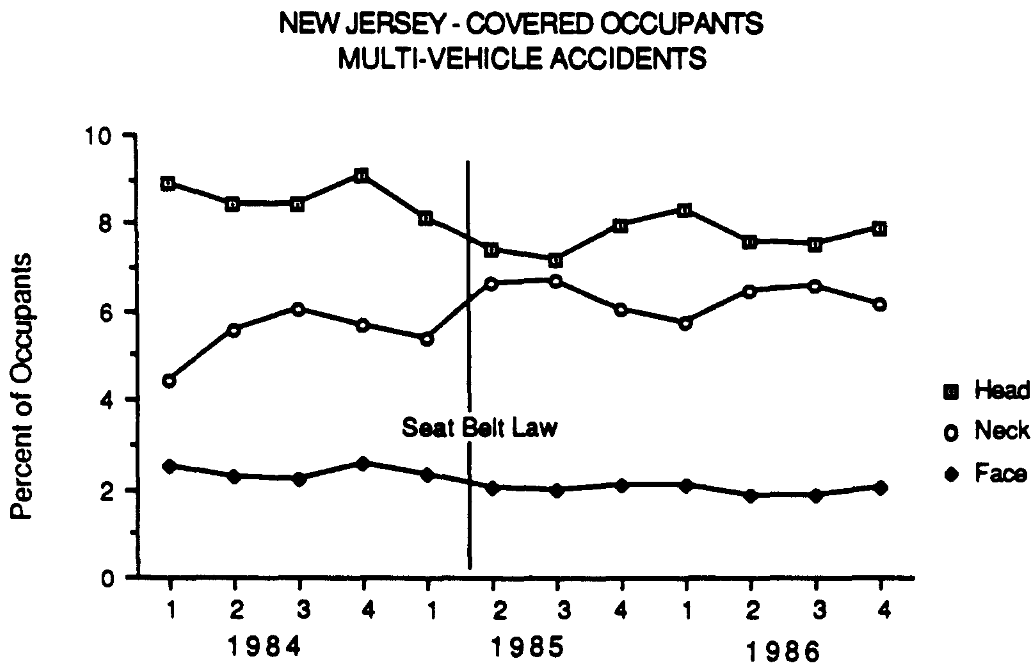
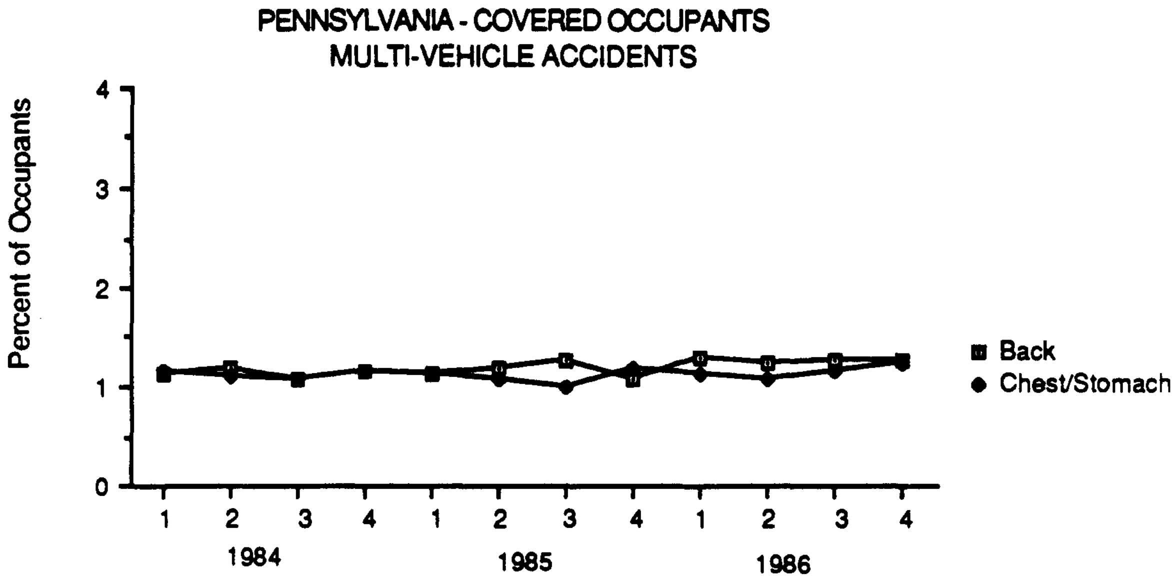


Figure 2.24. Percent of occupants in multi-vehicle accidents with certain injury locations across time periods (PA and NJ data).

a)



b)

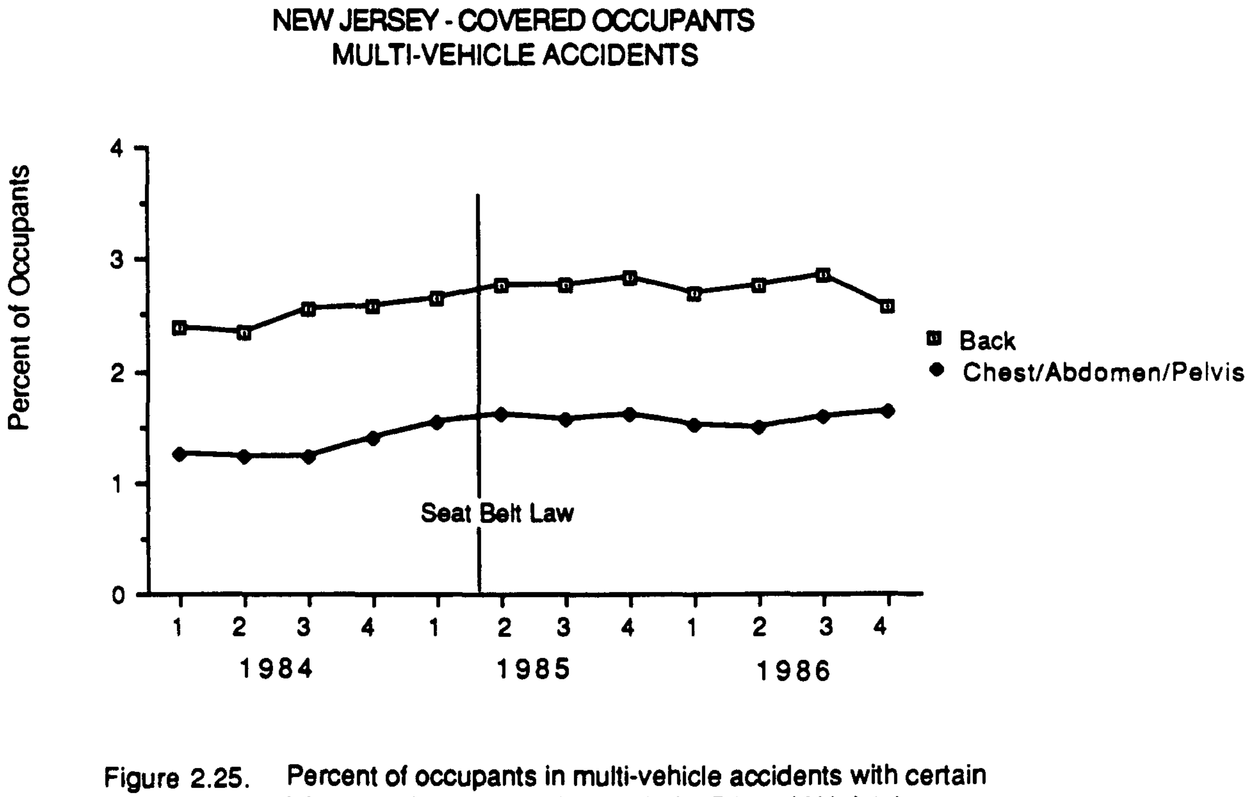


Figure 2.25. Percent of occupants in multi-vehicle accidents with certain injury locations across time periods (PA and NJ data).

injury, officers were continuing to rely primarily on whatever claims were made by the victim.

Similarly, for Pennsylvania (where no seat belt law was in place during the time period of this analysis), our contact in the Information Management Division of the State DOT indicated that there had been no changes in accident reporting procedures, and that no training or other intervention that might affect coding of injuries had taken place (at least not on a large scale). Like the New Jersey contact, he indicated a general increased awareness of seat belt issues by the police and highway patrol, but did not feel that these would have impacted on the injury coding. (The same would also be true for North Carolina.) From these contacts, it does appear that any observed trends in our New Jersey and Pennsylvania data should reflect real changes in accidents/injuries, rather than changes in reporting or coding procedures in these states.

Restrained Occupant Injury Trends Using Indiana Data

Similar to New Jersey and Pennsylvania, the Indiana accident report form contains supplemental injury codes pertaining to injury type and body location. A major difference, however, is that uninjured occupants are excluded from the accident report form. Thus, the analyses that follow necessarily pertain to drivers only.

The Indiana belt law became effective in July 1987. Our analysis period begins with the start of the 1985 calendar year and ends with the third quarter of 1988. Thus, five quarters of injury data are available following the onset of the law.

Statewide seat belt use data for the driving population are available from on-road surveys conducted by Indiana University and Purdue University, as shown below:

Date	Belt Use Rate	Comments
May 1985	20%	Pre-law
June 1987	28%	Pre-law
August 1987	51%	Immediate post-law
October 1987	46%	Post-law
April 1988	43%	Post-law
July 1988	46%	Post-law
October 1988	44%	Post-law
April 1989	44%	Post-law

Thus, the belt use rate almost doubled after enforcement of the law became effective, with a small decline thereafter.

The analyses for Indiana are similar to those performed with the New Jersey and Pennsylvania data. In other words, the belt use in the crash as reported by the investigating officer is disregarded because of the known bias in this variable with the passage of SBUL's. The analyses pay attention to occupants in vehicles covered and not covered by the law. "Covered" occupants are drivers of passenger vehicles, while "not covered" occupants are the rear seat occupants of passenger vehicles as well as occupants of non-covered vehicles (vehicles other than passenger cars, station wagons, and vans). Finally, children under five years of age were deleted from the analyses to eliminate the vast majority of occupants in child safety seats.

KABCO-Like Results. The reporting threshold for Indiana is $200, as compared to $500 for New Jersey and property damage of an amount that makes the vehicle a "towaway" for Pennsylvania. The Indiana accident report form does not use standard KABCO codes, but NHTSA has developed an algorithm that converts their injury classifications to the KABCO scale. Figure 2.26 portrays the KABCO-like results for covered drivers in all accidents. The percent of drivers killed, injured, or not injured across time is virtually unchanged.

Injury Type. Figure 2.27 concerns the injury type for covered drivers. While there appears to be a downward trend (actually starting before the belt law) for injuries like abrasions, contusions, and bruises, the more serious injuries like fractures/dislocations and internal injuries appear relatively unchanged.

Injury distributions are shown in Figure 2.28 for bleeding, serious and fatal (A+K), and complaint of pain injuries. Starting in 1985, the percentages of drivers with bleeding and A+K injuries show slight downward trends (with the bleeding injury trend more pronounced), while the complaint of pain injuries seem to exhibit only seasonal variation.

Figures 2.29 and 2.30 pertain to injured body parts. Both head and face injuries (Figure 2.29) appear to be declining over time, although it is not at all clear whether the decline is associated with the onset of the seat belt law. Neck injuries appear to be slightly increasing. The trends for the head and neck injuries are similar to the results in New Jersey. Chest/abdomen/pelvis injuries (Figure 2.30) appear to have increased since the onset of the

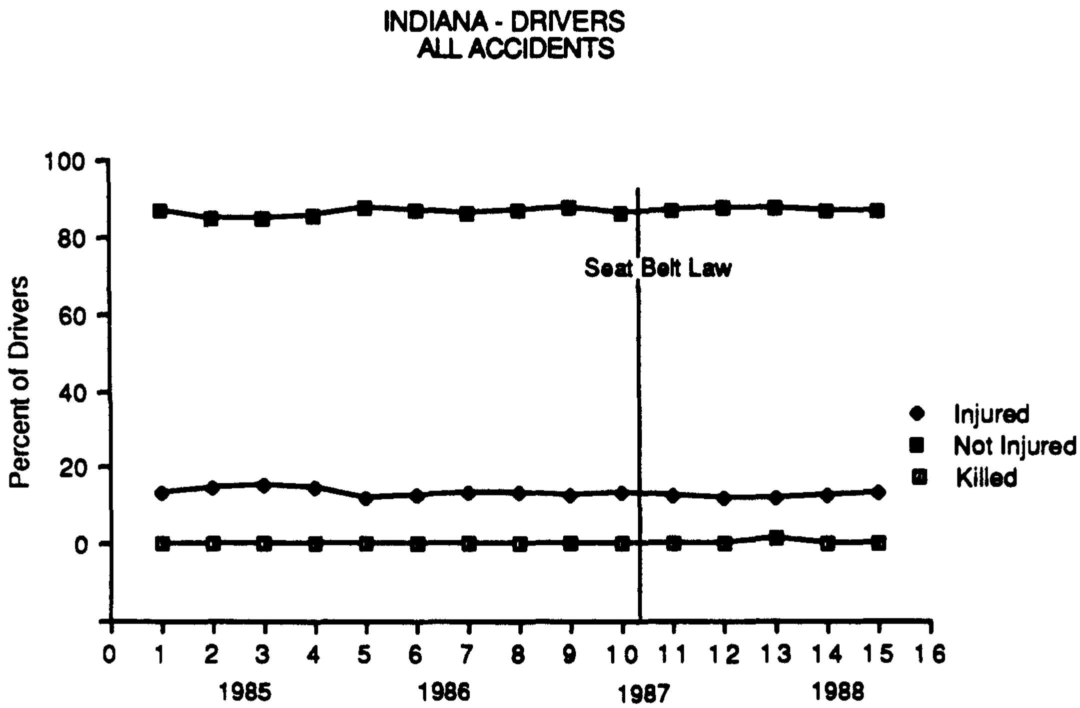


Figure 2.26. Percent of Indiana drivers in all accidents killed, injured, or not injured across time periods.

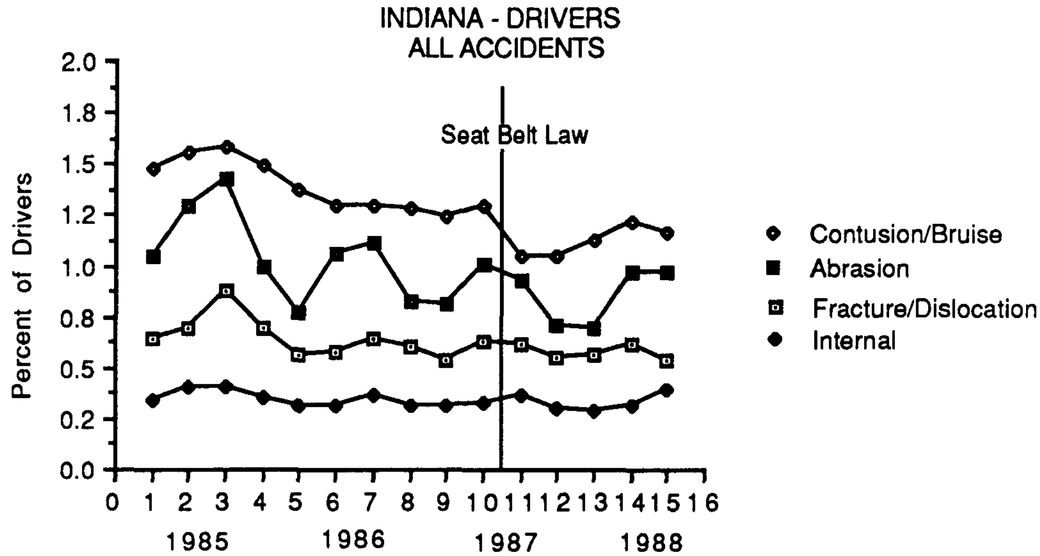


Figure 2.27. Percent of Indiana drivers in all accidents with certain injury types across time periods.

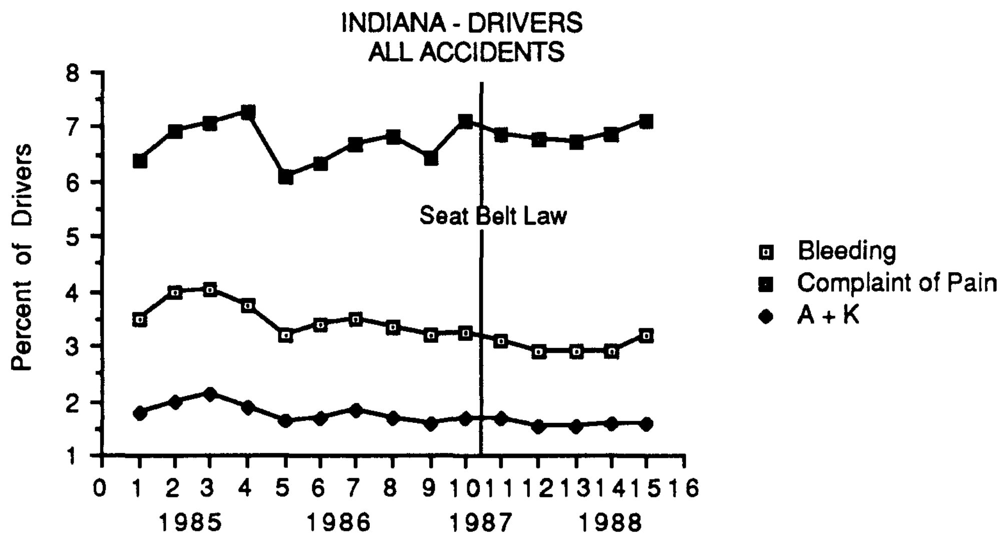


Figure 2.28. Percent of Indiana drivers in all accidents with complaint of pain, bleeding or serious (A+K) injuries across time periods.

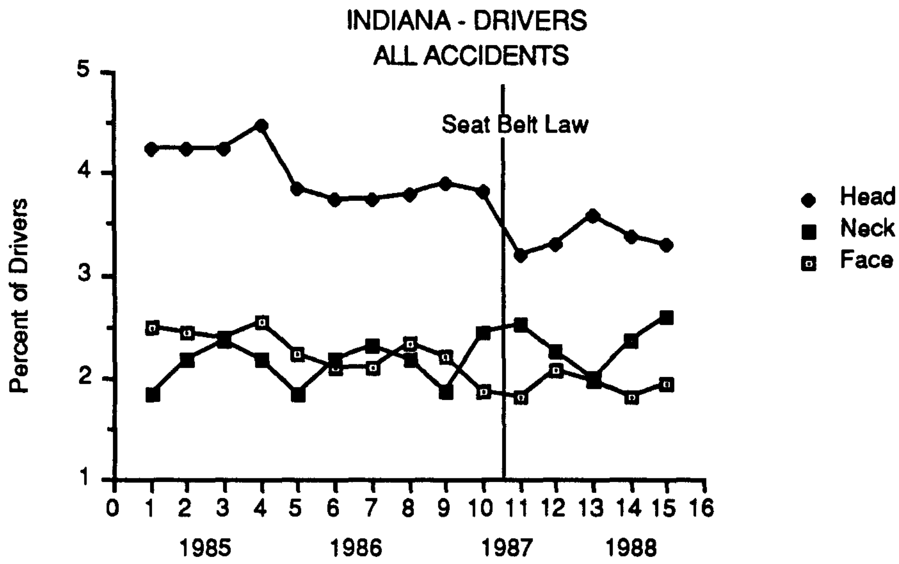


Figure 2.29. Percent of Indiana drivers in all accidents with certain injury locations across time periods.

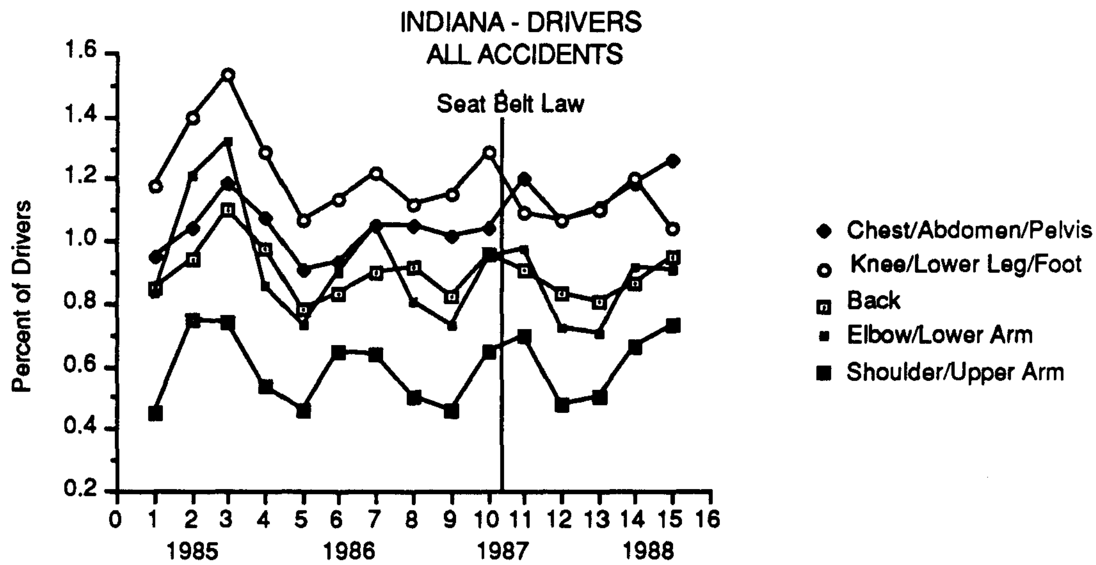


Figure 2.30. Percent of Indiana drivers in all accidents with certain injury locations across time periods.

seat belt law, while knee/lower leg and elbow/lower arm injuries appear to have slightly declined.

A Comparison of Rollover and Non-Rollover Accidents. The remaining portion of this analysis covers several accident types, the first of which are rollovers and non-rollovers. Figure 2.31 pertains to serious (A+K) and bleeding injuries. Here the Indiana data behave much like the Pennsylvania data, in that there is some seasonal variation, although no apparent upward or downward trend. Figure 2.32 is a companion plot that pertains to non-rollover serious (A+K) and bleeding injuries. The non-rollover bleeding injuries seem to be decreasing over time, but the effect appears to be long term and not associated with the onset of the seat belt law.

Figure 2.33 portrays the percent of uninjured drivers in rollover and non-rollover crashes. While the percent uninjured in non-rollover crashes appears relatively constant at around 86 percent, a range in percent from about 40 to 60 is the case for the drivers in rollover crashes, with perhaps only a seasonal trend.

The last set of plots (Figures 2.34-2.37) for this group concern the part of the body injured. In Figure 2.34, neck injuries appear to be slightly increasing over time, while the trends for head and face injuries are unclear. For the non-rollover crashes (Figure 2.35), both the head and face injuries appear to slightly decrease after the seat belt law, while again the opposite is true for the neck injuries. For the other body parts, only the chest/abdomen/pelvis injuries show much of a change over time, and here the trend is slightly upward for the non-rollover crashes (Figure 2.37).

A Comparison of Head-On and Non-Head-On Accidents. The next accident types examined are head-on and non-head-on impacts. Figure 2.38 portrays the serious (A+K) and bleeding injuries for the head-on impacts. Although the trend is not strong, it appears that over time the bleeding injuries are slightly decreasing. This change does not appear to be associated with the onset of the seat belt law, however. The same type of result appears for the non-head-on accidents (Figure 2.39). The percentage of drivers uninjured in both head-on and non-head-on crashes appears unchanged over time (Figure 2.40).

Examining the driver body part injuries shows some change for these crashes. In head-on events, injuries both to the head and face appear to decline over time, while neck injuries again appear to slightly increase (Figure 2.41). However, none of these changes appear directly related to the

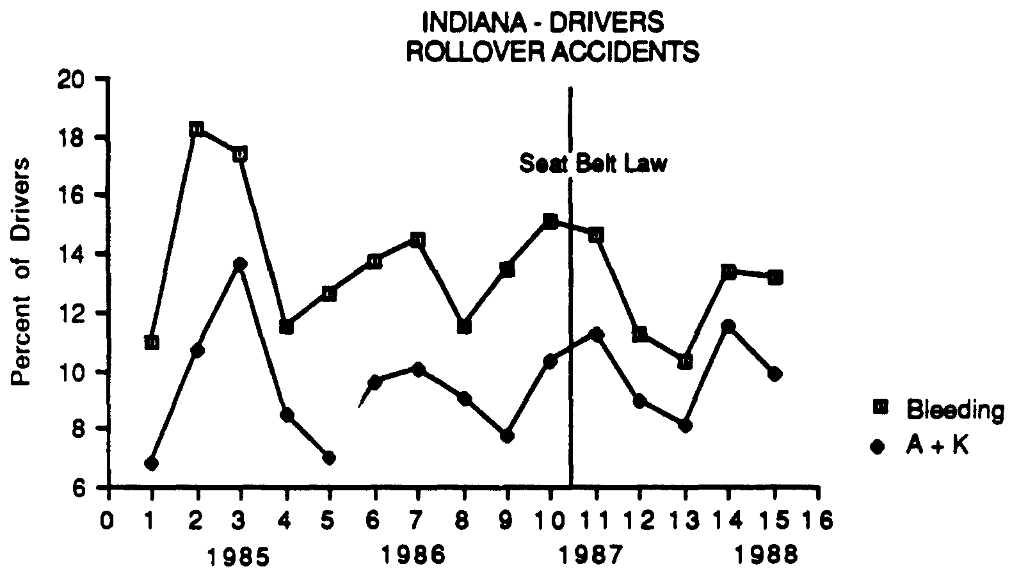


Figure 2.31. Percent of Indiana drivers in rollover accidents with bleeding or serious (A+K) injuries across time periods.

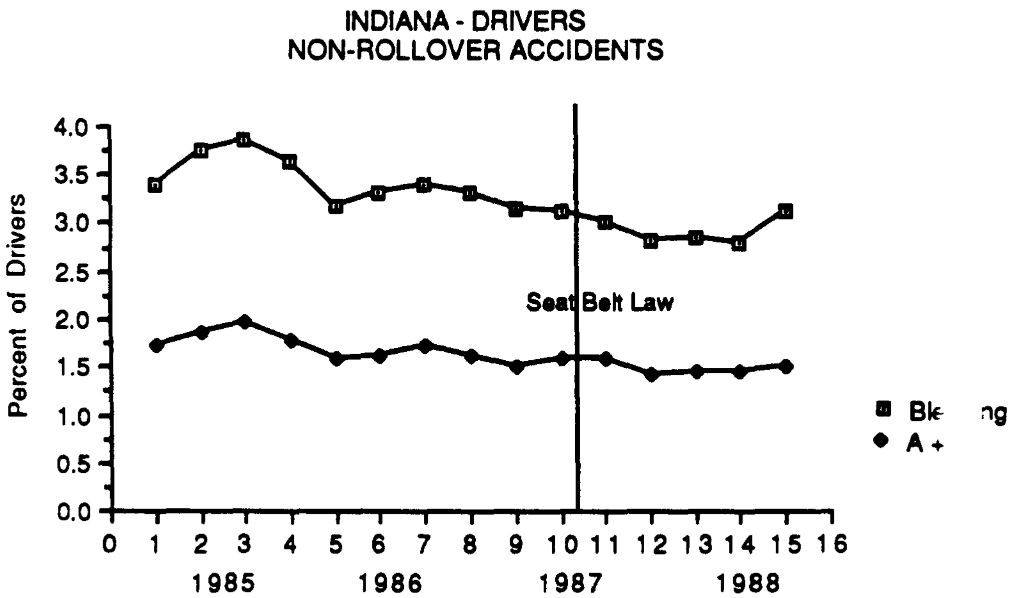


Figure 2.32. Percent of Indiana drivers in non-rollover accidents with bleeding or serious (A+K) injuries across time periods.

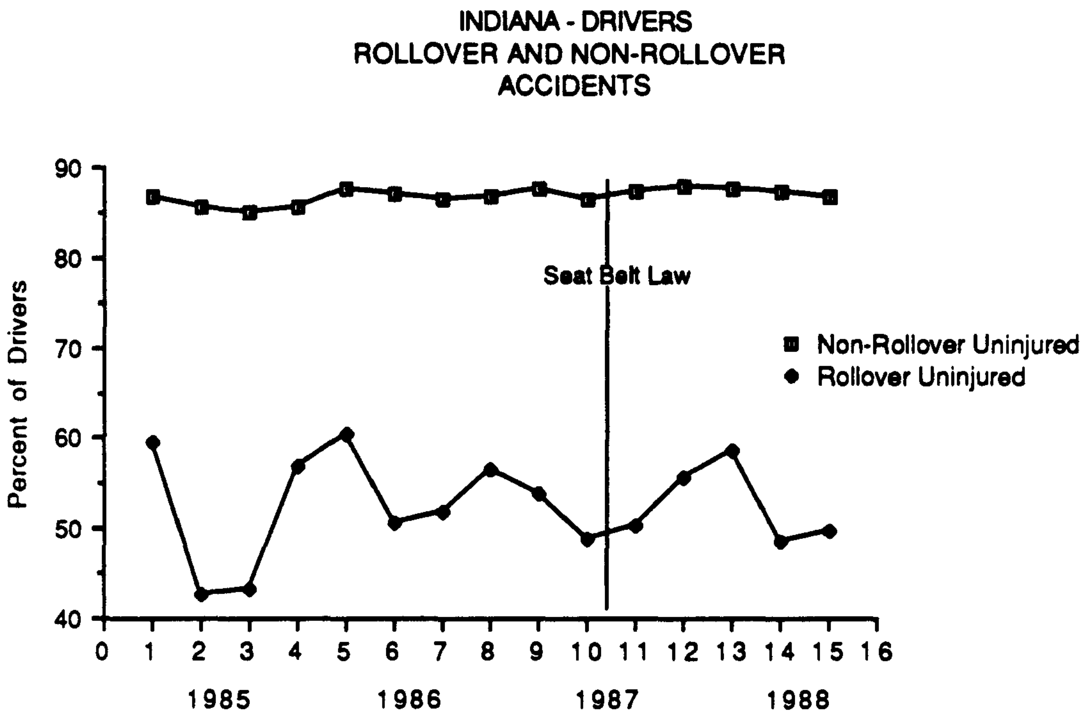


Figure 2.33. Percent of uninjured Indiana drivers in rollover and non-rollover accidents across time periods.

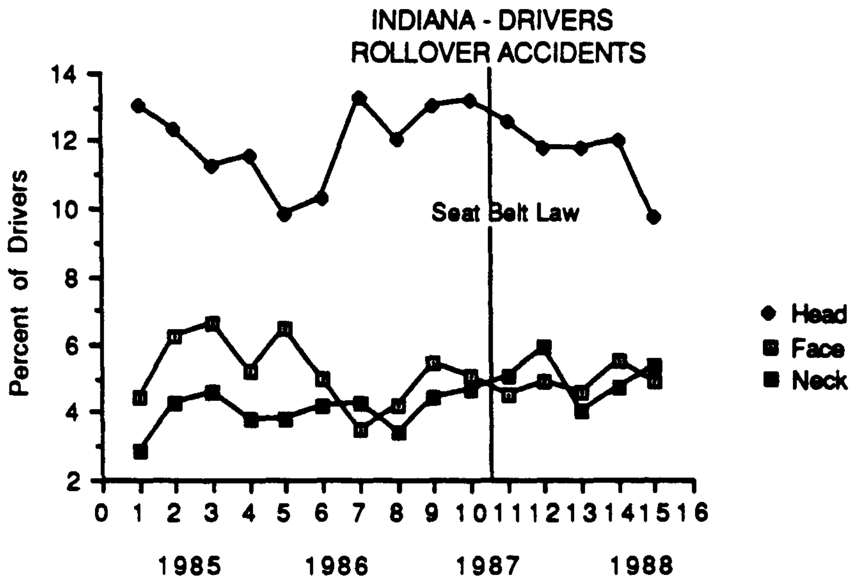


Figure 2.34. Percent of Indiana drivers in rollover accidents with head, neck, and face injuries across time periods.

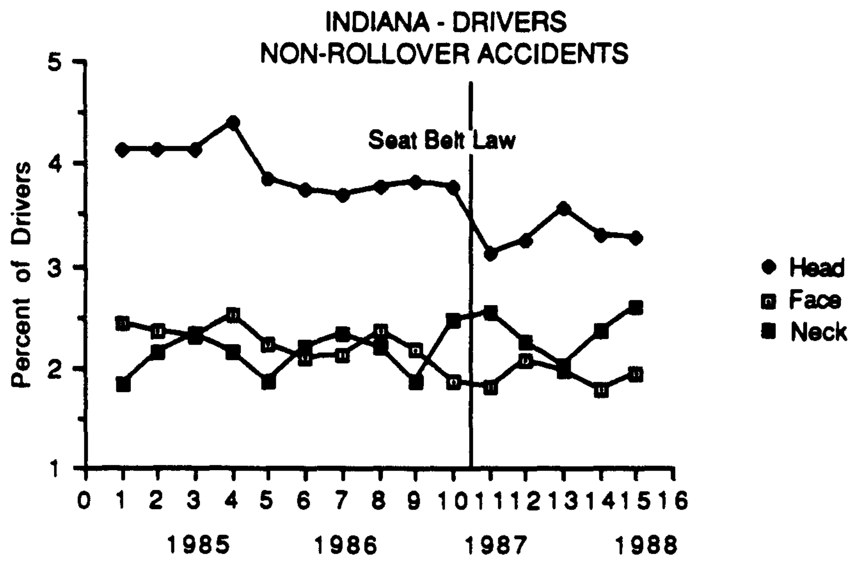


Figure 2.35. Percent of Indiana drivers in non-rollover accidents with head, neck, and face injuries across time periods.

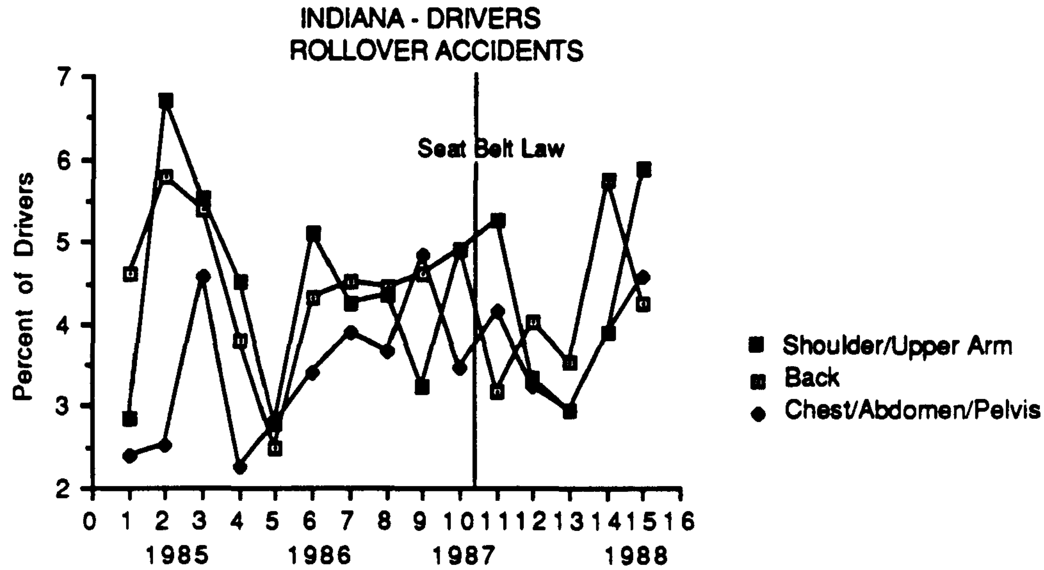


Figure 2.36. Percent of Indiana drivers in rollover accidents with certain injury locations across time periods.

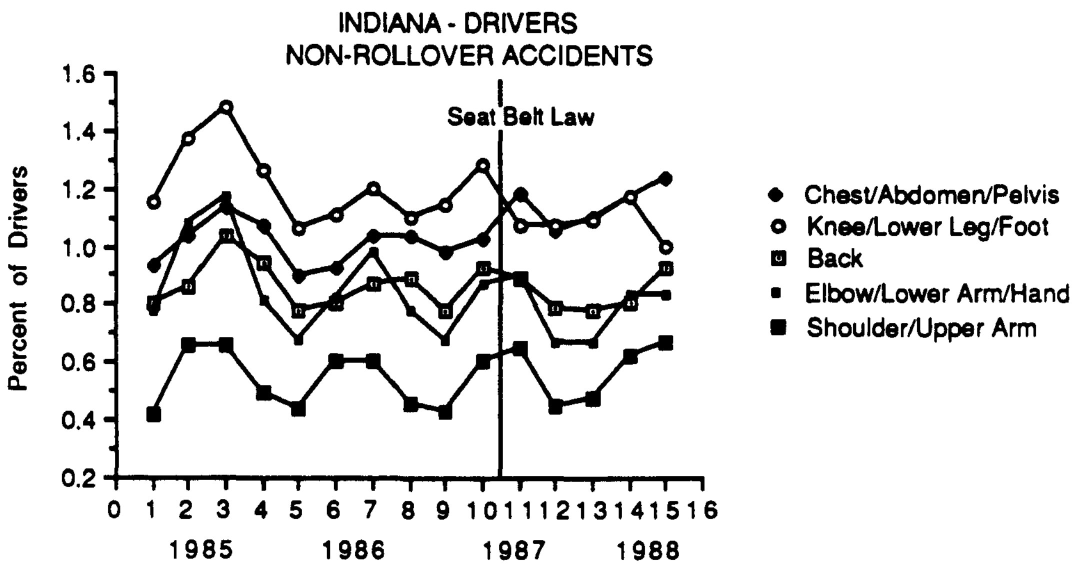


Figure 2.37. Percent of Indiana drivers in non-rollover accidents with certain injury locations across time periods.

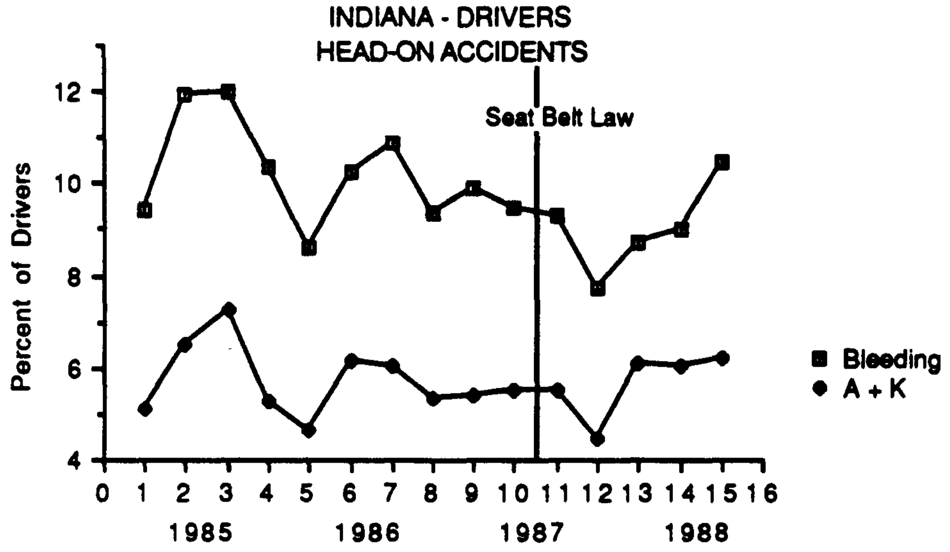


Figure 2.38. Percent of Indiana drivers in head-on accidents with bleeding and serious (A+K) injuries across time periods.

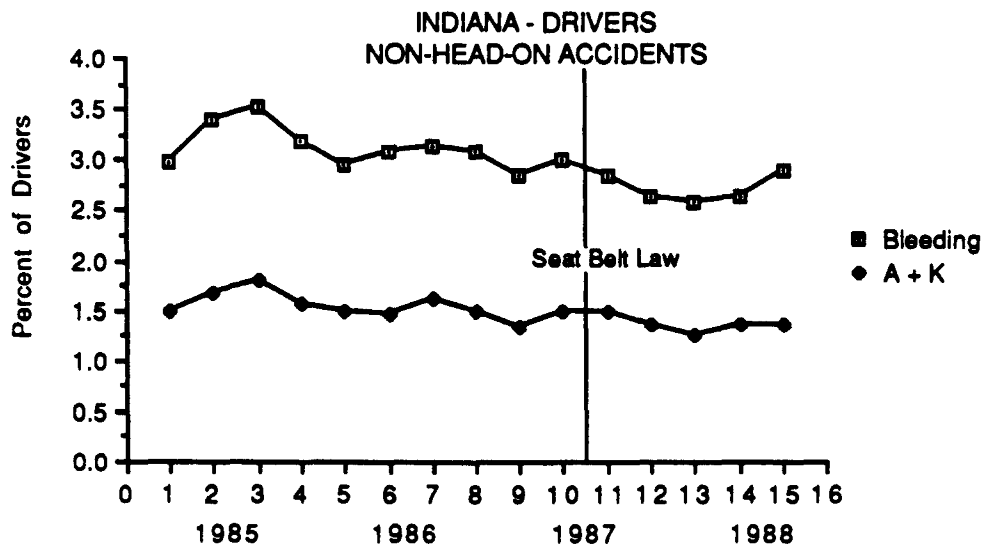


Figure 2.39. Percent of Indiana drivers in non-head-on accidents with bleeding and serious (A+K) injuries across time periods.

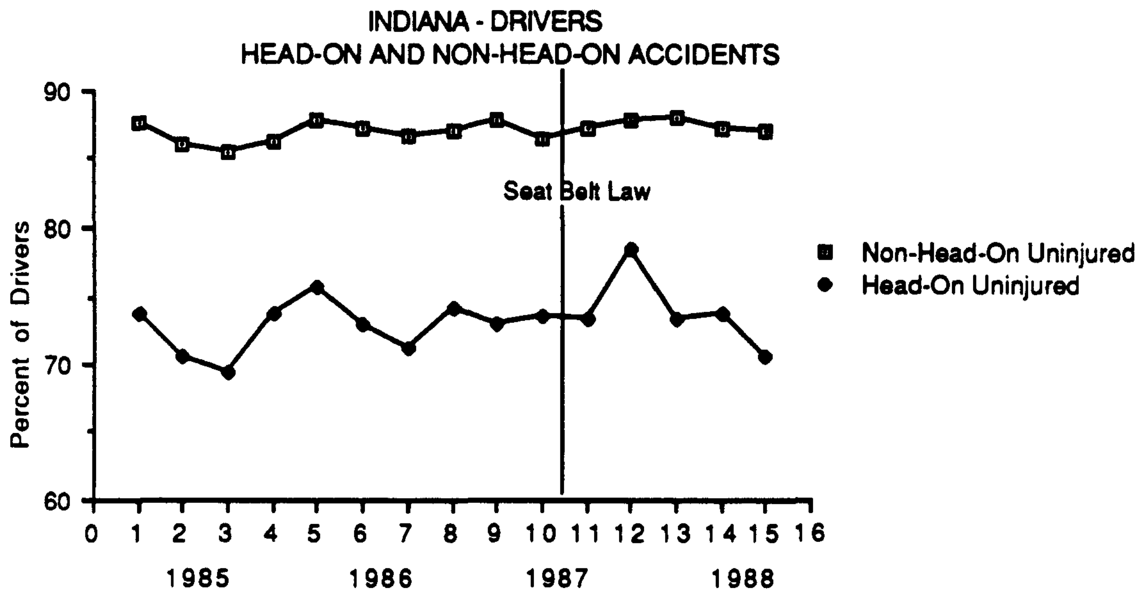


Figure 2.40. Percent of uninjured Indiana drivers in head-on and non-head-on accidents across time periods.

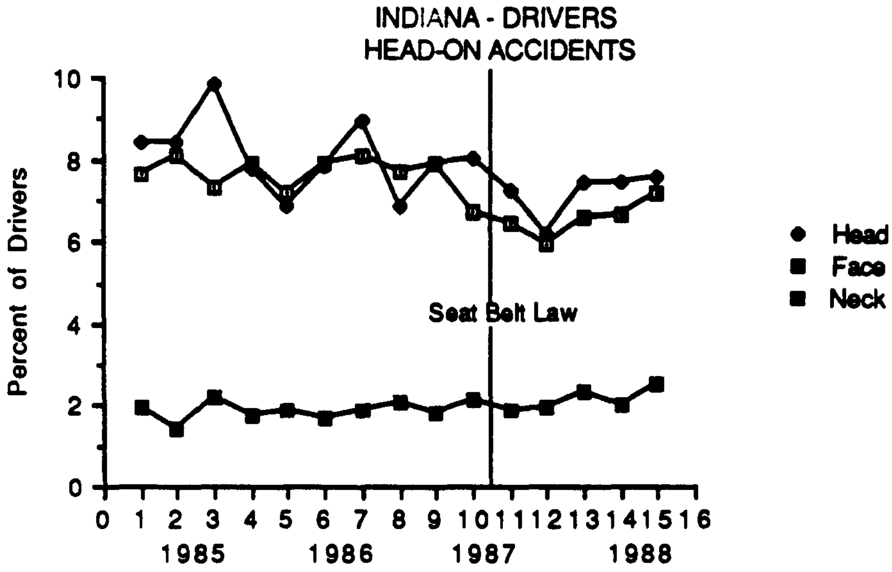


Figure 2.41. Percent of Indiana drivers in head-on accidents with head, face, and neck injuries across time periods.

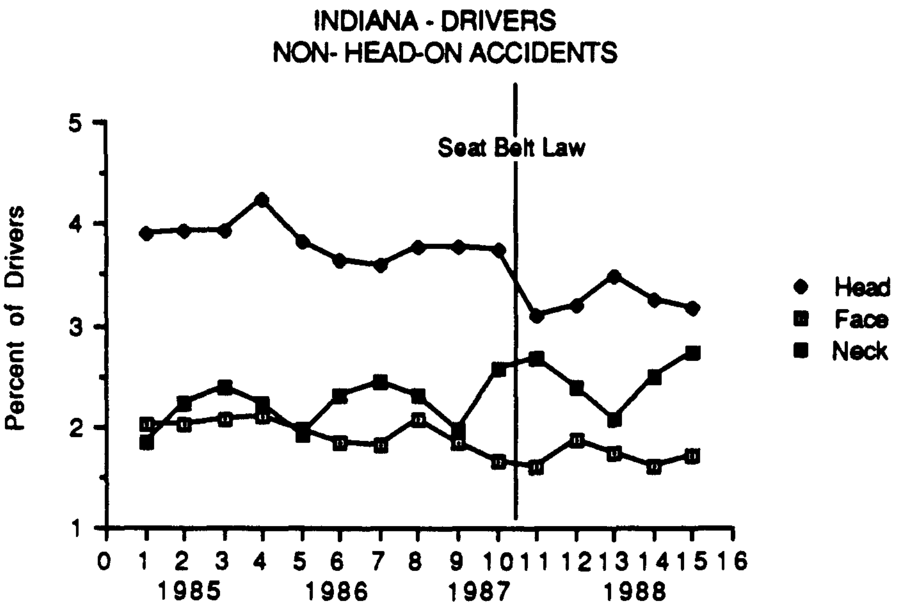


Figure 2.42. Percent of Indiana drivers in non-head-on accidents with head, face, and neck injuries across time periods.

seat belt law. The same types of changes can be seen in the non-head-on crashes (Figure 2.42). In this plot, however, there does appear to be a shift to fewer head injuries after the belt law becomes effective.

Figures 2.43 and 2.44 show injuries to other parts of the body. The only apparent change involves an increase to chest/abdomen/pelvis injuries, and in both plots the changes appear to occur when the seat belt law becomes effective. The overall trends for injuries by body region resemble those for New Jersey and Pennsylvania.

A Comparison of Single-Vehicle and Multi-Vehicle Accidents. The next crash types examined are single-vehicle and multi-vehicle. For single-vehicle serious (A+K) and bleeding injuries, some seasonal variation is present but no clear cut trend (Figure 2.45). The multi-vehicle crashes show a slight downward trend over time for these same injuries (Figure 2.46), but the trend seems long term and not associated with the seat belt law. The increased severity of the single-vehicle compared to the multi-vehicle crashes is evident in Figure 2.47 (uninjured drivers), but no trend within crash type can be identified.

For the body part injuries, the results are similar to those seen for other Indiana crashes. The trends show decreases in head and face injuries and an increase in neck injuries for both single- (Figure 2.48) and multi-vehicle (Figure 2.49) crashes. The single-vehicle plots show no apparent changes for the other body part injuries (Figure 2.50), but the multi-vehicle plots show a slight increase in chest/abdomen/pelvis injuries over time (Figure 2.51). Once again, none of these changes appears to be associated with the seat belt law.

Summary. For the Indiana data examined, the changes in the percentage of injuries for drivers covered by the seat belt law are relatively similar to those seen for the covered occupants in New Jersey. For all accidents, head and face injuries tend to decline over time, and neck and chest/abdomen/pelvis injuries tend to increase. The same tendency is present for the different crash types examined. However, almost all of the changes appear to be long term and not directly associated with the seat belt law.

A Comparison of Restrained and Unrestrained Occupants

To address the question of how restrained people are injured, we used pre-law 1984 accident data for New Jersey and Pennsylvania in order to minimize the bias in police-reported usage rates found after the introduction of a belt law.

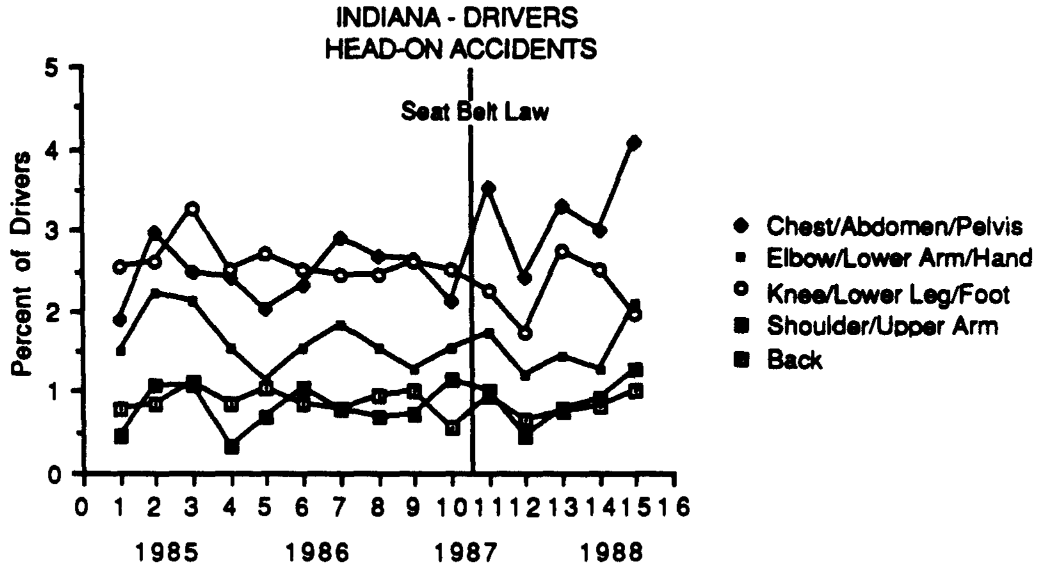


Figure 2.43. Percent of Indiana drivers in head-on accidents with certain injury locations across time periods.

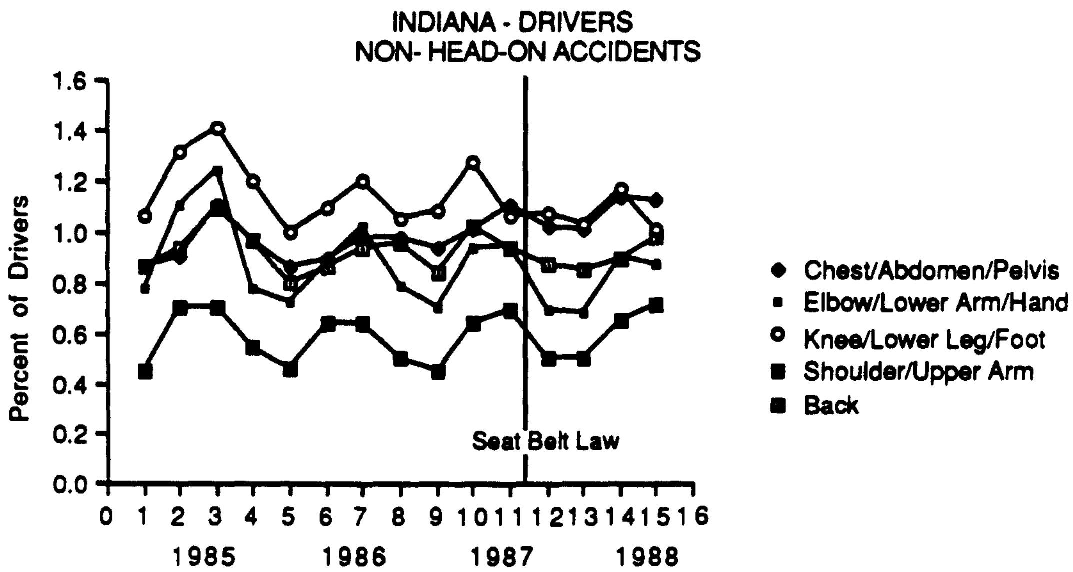


Figure 2.44. Percent of Indiana drivers in non-head-on accidents with certain injury locations across time periods.

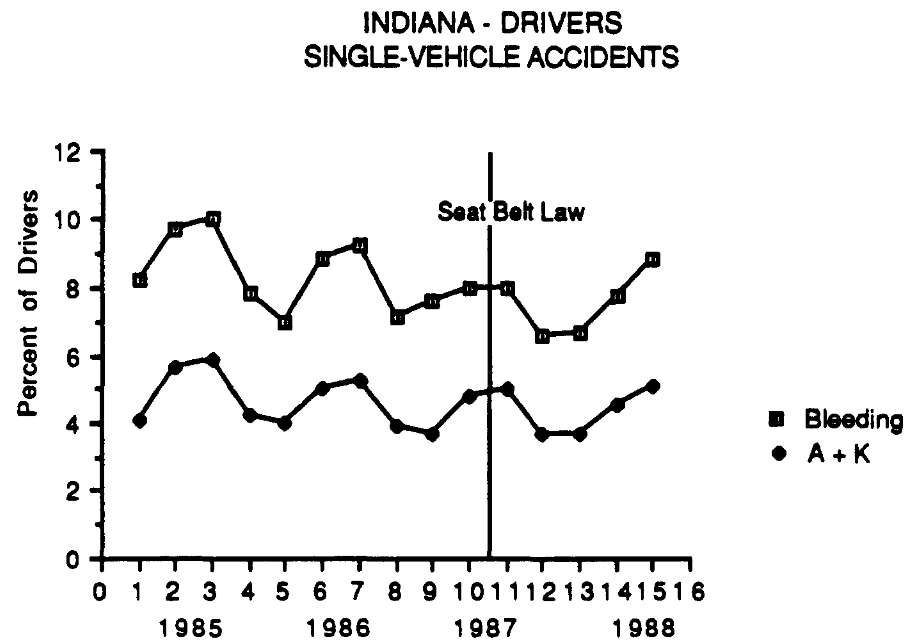


Figure 2.45. Percent of Indiana drivers in single-vehicle accidents with bleeding and serious (A+K) injuries across time periods.

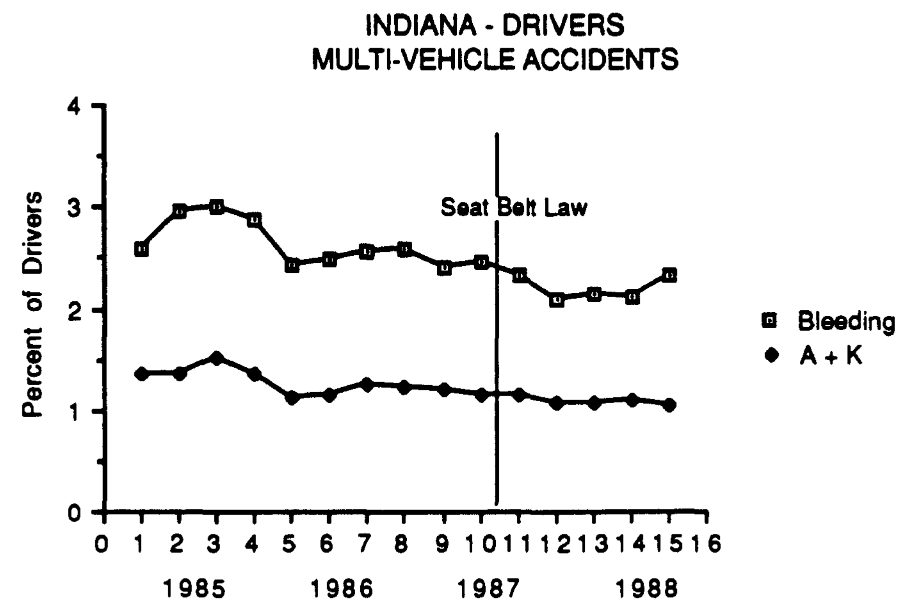


Figure 2.46. Percent of Indiana drivers in multi-vehicle accidents with bleeding and serious (A+K) injuries across time periods.

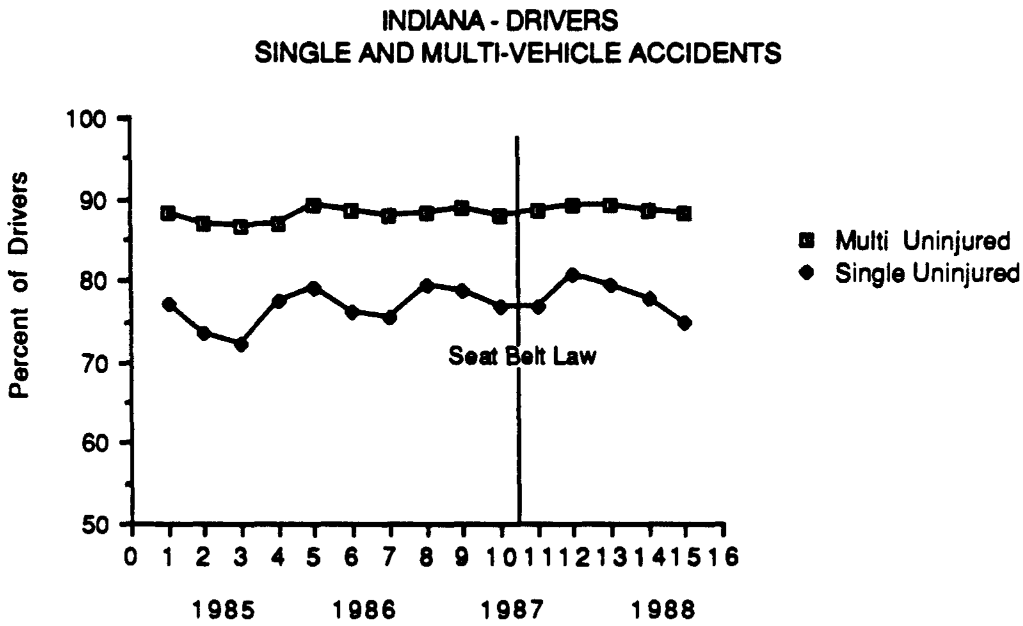


Figure 2.47. Percent of uninjured Indiana drivers in single- and multi-vehicle accidents across time periods.

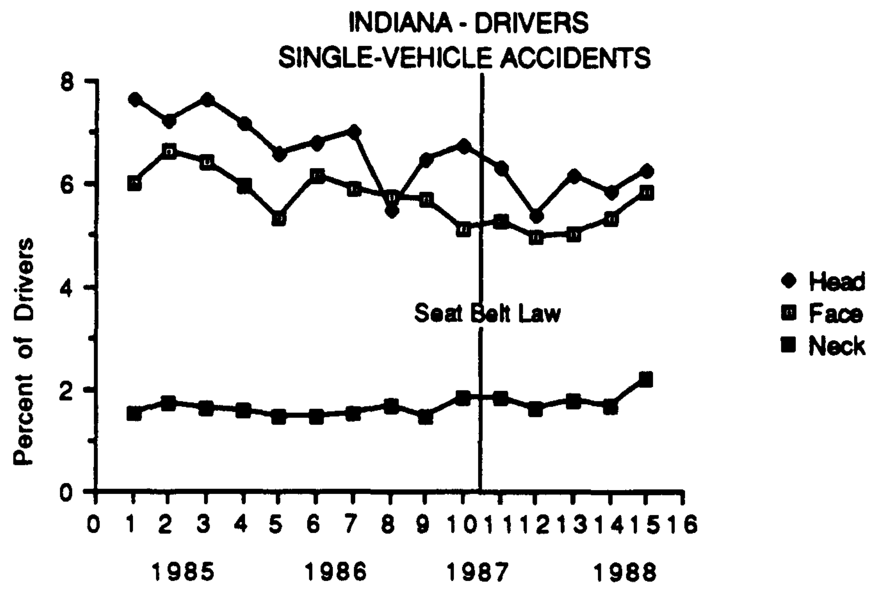


Figure 2.48. Percent of Indiana drivers in single-vehicle accidents with head, face, and neck injuries across time periods.

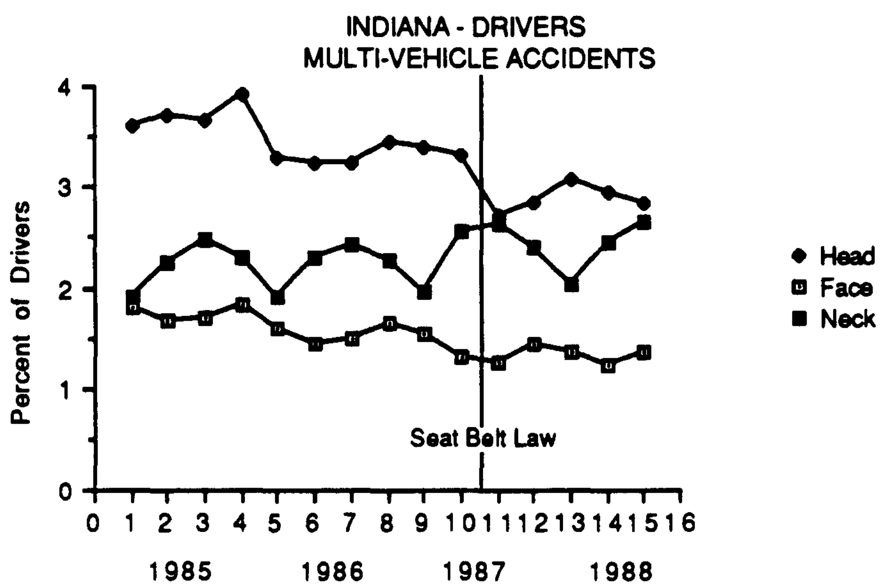


Figure 2.49. Percent of Indiana drivers in multi-vehicle accidents with head, face, and neck injuries across time periods.

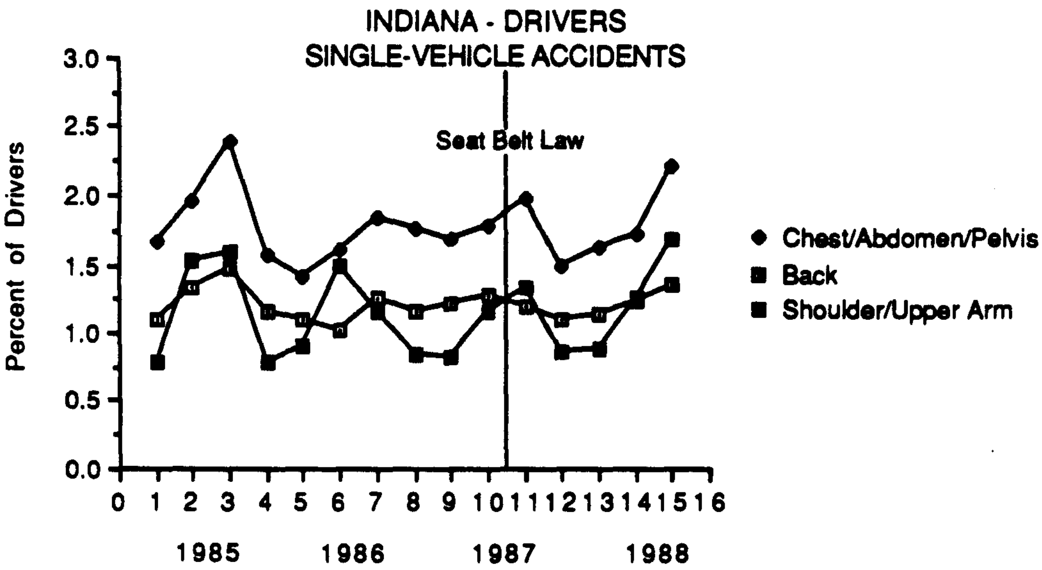


Figure 2.50. Percent of Indiana drivers in single-vehicle accidents with certain injury locations across time periods.

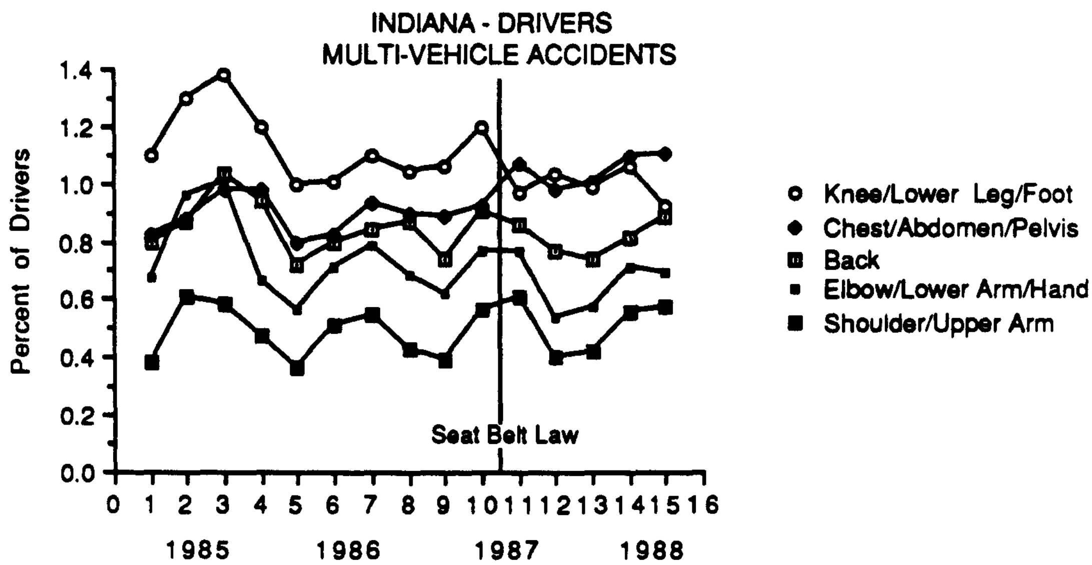


Figure 2.51. Percent of Indiana drivers in multi-vehicle accidents with certain injury locations across time periods.

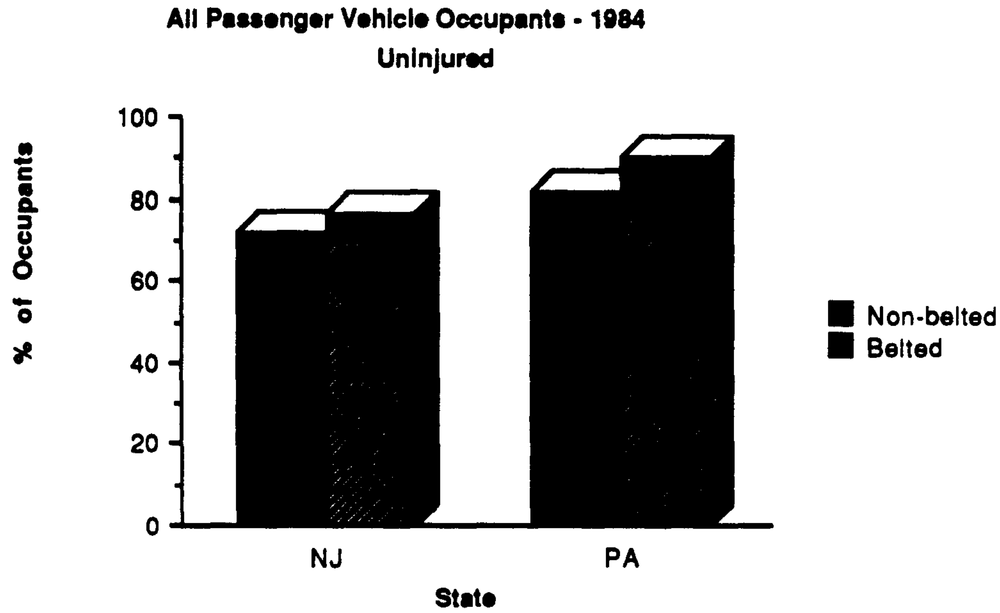
Data from 1984 are the earliest available data for both states in this current report. All occupants in passenger vehicles over the age of five are included and have been categorized according to restraint usage: belted or non-belted. An attempt was made to exclude vehicles whose model year was pre-1974, but due to model year not being available for New Jersey, this could not be done.

Data available to characterize injuries in both New Jersey and Pennsylvania are injury severity, nature of injury, and injury location. These data were compared for belted and non-belted occupants within each of the states for all crashes. Also of interest was how occupants are injured in specific types of crashes. These types include: rollovers, head-ons, single vehicle crashes, and ejection accidents. The statistical significance for selected comparisons is assessed by means of the z-statistic for the difference of two proportions (Fleiss, 1973).

Overall Results. From Figure 2.52, for all accidents in Pennsylvania and New Jersey, occupants who are belted are injured less, and when injured sustain less severe injuries then those occupants who are nonbelted. In New Jersey, the proportions of restrained and unrestrained occupants who are uninjured are 77 percent and 72 percent, respectively, while in Pennsylvania, the corresponding proportions are 90 percent and 82 percent. (Pennsylvania, even with its higher reporting threshold, has a higher proportion of uninjured occupants because complaint of pain injuries are included with the uninjured.) In both states, these differences are significant ($p < .001$). When seat belts are used, the odds of sustaining a major injury or being killed are about half as much as when seat belts are not being used. For New Jersey, the proportions are 0.9 percent vs. 1.6 percent, belted vs. not belted, and for Pennsylvania 1.4 percent vs. 3.3 percent, respectively.

The most common injury types for all occupants of vehicles involved in accidents are: complaint of pain; bleeding; contusions, bruises and abrasions; fractures and dislocations; and concussions. The difference in the proportion of restrained and unrestrained occupants reporting complaint of pain as the most severe type of injury was minimal in both states (15.8 percent vs. 16.5 percent, respectively, in New Jersey, and 4.2 percent vs. 5.2 percent, respectively, in Pennsylvania); likewise, for the proportion reporting contusions, bruises and abrasions as their most severe type of injury. Concussions, fractures and dislocations, and bleeding injuries were about twice

a)



b)

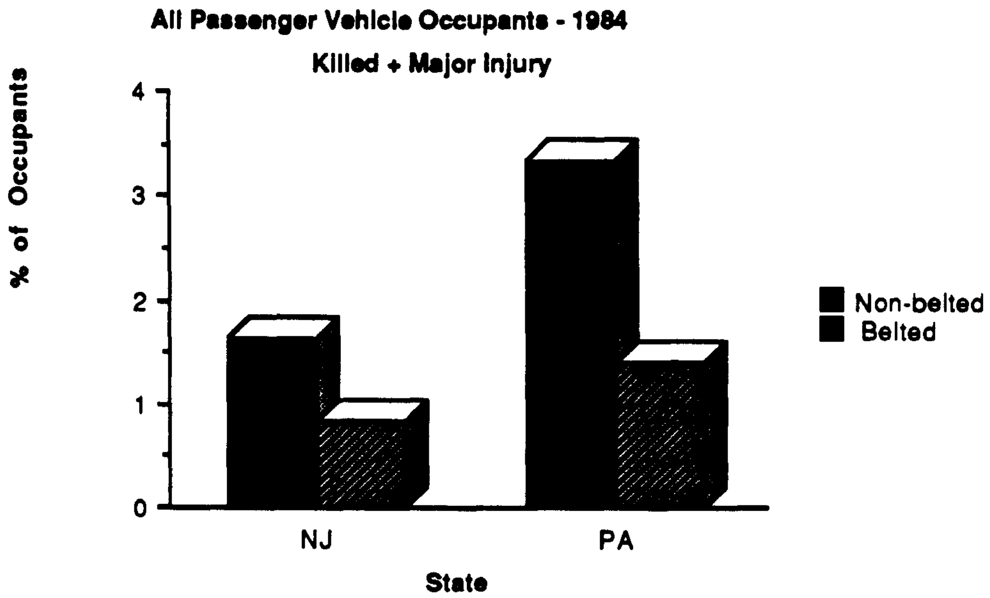


Figure 2.52. Percent of belted and unbelted occupants in all accidents uninjured, and with major or fatal injuries.

as likely to happen to non-belted occupants as belted occupants in both New Jersey and Pennsylvania. (See Figures 2.53 and 2.54)

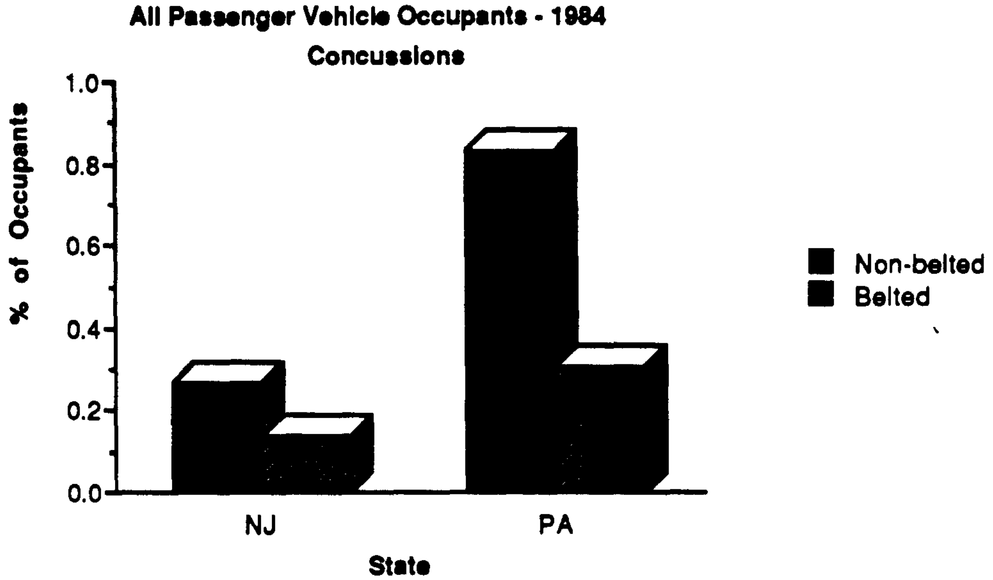
Figure 2.55 shows the distribution of injury locations for all occupants in both New Jersey and Pennsylvania. The percentage of head (H) and face (F) injuries is clearly smaller when belts are used than when belts are not used. In New Jersey, the percentage of neck (N) injuries rises slightly when seat belts are used compared to when belts are not being used, while in Pennsylvania the percentage of neck injuries is slightly smaller when seat belts are used. For both states, again a slightly larger percentage of belted occupants sustained chest/abdomen (C) injuries than non-belted occupants.

Rollover Accidents. Figure 2.56 shows the distribution of the percentage uninjured occupants -- belted and non-belted -- in rollover (R) accidents and all other (O) accidents. A smaller percentage of occupants remain uninjured in rollover accidents than in other accidents, and in both New Jersey and Pennsylvania the percentage of uninjured is consistently higher for restrained occupants than for unrestrained occupants. The percent injured in New Jersey in rollover accidents is 53 percent for unrestrained occupants and 45 percent for restrained occupants. In Pennsylvania, the corresponding percentages of injured occupants in rollover accidents are 40 percent and 23 percent. Both of these differences are significant at the $p = .001$ level.

Figure 2.56b shows A+K comparisons for rollover (R) and non-rollover (O) accidents. In both states the percentage of A+K is highest for unrestrained occupants in rollover accidents. In Pennsylvania, more so than in New Jersey, there is a reduction in A+K injuries when belts are used. In New Jersey, the percentages of A+K injuries are 6.3 percent and 4.8 percent for unrestrained and restrained occupants, respectively, and in Pennsylvania are 10.3 percent and 4.2 percent, respectively. The difference in the proportion of A+K injuries is significant in Pennsylvania ($p < .001$), but not in New Jersey ($p > .2$). In all other accidents, the percentage of A+K injuries is lower than in rollover accidents, and as before restrained occupants incur a smaller percentage of A+K injuries than unrestrained occupants.

Figures 2.57 and 2.58 show the distribution of three of the most common types of injuries in rollover (R) and non-rollover (O)accidents: concussions, contusions, and bleeding. In rollover accidents in both states, there is a reduction in the percentage of these three types of injuries when restraints

a)



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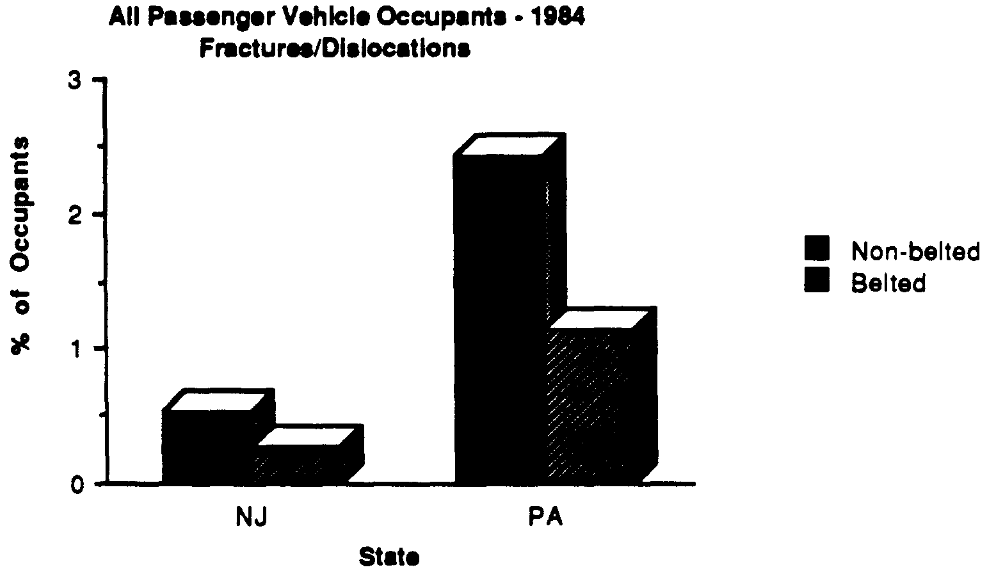
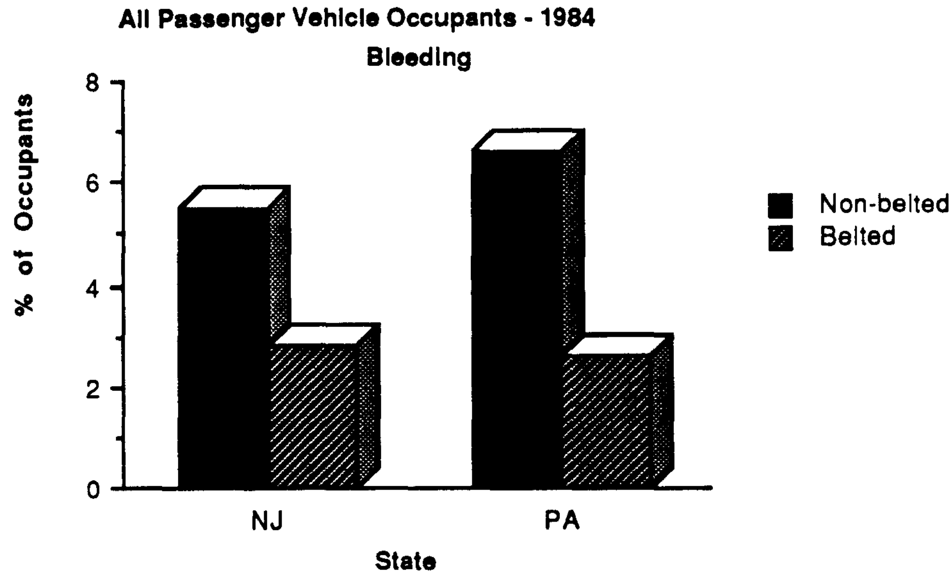


Figure 2.53. Percent of belted and unbelted occupants with concussions or fractures/dislocations.

a)



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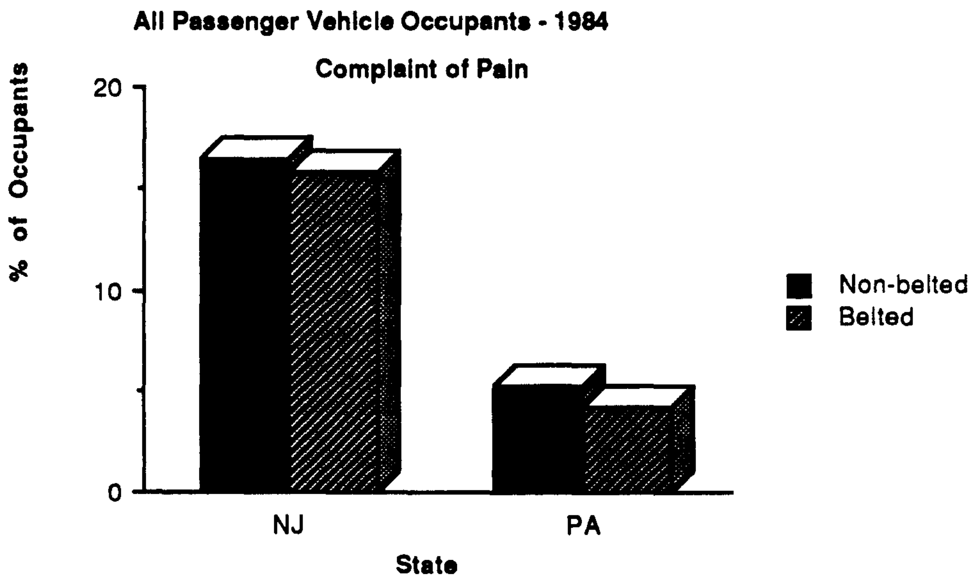
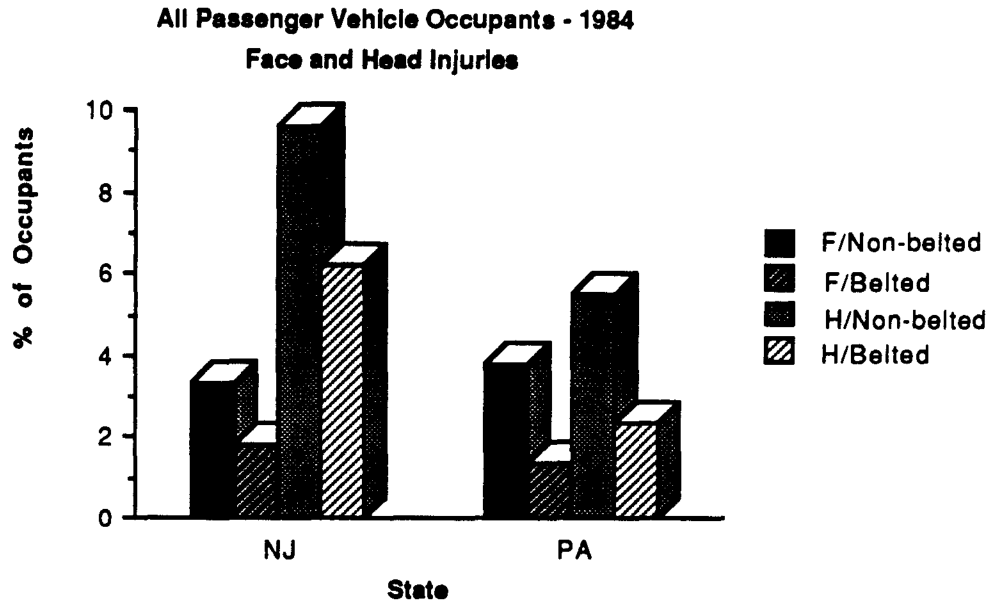


Figure 2.54. Percent of belted and unbelted occupants with bleeding or complaint of pain injuries.

a)



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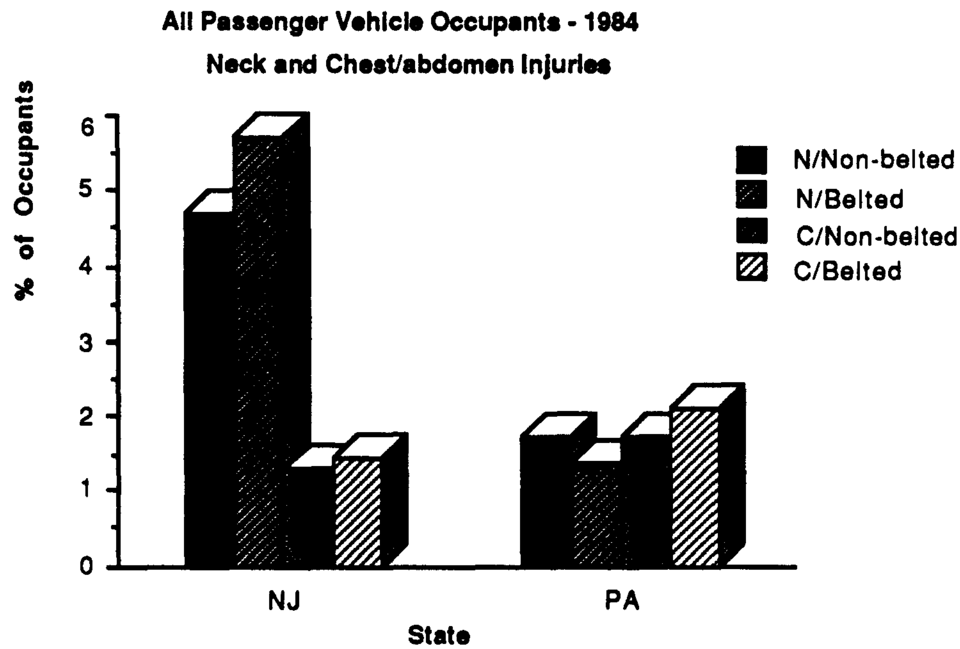
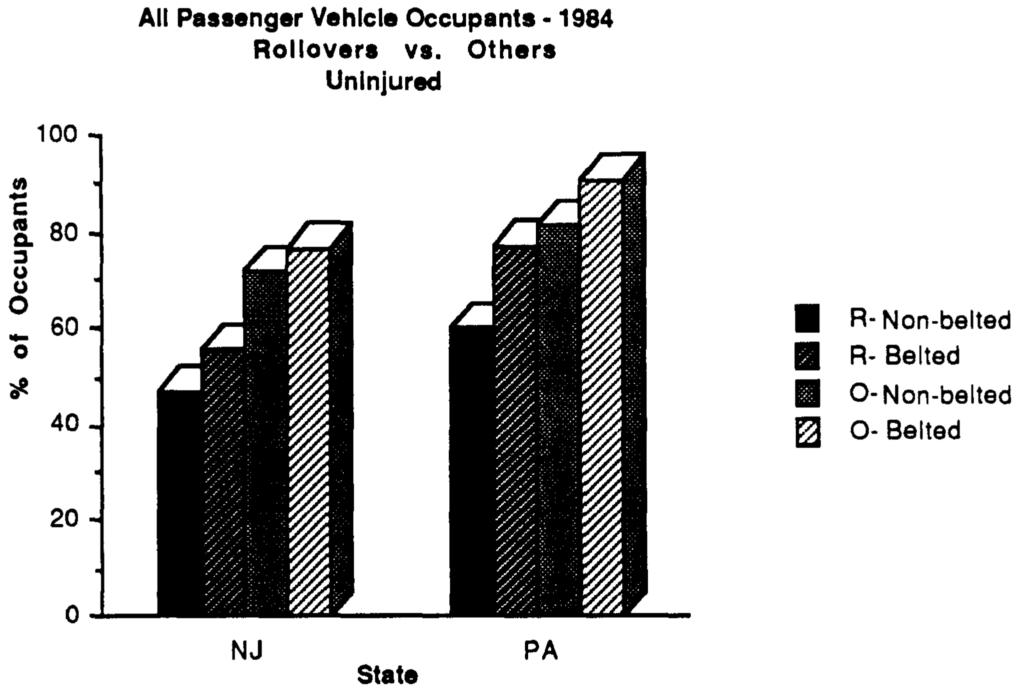


Figure 2.55. Percent of belted and unbelted occupants with certain injury locations.

a)



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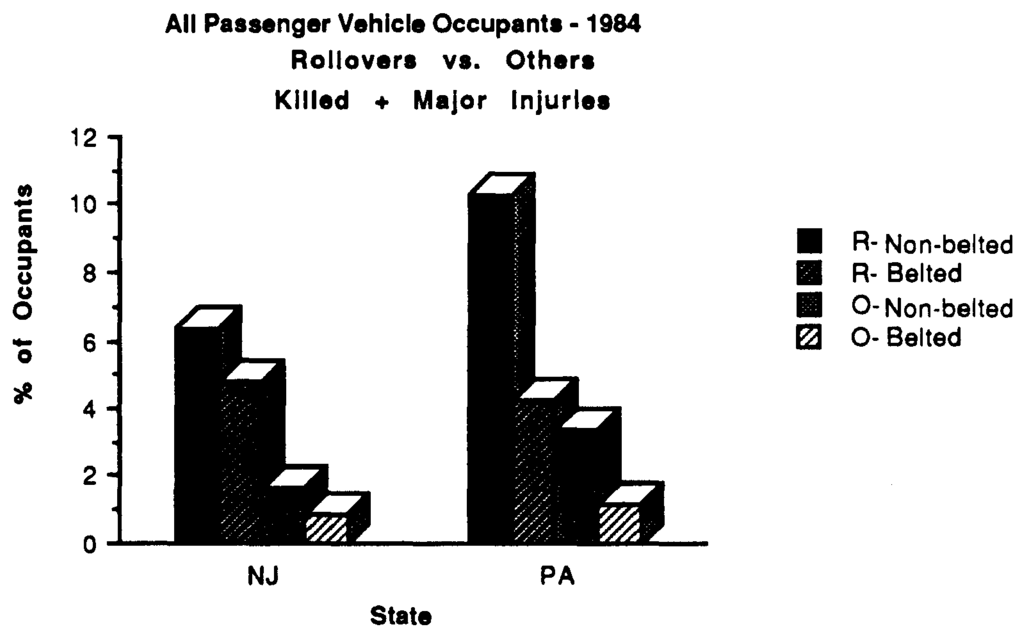
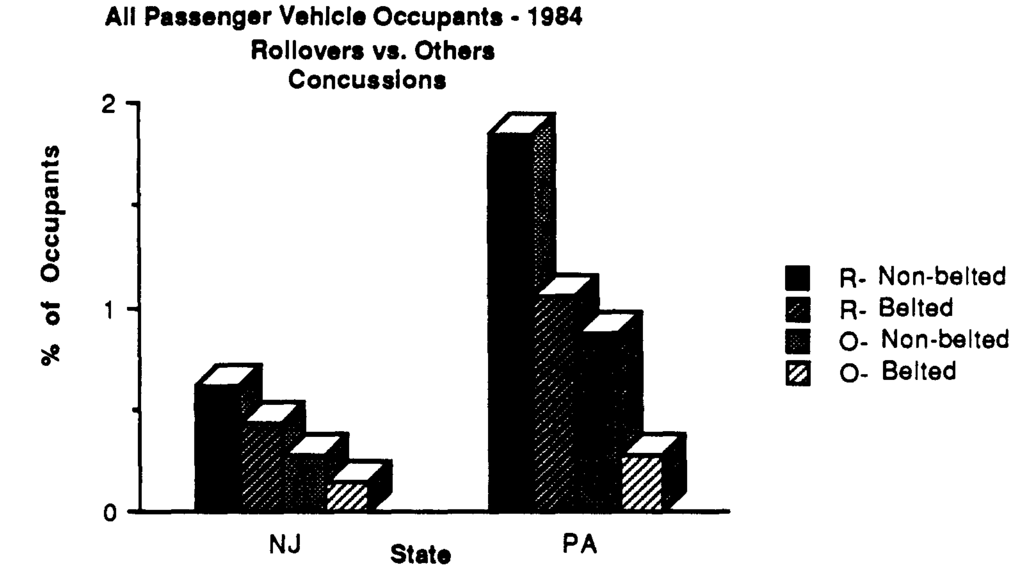


Figure 2.56. Percent of belted and unbelted occupants in rollover or other accidents uninjured, or with major or fatal injuries.

a)



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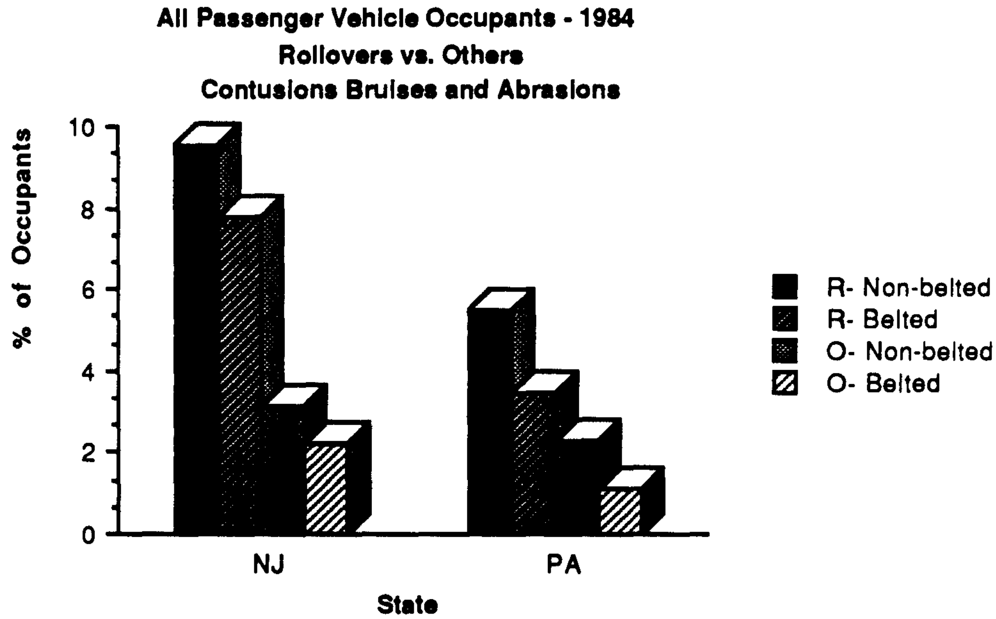


Figure 2.57. Percent of belted and unbelted occupants in rollover or other accidents with concussions or contusions.

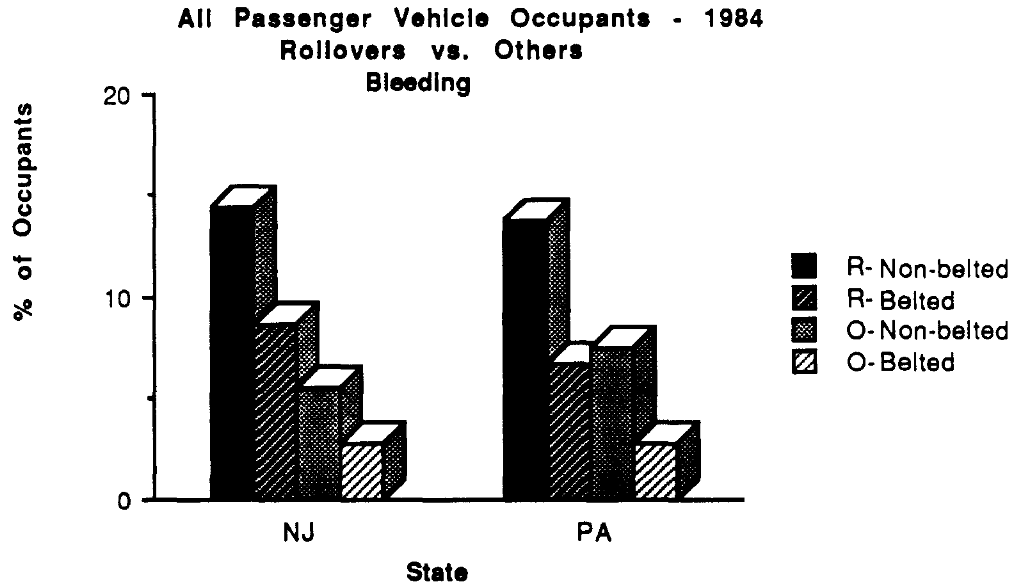


Figure 2.58. Percent of belted and unbelted occupants in rollover or other accidents with bleeding injuries.

are used. A similar pattern exists for all other accidents; as expected, the percentages are smaller for non-rollover accidents.

In rollover accidents injuries to the head, face, back and arm are the most common. Figures 2.59 and 2.60 show that there is a reduction in these injuries in rollover crashes when restraints are used in both New Jersey and Pennsylvania. Comparisons between rollover accidents and all other accidents indicate a larger percentage of head, back and arm injuries in rollover accidents.

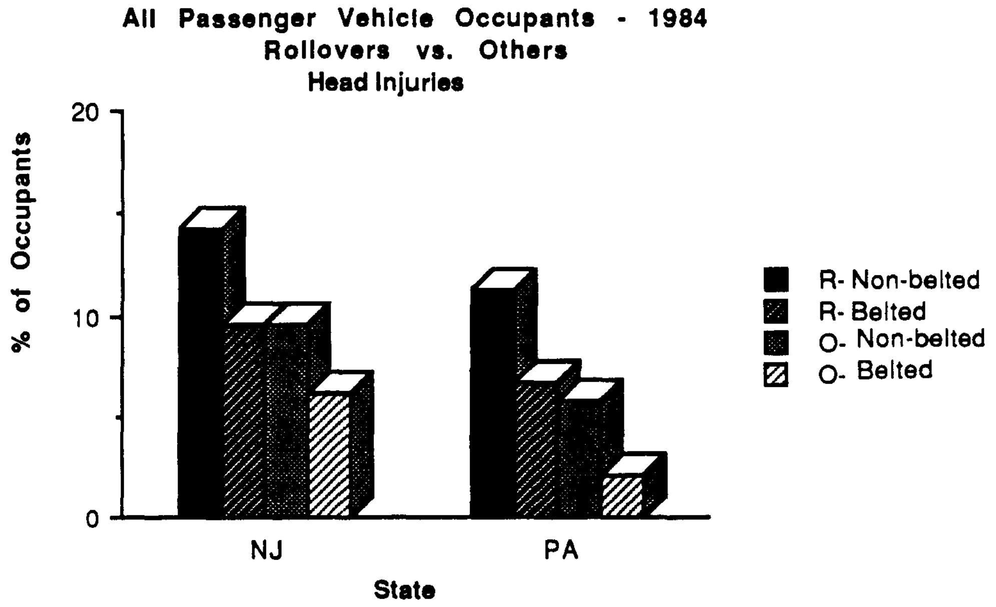
Head-on Accidents. The next item of interest is the head-on crash. Figure 2.61a presents the distribution of percent uninjured non-restrained and restrained occupants for head-on (H) and all other (O) types of crashes in New Jersey and in Pennsylvania. Similar to previous analyses, a smaller percentage of occupants are uninjured in head-on crashes than other accidents and for unrestrained occupants than restrained occupants (see Figure 2.61a). The respective percentages of injured are 26 percent for unrestrained occupants and 23 percent for restrained occupants in New Jersey, and 27 percent for unrestrained occupants and 16 percent for restrained occupants in Pennsylvania. The differences in the proportions in both states were statistically significant ($p < .001$). For both states, the A+K graph (see Figure 2.61) follows the same pattern as described for rollover crashes.

The distributions of bleeding and fracture and dislocation injuries are shown in Figure 2.62. The percentage of bleeding injuries is consistently higher for unrestrained people than for restrained occupants, in both states. Bleeding injuries also tend to occur with higher frequency in head-on (H) accidents than in other accidents (O). The same is true for fractures and dislocations (see Figure 2.62).

Figure 2.63 shows the distribution of concussions and contusions in head-on (H) and all other (O) accidents. In New Jersey, the percentage of contusions and concussions is consistently higher in head-on crashes than other accidents, and consistently higher among unrestrained occupants than among restrained occupants. The results are similar in Pennsylvania.

Figures 2.64, 2.65 and 2.66 show the percentages of injuries by body part injured. For head-on (H) crashes, the percentage of face and head injuries, as well as back injuries, is smaller for belted occupants than for non-belted occupants, while for chest/abdomen injuries the percentages are higher for belted occupants than non-belted occupants, for both states. The distribution

a)



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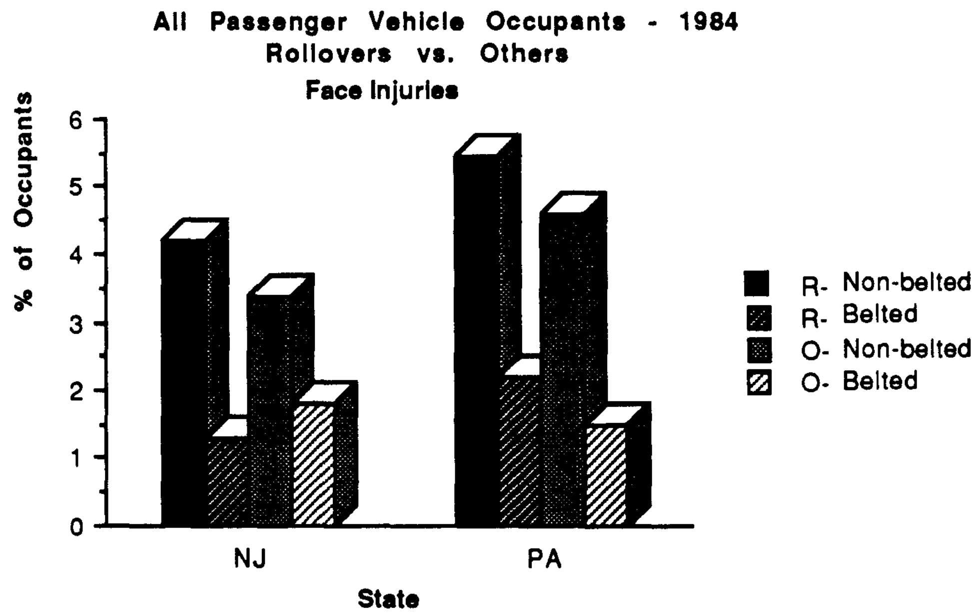
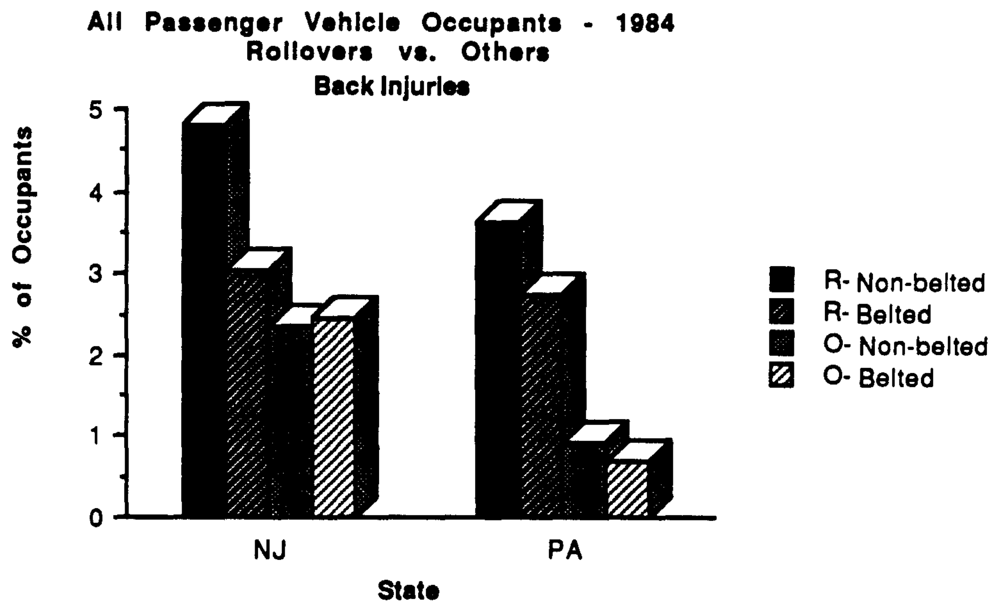


Figure 2.59. Percent of belted and unbelted occupants in rollovers or other accidents with head or facial injuries.

a)



b)

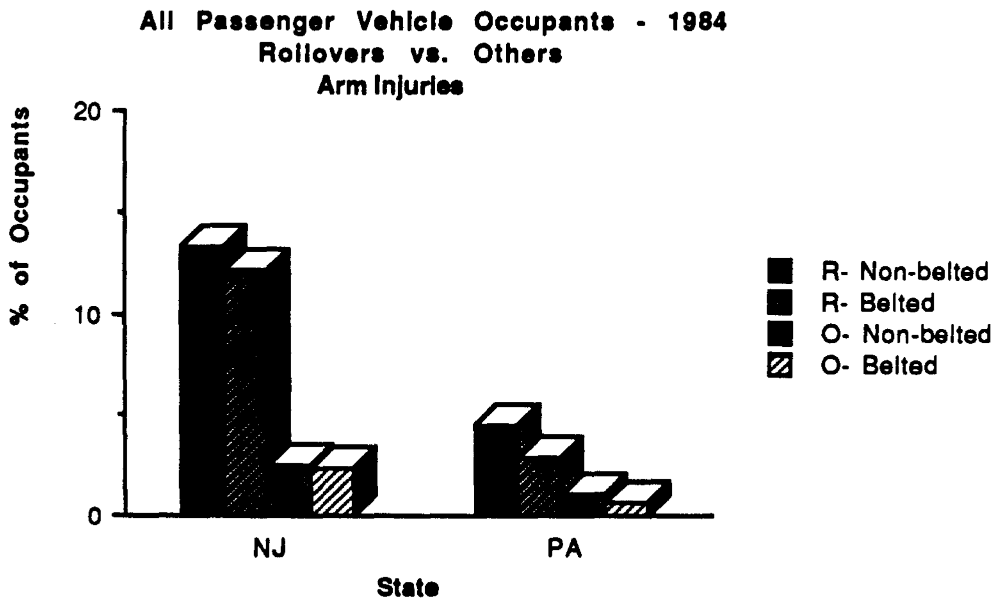
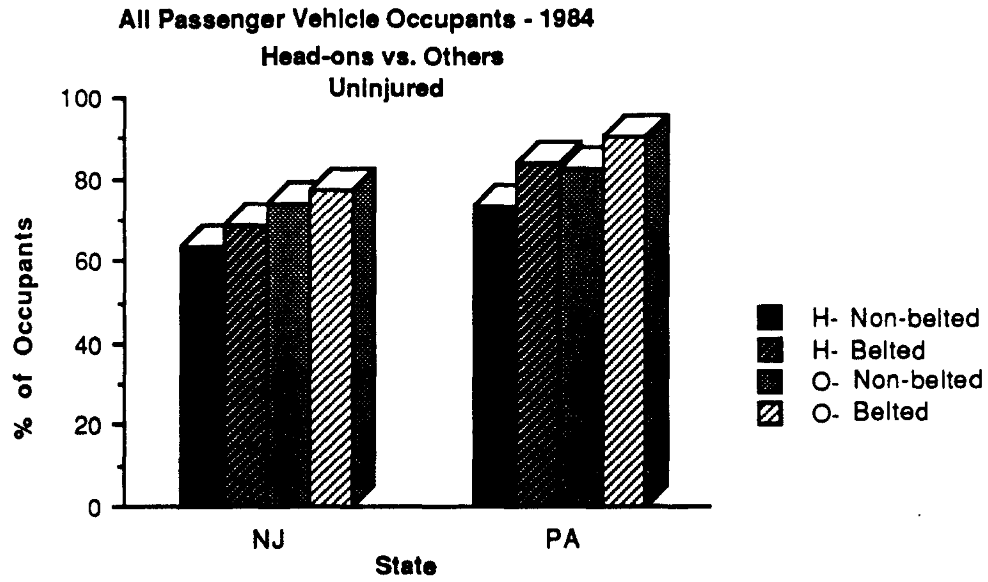


Figure 2.60. Percent of belted and unbelted occupants in rollover or other accidents with back or arm injuries.

a)



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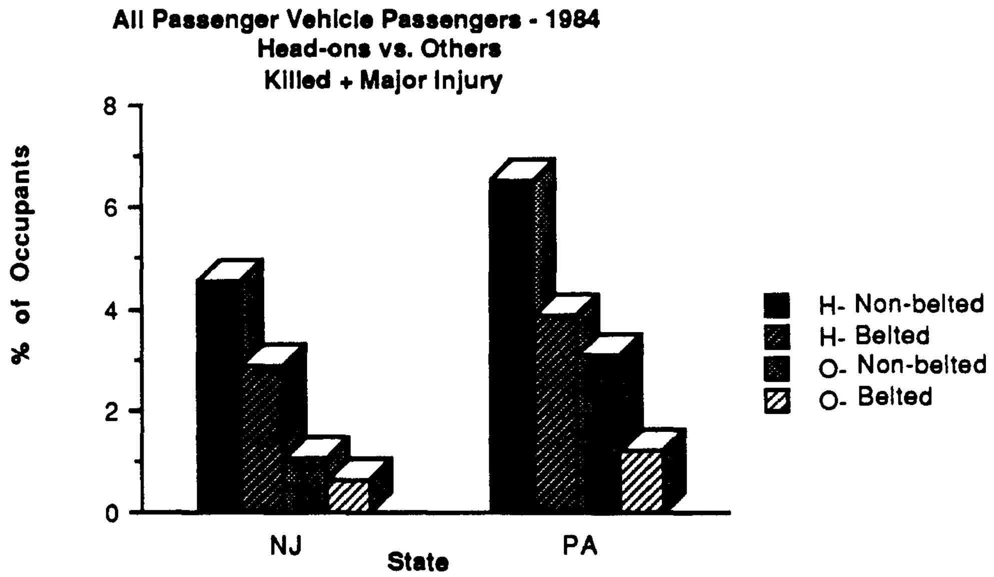
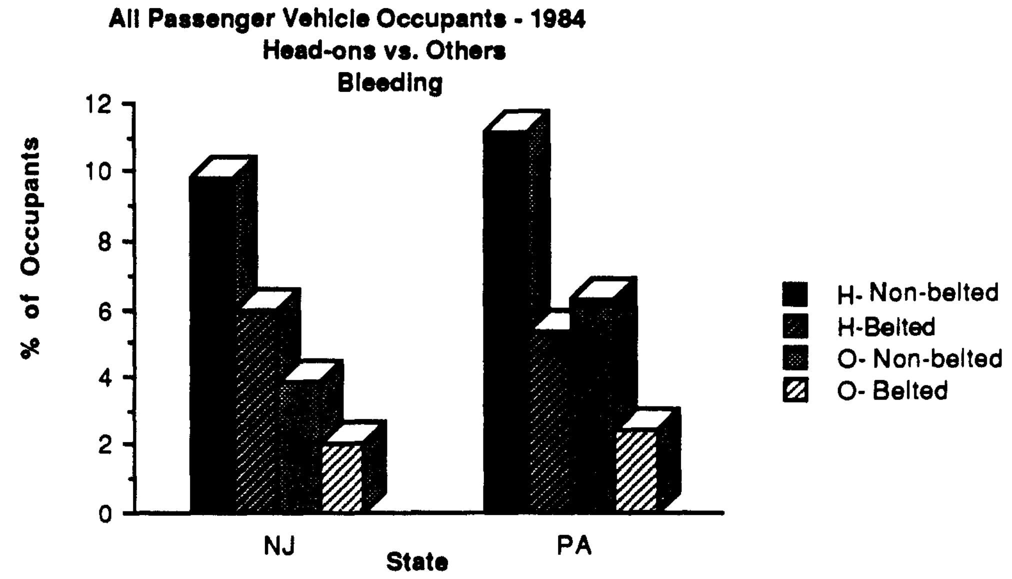


Figure 2.61. Percent of belted and unbelted occupants in head-on and non-head-on accidents uninjured or with major or fatal injuries.

a)



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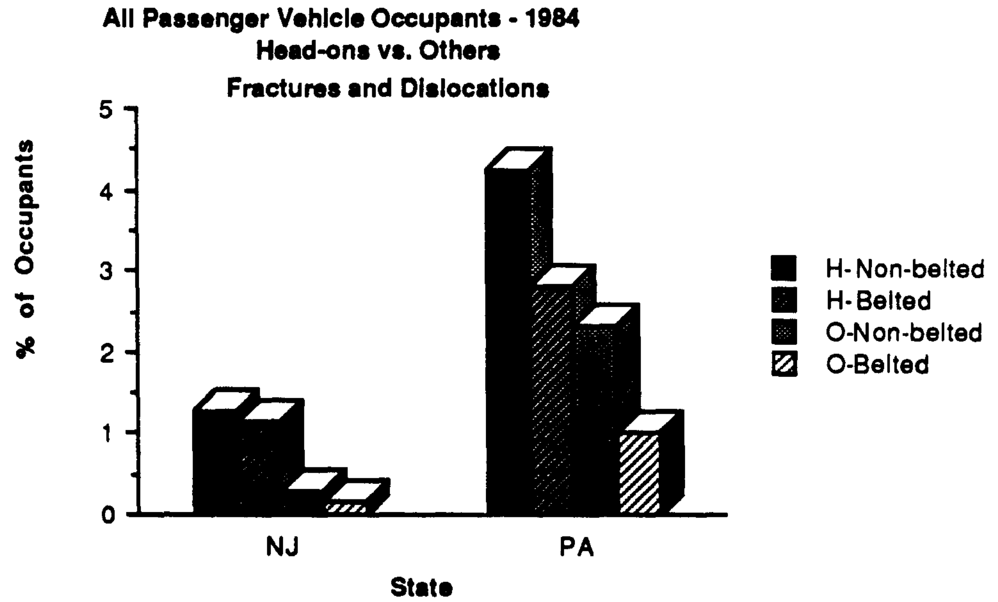
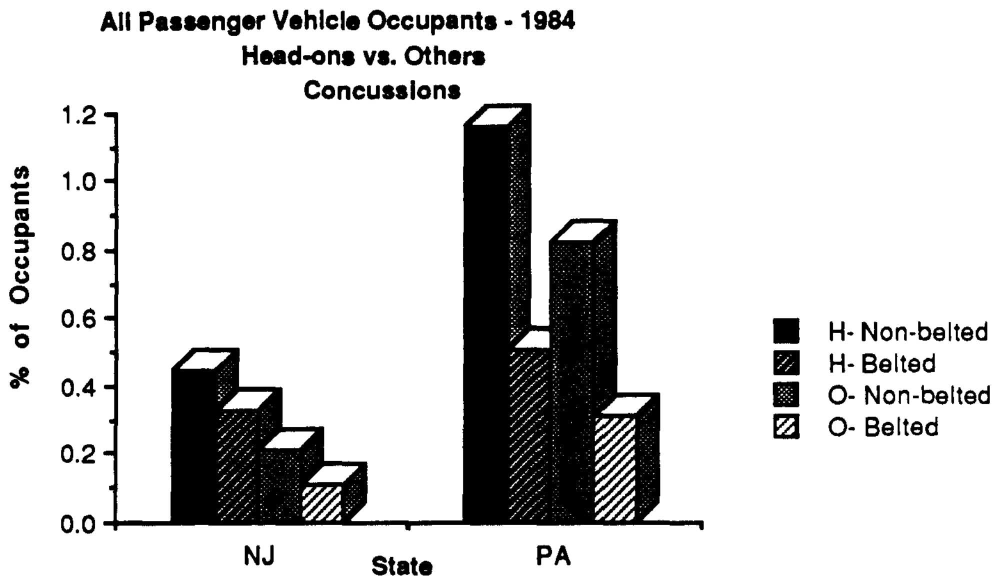


Figure 2.62. Percent of belted and unbelted occupants in head-on or non-head-on accidents with bleeding or fracture/ dislocation injuries.

a)



b)

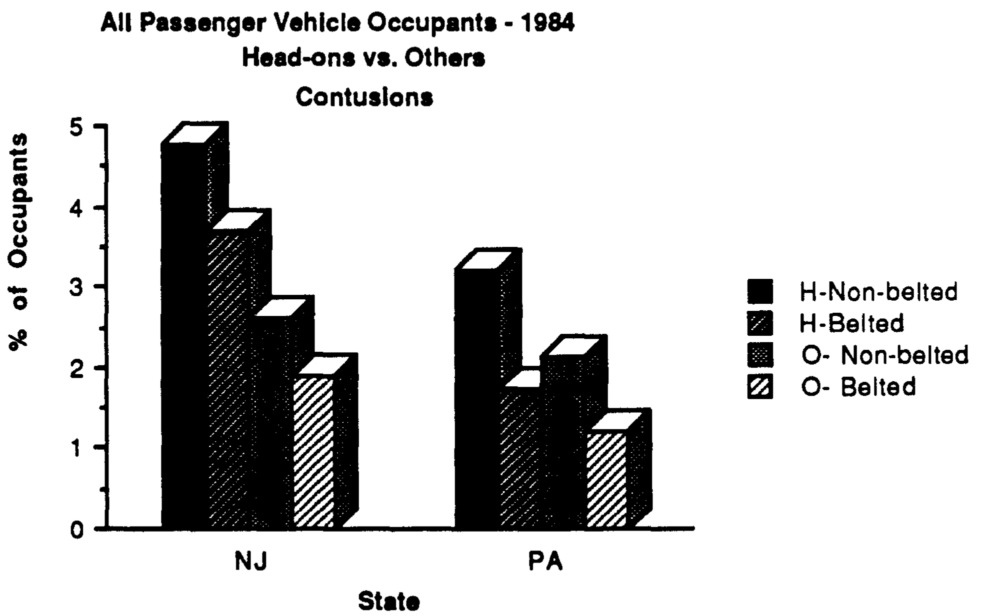
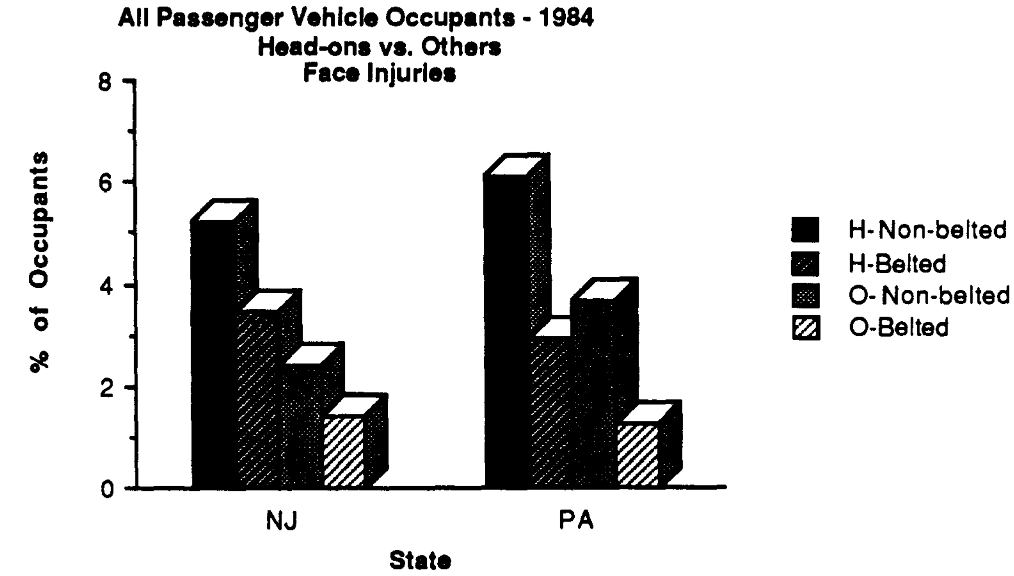


Figure 2.63. Percent of belted and unbelted occupants in head-on or non-head-on accidents with concussions or contusions.

a.)



b.)

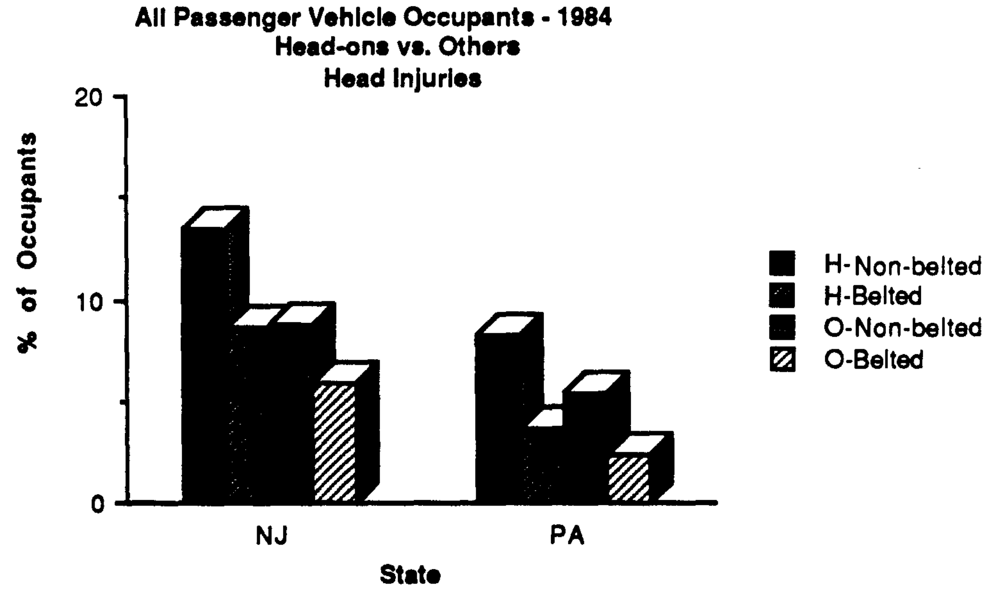
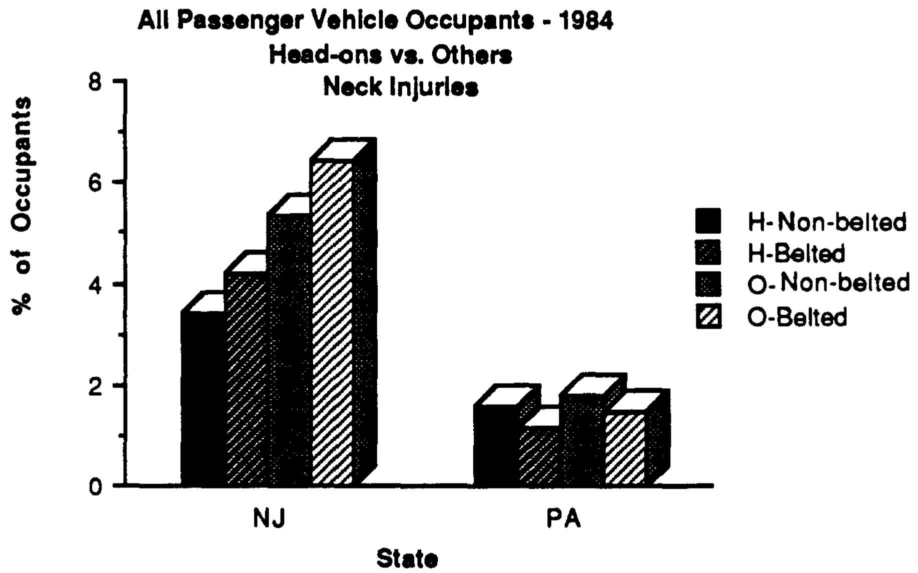


Figure 2.64. Percent of belted and unbelted occupants in head-on or non-head-on accidents with face and head injuries.

a)



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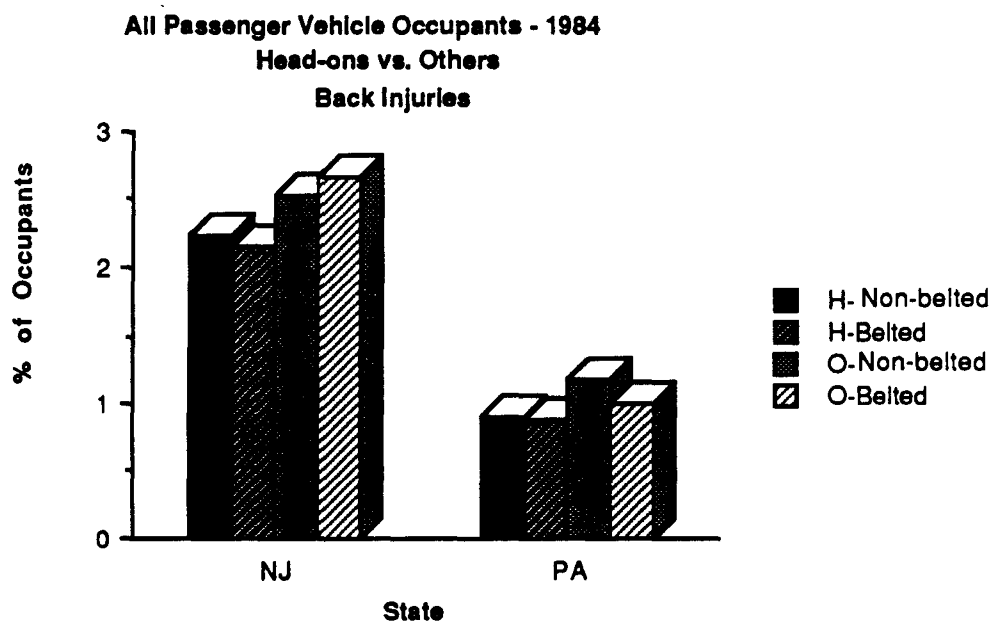


Figure 2.65. Percent of belted and unbelted occupants in head-on or non-head-on accidents with neck and back injuries.

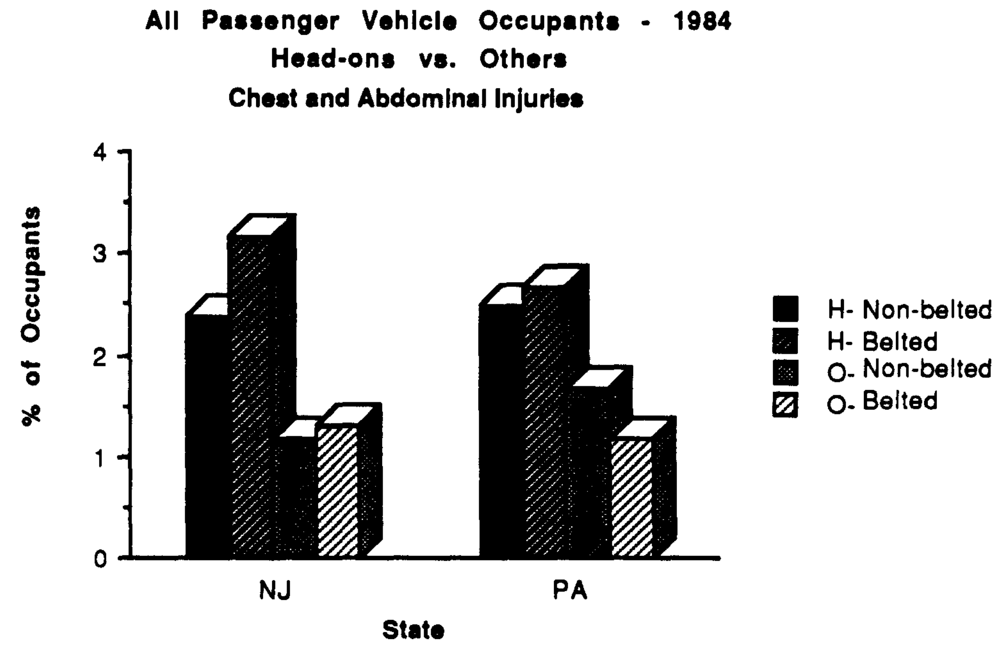


Figure 2.66. Percent of belted and unbelted occupants in head-on or non-head-on accidents with chest and abdominal injuries.

of neck injuries was different in each state. In New Jersey, the percentage of neck injuries was higher among belted occupants than non-belted occupants, while in Pennsylvania the percentage of neck injuries was highest among the non-belted occupants. The results were similar for the non-head-on crashes.

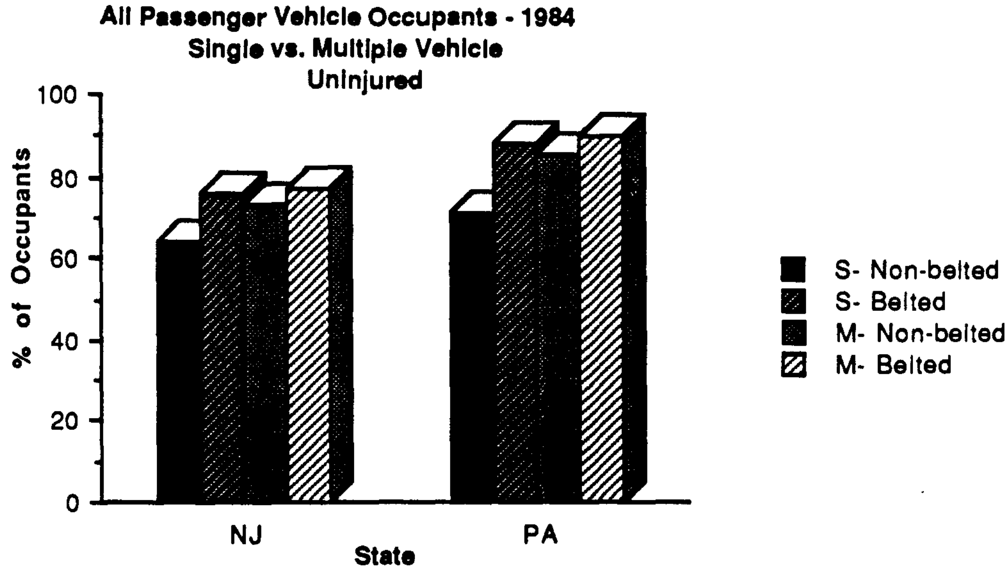
Single Vehicle vs Multiple Vehicle Accidents. Figures 2.67 to 2.72 present percentages of selected injuries for single vehicle (S) and multiple vehicle (M) accidents. Non-belted occupants of single vehicle crashes incurred the largest percentage of all injuries (NJ: 36 percent; PA: 28 percent) and the largest percentage of A+K injuries (NJ: 4 percent; PA: 6 percent). Belted occupants were injured less frequently than non-belted occupants in both states and in both types of crashes. The percentage of belted occupants injured in single vehicle crashes (S) are 24 percent and 12 percent, in New Jersey and Pennsylvania, respectively. In multiple vehicle accidents (M), 27 percent and 15 percent of non-belted occupants, and 23 percent and 10 percent of belted occupants, in New Jersey and Pennsylvania, respectively, were injured. The differences in percentages are significant for both the uninjured and the A+K injuries ($p < .005$).

In single vehicle crashes, bleeding, contusions, concussions, and fractures and dislocations occurred for a larger percentage of occupants who were non-belted than for belted occupants. Figures 2.68 to 2.70 show that a similar pattern also exists for multiple vehicle accidents.

Figures 2.71 and 2.72 show the distribution of injuries by body part. For both states, in single vehicle accidents, face, head and back injuries were incurred more often among non-belted occupants than among belted occupants. In Pennsylvania, a larger percentage of non-belted occupants incurred neck injuries than belted occupants, while in New Jersey the relationship was reversed. For New Jersey multi-vehicle accidents, there was a slight increase in the percent of back injuries for belted versus non-belted occupants.

Ejection Accidents. Figure 2.73 and Table A.31 present the percent of ejected (E) and non-ejected (NE) occupants who were uninjured and the percent of ejected (E) and non-ejected (NE) occupants who were killed or incurred a severe injury. Because the number of ejected occupants who were coded as restrained is larger than we would have expected, we are hesitant to make injury comparisons based on the restrained versus unrestrained variable. An examination of the unrestrained occupants shows that those who are ejected are more likely to incur severe injuries. In New Jersey, the percentage of

a)



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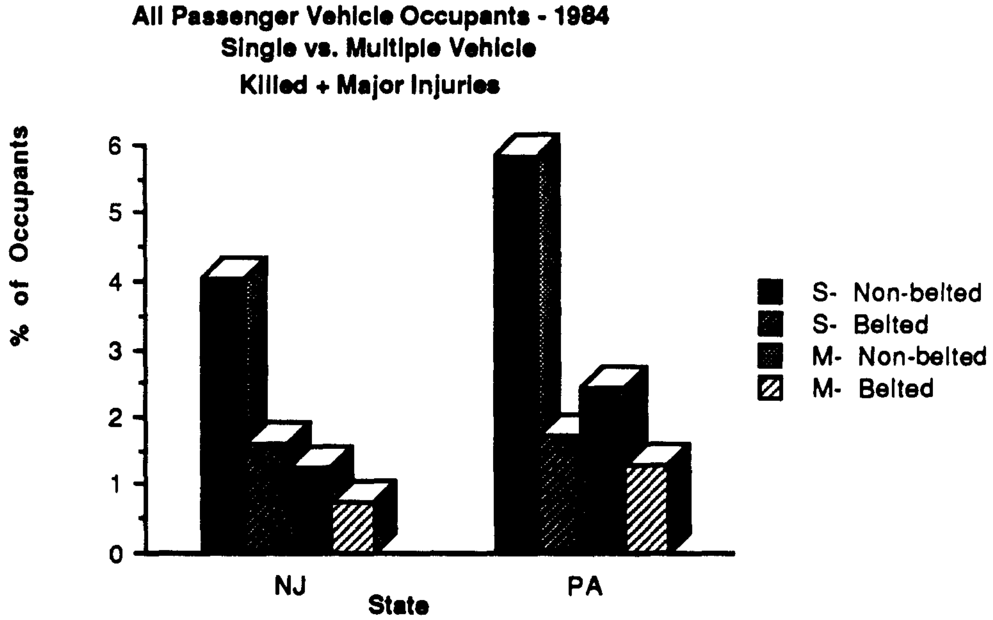


Figure 2.67. Percent of belted and unbelted occupants in single or multiple vehicle accidents uninjured or with major or fatal injuries.

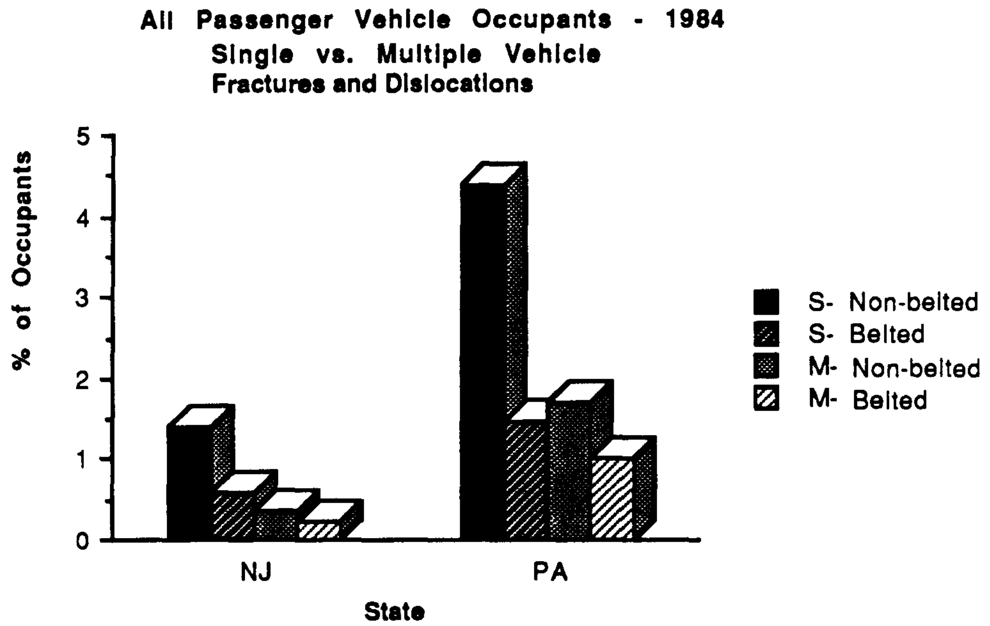
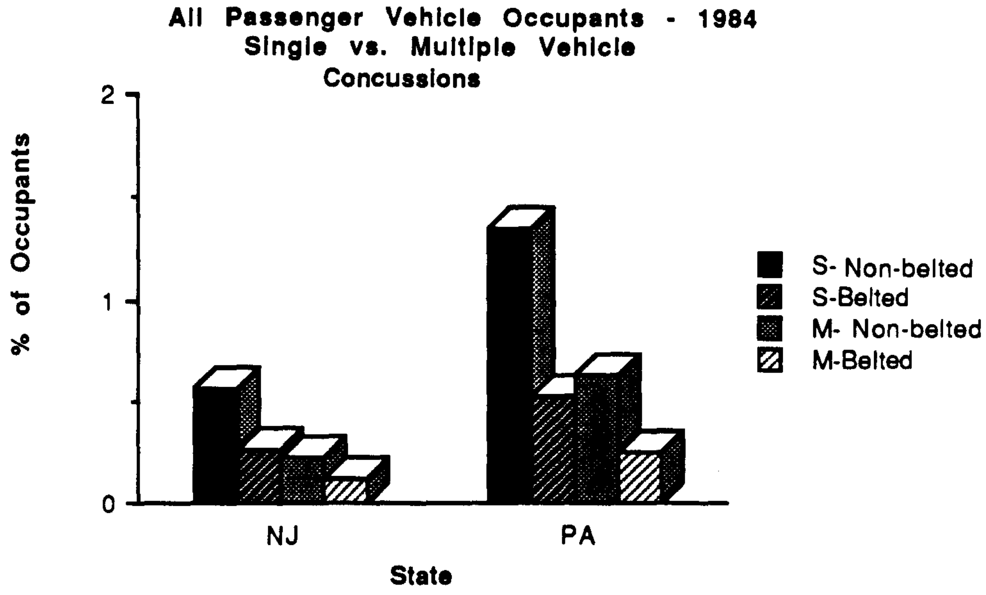


Figure 2.68. Percent of belted and unbelted occupants in single or multiple vehicle accidents with fractures/ dislocations.

a)



b)

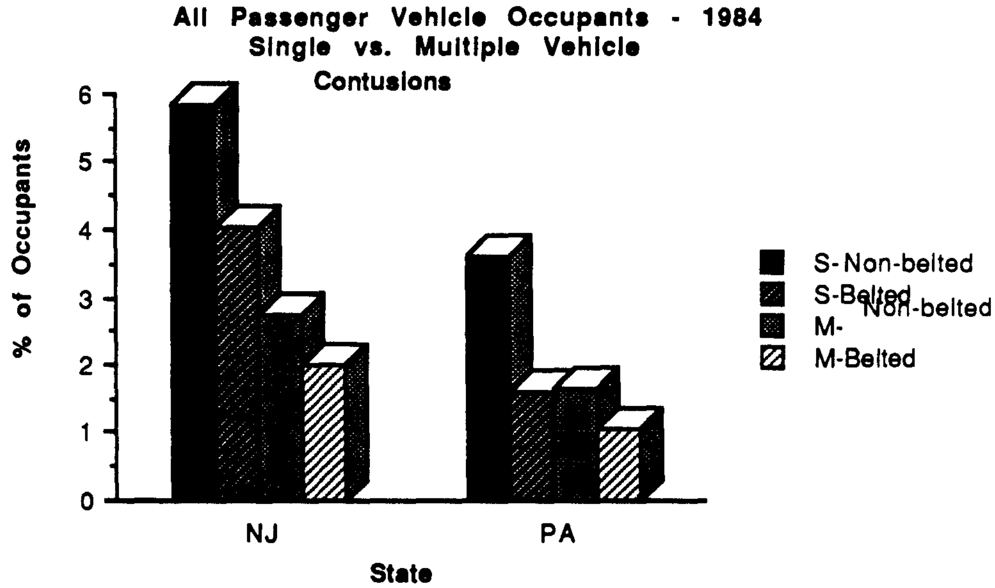


Figure 2.69. Percent of belted and unbelted occupants in single or multiple vehicle accidents with concussions or contusions.

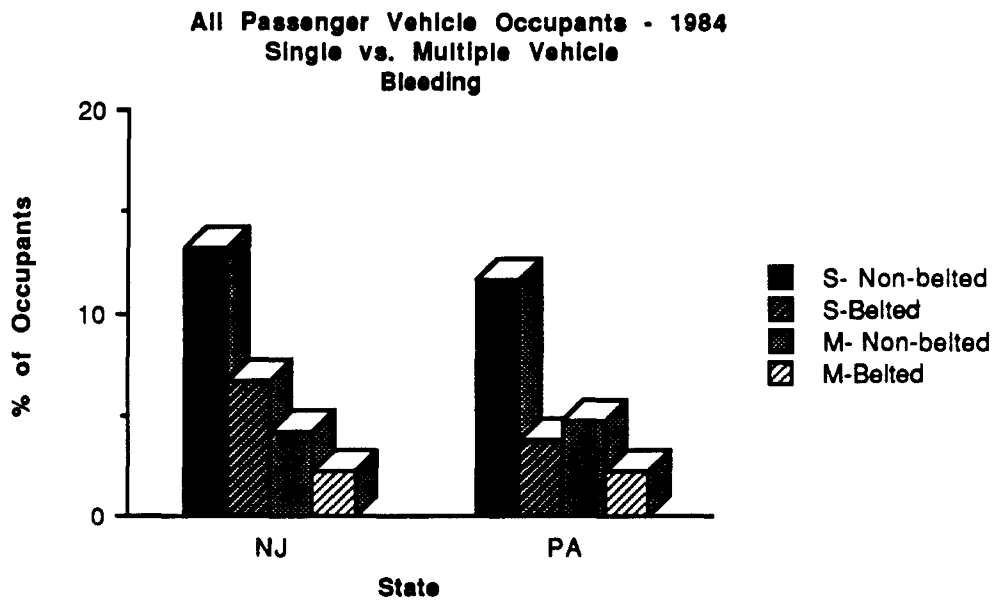
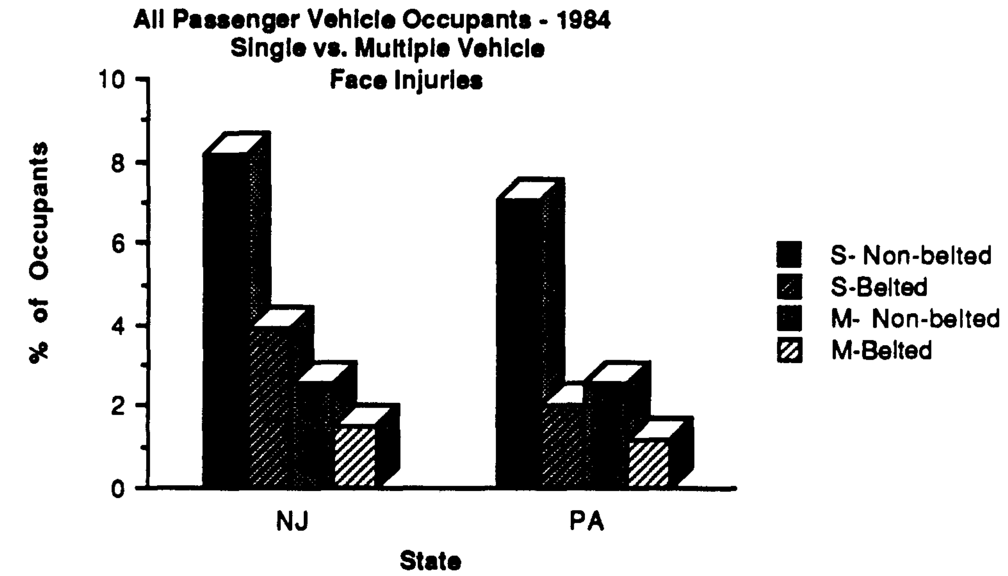


Figure 2.70. Percent of belted and unbelted occupants in single or multiple vehicle accidents with bleeding injuries.

a)



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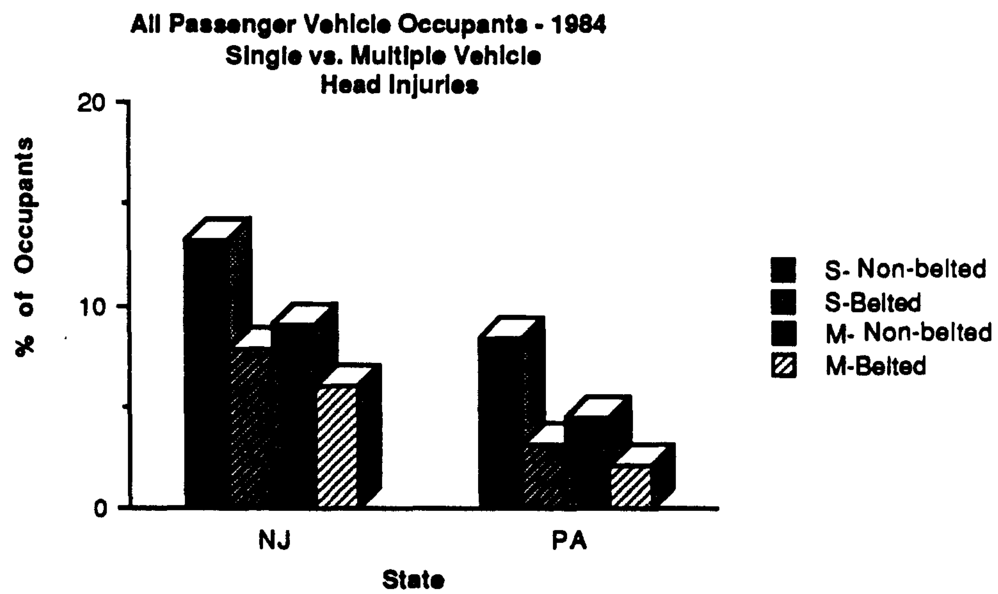
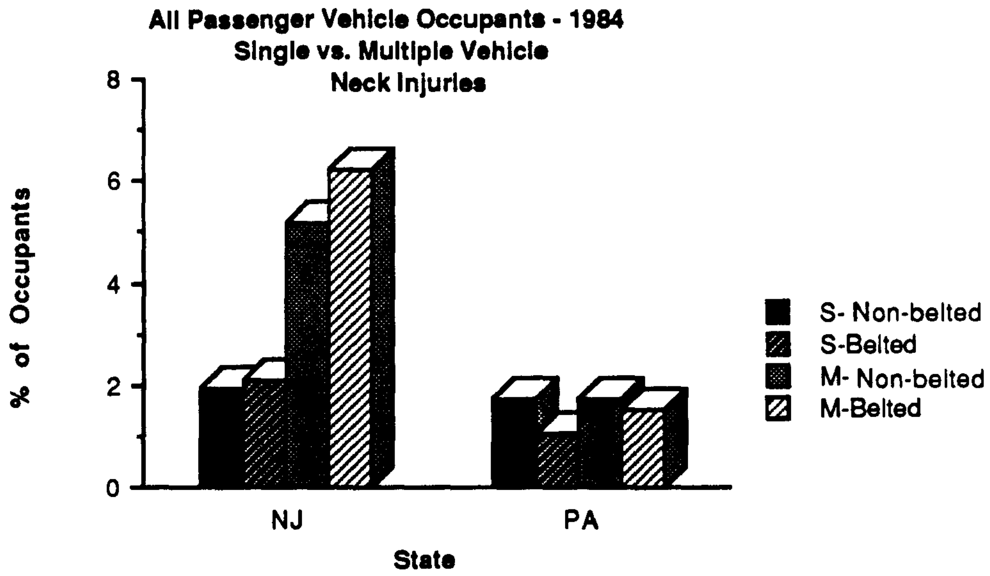


Figure 2.71. Percent of belted and unbelted occupants in single or multiple vehicle accidents with injuries to the face and head.

a)



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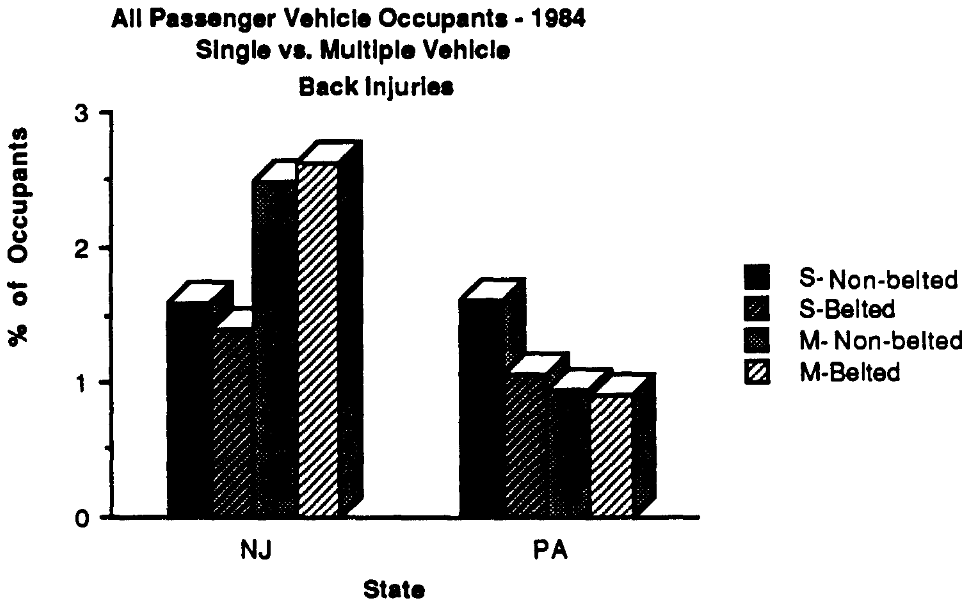
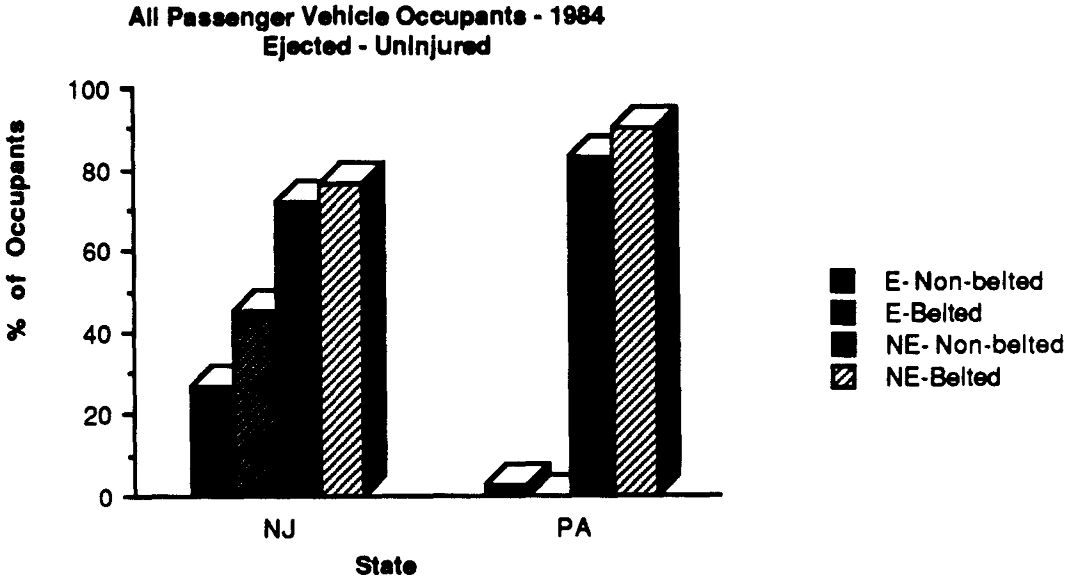


Figure 2.72. Percent of belted and unbelted occupants in single or multiple vehicle accidents with injuries to the neck and back.

a)



b)

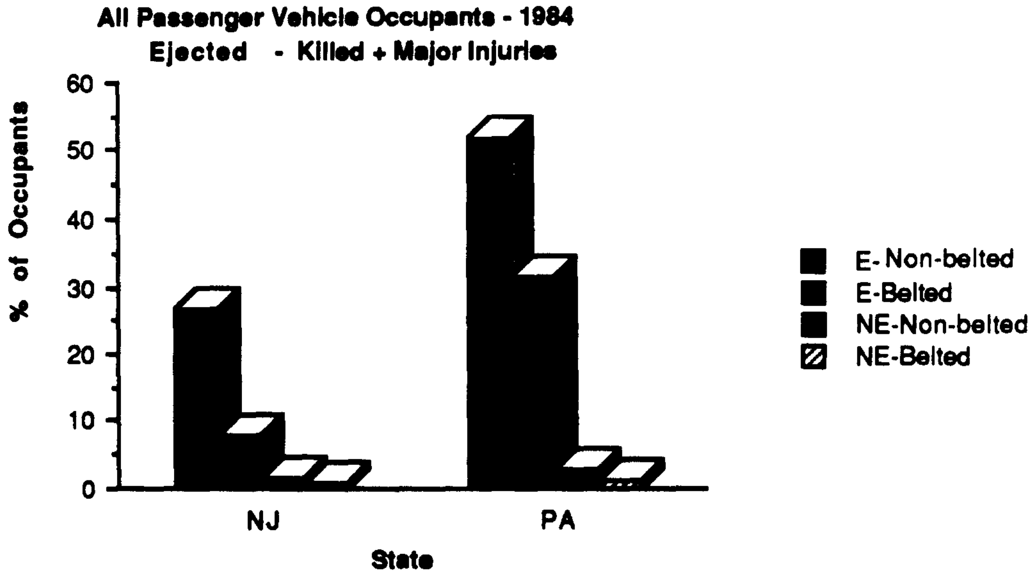


Figure 2.73. Percent of belted and unbelted occupants, ejected or not ejected, uninjured or with major or fatal injuries.

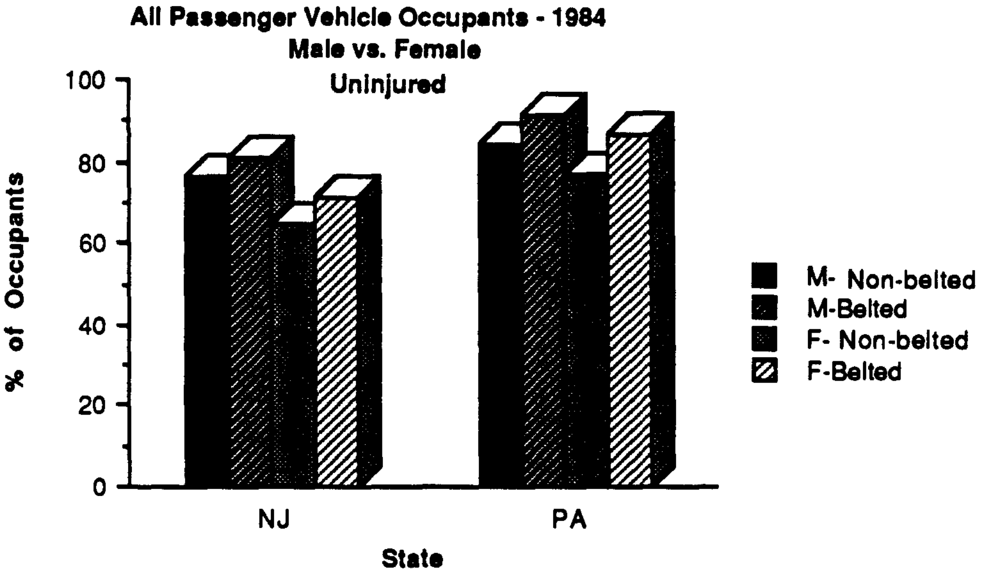
unrestrained occupants who were severely injured or killed in ejection (E) accidents was 27 percent, compared to 52 percent for Pennsylvania.

Comparison of Males and Females. A comparison of injuries between restrained and unrestrained males (M) and females (F) in accidents in 1984 in New Jersey and Pennsylvania is also of interest. Figure 2.74a shows the percentage of all male and female occupants of vehicles who were uninjured. A smaller percentage of restrained (NJ: 19 percent; PA: 8 percent) and unrestrained (NJ: 23 percent; PA 16 percent) males were injured than restrained (NJ: 29 percent; PA 13 percent) and unrestrained (NJ: 35 percent; PA 23 percent) females. The differences between the males and females were all significant at $p < .01$. Overall from Figure 2.74b, a slightly smaller percentage of male occupants were killed or sustained a major injury than female occupants. The difference was not significant ($p=.69$). The results are similar in both New Jersey and Pennsylvania.

Contusions, concussions, and fractures and dislocations occurred for a larger percentage of restrained and unrestrained female occupants than for male occupants. Figures 2.75 and 2.76 show these results.

Figures 2.77, 2.78, and 2.79 show the distribution of injuries by body part. For both New Jersey and Pennsylvania, female occupants -- restrained and unrestrained -- sustained a larger percentage of head, face, neck, back and abdominal injuries than male occupants.

a)



b)

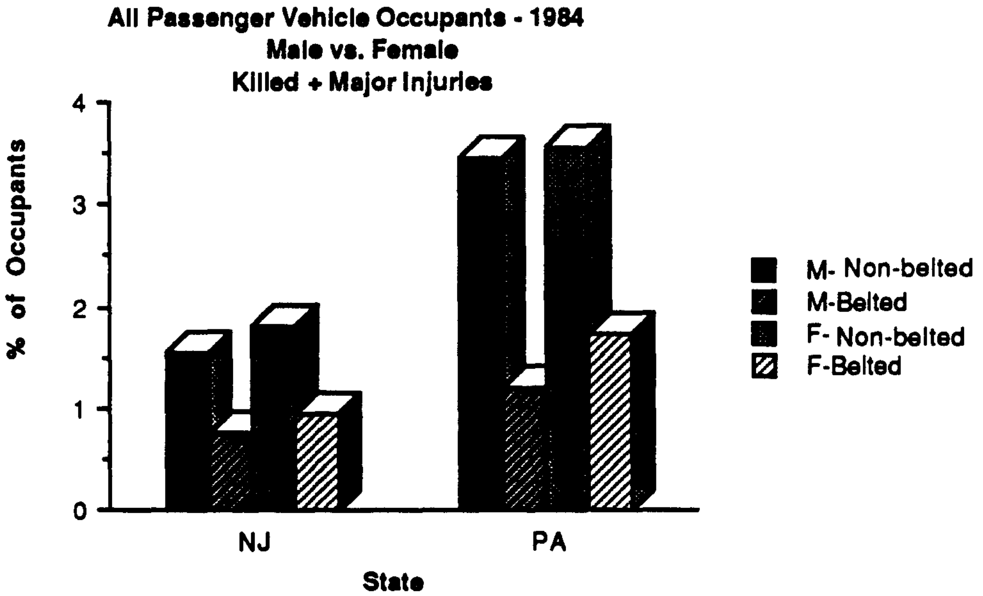


Figure 2.74. Percent of male and female occupants in all accidents uninjured and with major or fatal injuries.

a)

b)

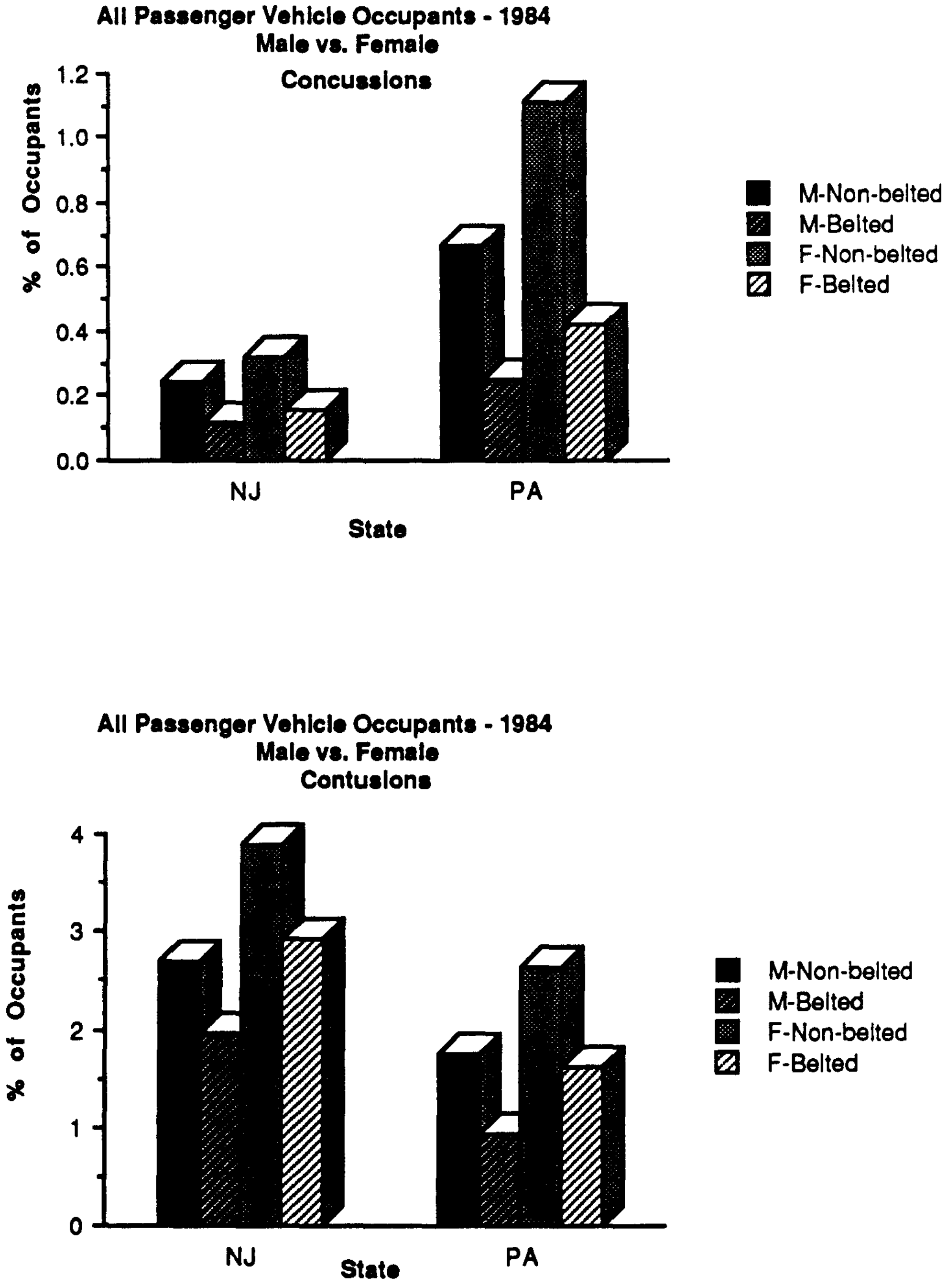


Figure 2.75. Percent of male and female, belted and unbelted occupants with concussions and contusions.

a)

b)

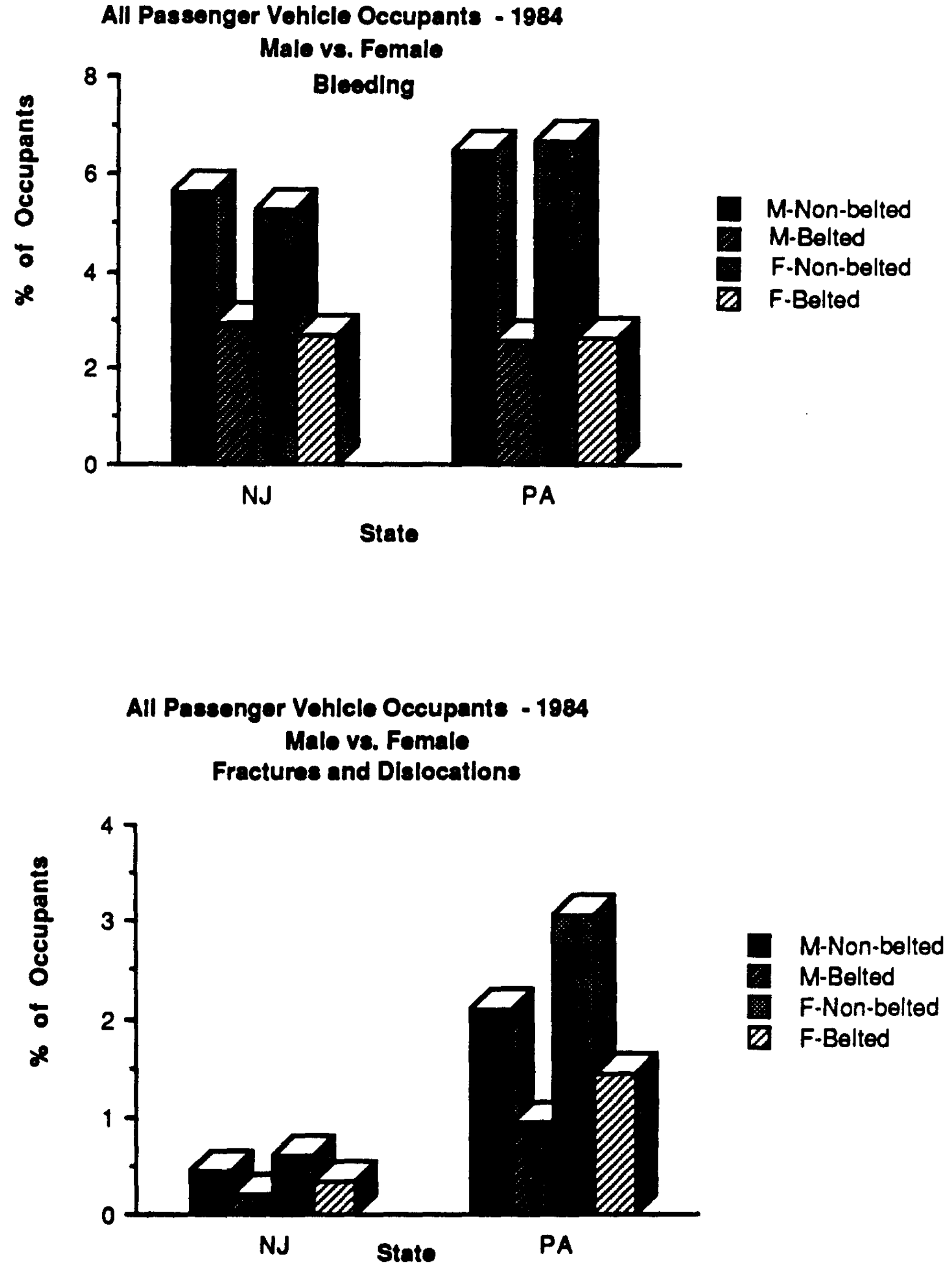
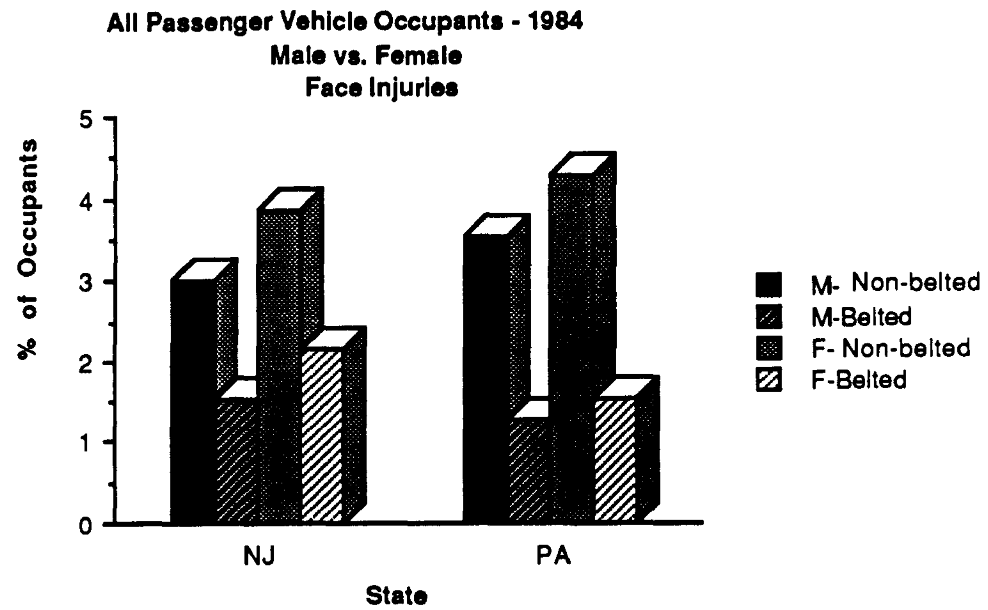


Figure 2.76. Percent of male and female, belted and unbelted occupants with bleeding injuries and fractures and dislocations.

a)



b)

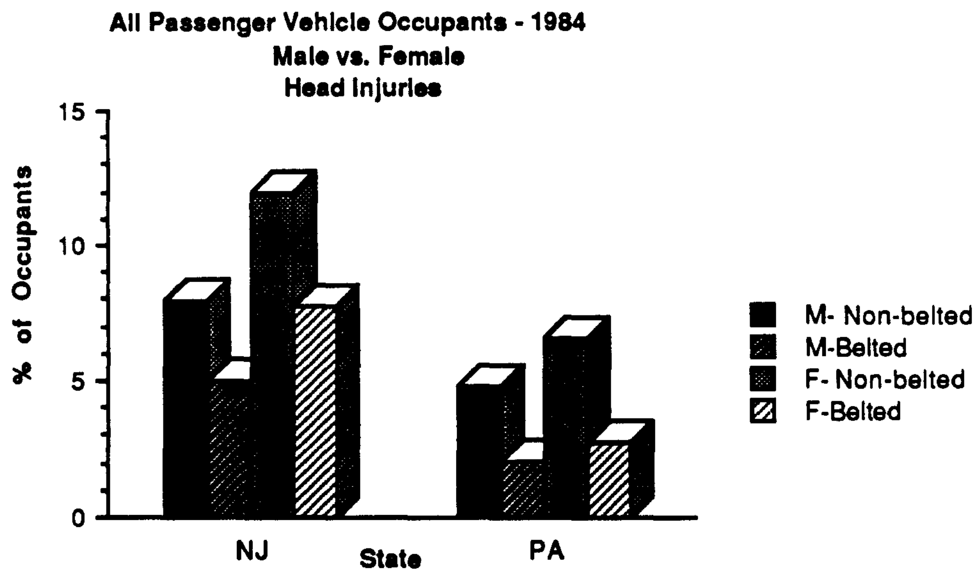
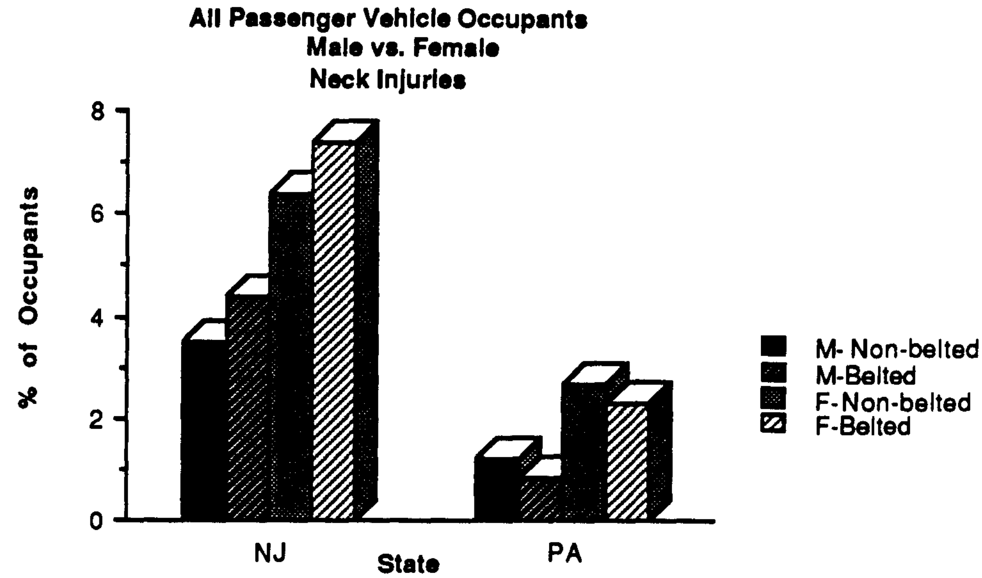


Figure 2.77. Percent of male and female, belted and unbelted occupants with injuries to the face and head.

a)



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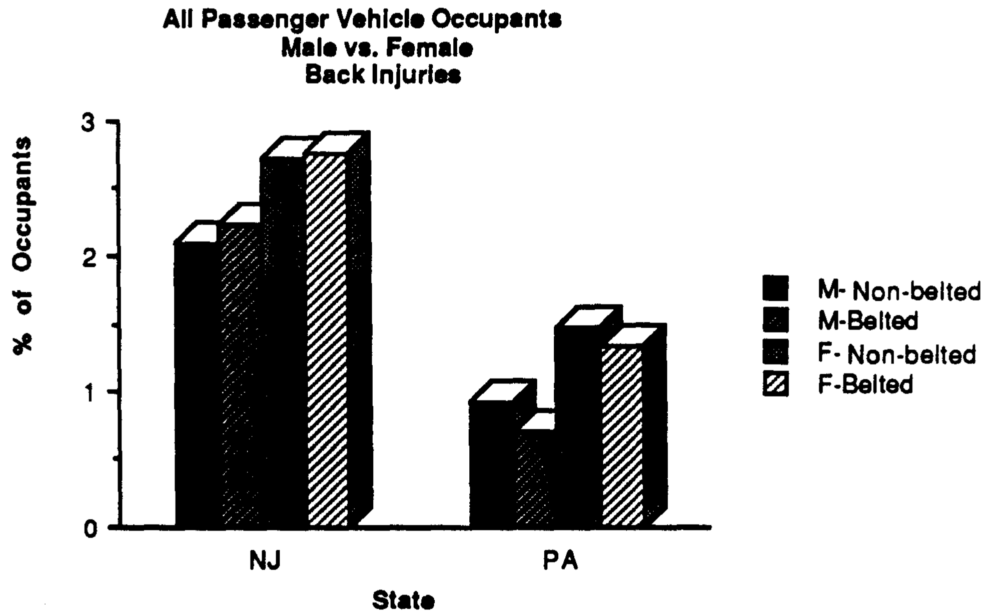

Figure 2.78. Percent of male and female, belted and unbelted occupants with injuries to the neck and back.

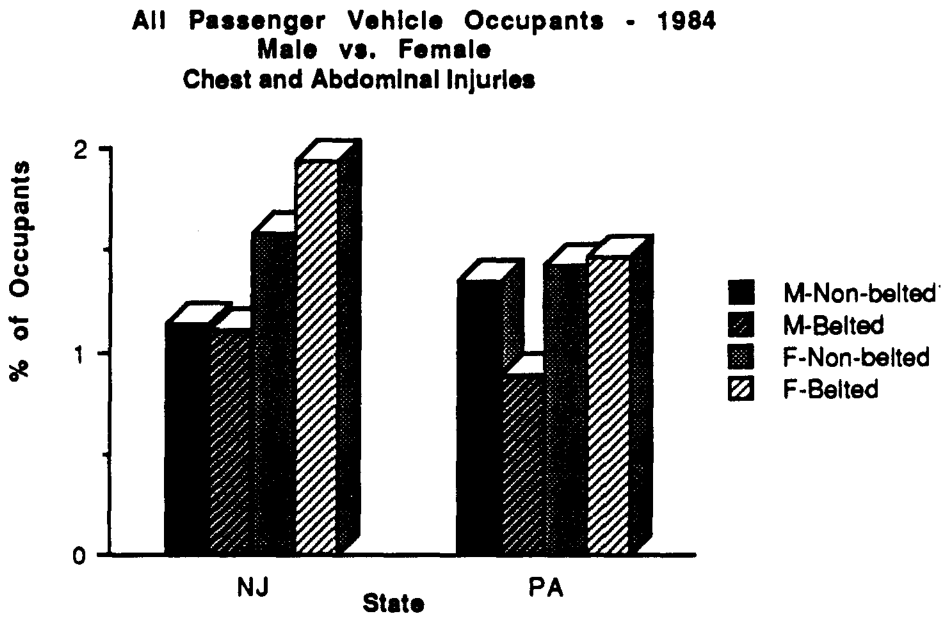

Figure 2.79. Percent of male and female, belted and unbelted occupants with chest and abdominal injuries.

CHAPTER 3. HOW DOES A STATE LAW AFFECT SEAT BELT USE?

Background

Currently 34 states and the District of Columbia have statewide seat belt use laws. The goal of each of these laws is primarily to increase the proportion of the driving population that is restrained in motor vehicles with the expectation of considerable reduction in morbidity and mortality from the inevitable highway crashes. This analysis question deals with the usage of restraints by accident-involved occupants but by necessity must also look at usage by the population-at-risk primarily as a comparison or normative group.

With respect to population-at-risk belt usage, Campbell, Stewart, and Campbell ("1985-1986 Experience with Belt Laws in the United States," 1987) present restraint usage results for 26 states plus the District of Columbia which currently have seat belt laws. They provide pre-law or baseline belt usage rates as well as the highest belt usage seen in the state and the most recent belt usage figures. Although the results are not as favorable as seen in many foreign countries such as Australia, England, Sweden and West Germany, it is nevertheless clear that the legislation has brought about a considerable increase in belt usage. Generally, pre-law belt usage ranged from around 10 percent to 25 percent among the states; highest belt use seen ranged from slightly over 20 percent to 77 percent in one state, while the most recent usage generally fell in the 35 to 60 percent range. Thus, it is clear that the collective legislation has resulted in increased belt usage by the population, which should translate into increased usage among accident-involved occupants.

Assessing the effect of belt use changes in the accident data is not as straightforward now that it is "the law" to wear seat belts. The direct approach would be to look at belt use as indicated on the accident report form for various subpopulations of interest for those persons covered by the law in a given state versus non-covered occupants as well as non-occupants (pedestrians, bicyclists, etc.) serving as control groups. As will be seen, there are considerable problems with this direct approach in the post-law era due to an increasing phenomenon referred to here as the "lie factor." Accident victims are now telling the investigating officer that they are wearing their belts in unbelievably high numbers. Unfortunately, the police officer often relies only on the response given by the accident victim, rather than looking for additional evidence.

This effort represents an attempt to look at various subgroups of accident data to see if the observed overall "lie factor" is as troublesome in certain of these subgroups; that is, to see if certain subsets of the data are less biased with respect to belt use in crashes in the post-law period. To do this, accident and population-at-risk data for North Carolina were utilized for three periods, namely the baseline (January 1, 1985 - June 30, 1985), warning ticket (January 1, 1986 - June 30, 1986), and the $25 citation phases (January 1, 1987 - June 30, 1987). All reportable crashes were examined and vehicle model year was limited to 1968 and later to guarantee availability of belts.

To examine the extent and nature of the "lie factor," population-at-risk data for various subgroups of the population are most useful. Relationships between observational data and accident data in pre-law eras have been studied extensively. One would expect many of these relationships seen previously to obtain if the belt use data in accidents is to be believed in the post-law era.

<u>Accident Versus Population-at-Risk Belt Usage</u>

With respect to the observational studies, seat belt usage in North Carolina has been sampled bi-monthly starting just prior to enactment of the law, with three major waves covering 72 sites and three mini-waves covering a subsample of 12 of the original sites surveyed annually. At the outset, a sampling plan was drawn up by which 72 locations were selected as long term sampling sites for North Carolina. Sites included one-third in the eastern or coastal part of the state, one-third in the central or piedmont section, and one-third in the western or mountainous portion. The twenty-four sites within each of the three areas were divided between rural and urban settings, and the specific sites within each area selected in order to cover the full variety of highways ranging from interstate to city streets to secondary roads and rural intersections, etc.

Data collected included time of day, day of week, and location as well as vehicle type and belt usage by race and sex of all front seat occupants of vehicles covered by the law. Each major wave of observations yielded information on over 20,000 drivers, while each of the mini-waves averaged around 4,000 vehicles. The overall belt usage for each sample is weighted according to traffic volume in order that the aggregate is representative of belt use trends across the state as a whole. Thus, it is felt that the estimates of belt use in the population-at-risk in North Carolina are representative of usage in the State as a whole.

The study groups of accident-involved vehicles consist of the following: covered (cars, vans, light trucks), non-covered (buses, big trucks), and non-occupant (pedestrians, bicyclists, motorcyclists). Certain other vehicle groups were excluded from the data such as farm equipment, recreational vehicles, etc. Using these vehicle groups, the study or analysis groups were defined as follows: covered occupants (front seat occupants of covered vehicles), non-covered occupants (rear seat occupants of covered vehicles and any occupants of non-covered vehicles), and non-occupants.

Examination of the post-law North Carolina accident data shows the obvious bias in the data when contrasted with the population-at-risk data. Over the years, belt usage in crashes has always been slightly lower than that seen in the population observed at the same period of time under similar circumstances (e.g., road type, time of day, sex, age, etc). Now that the various states, including North Carolina, have seat belt laws, that relationship has reversed dramatically.

Figure 3.1 shows the overall belt usage rates in crashes for North Carolina for each of the three study periods -- pre-law or baseline, warning, and citation phase. The population-at-risk versus accident wearing rates are 24.1 versus 21.3 percent in the pre-law period, 43.1 versus 60.4 percent in the warning ticket phase and 70.7 versus 90.0 percent in the citation phase, respectively! Clearly, as mentioned previously, accident victims are telling the investigating officer that they are now wearing their belts in unbelievably high numbers.

Also plotted in Figure 3.1 are the corresponding results for the Highway Patrol, whose accident investigating and reporting should be at the highest level of quality among police agencies in North Carolina. Although the Highway Patrol belt usage percentages in crashes are consistently lower than those for all reporting agencies (19.9 vs 21.3, 54.7 vs 60.4, and 87.5 vs 90.0 percent, respectively), they are still considerably higher in the warning ticket and $25 citation phases than the belt usage rates seen in the corresponding rural areas of North Carolina.

Belt usage is also available by race and by sex for the population-at-risk as well as for crash-involved occupants. Historically, lower usage rates have been found among both blacks and among males (Campbell, 1969; Campbell, et al.,

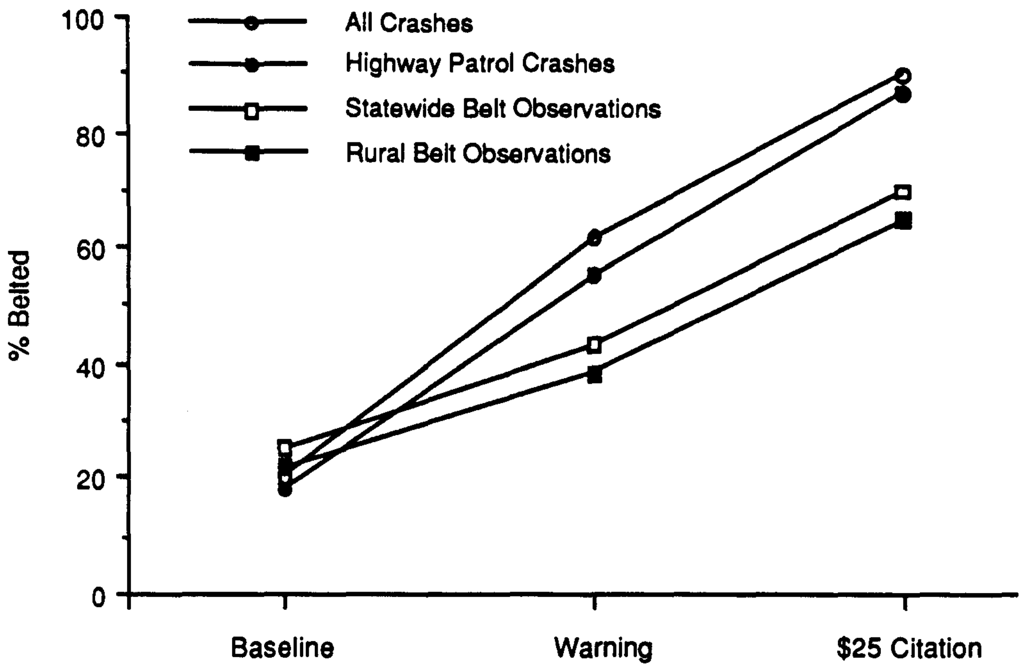

Figure 3.1. Accident vs. population-at-risk belt usage for covered occupants across time periods (NC).

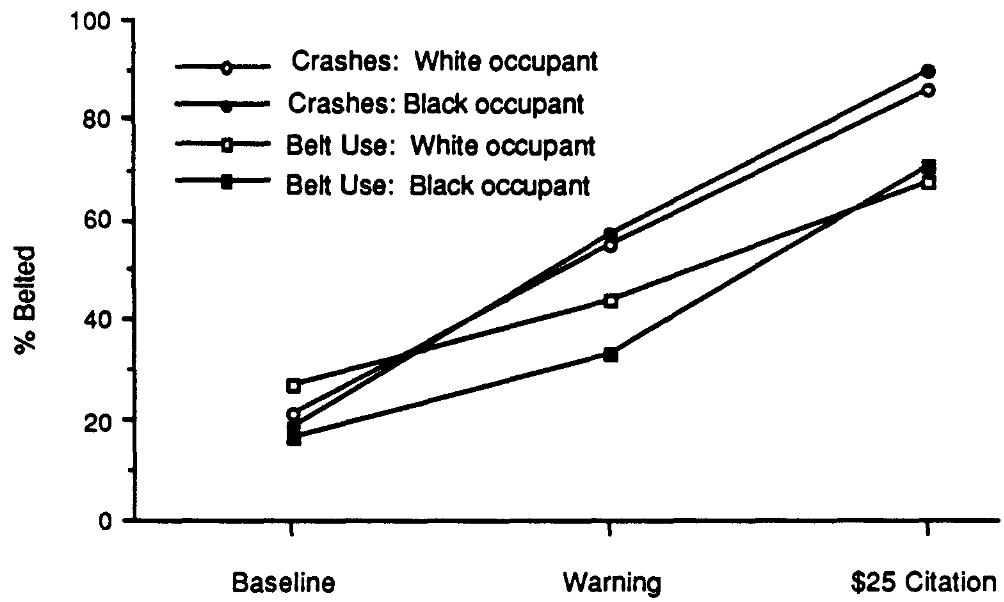

Figure 3.2. Accident vs. population-at-risk belt usage by race of covered occupants across time periods (NC).

1984; and Reinfurt, et al., 1988). As can be seen in Figure 3.2, belt usage is higher for both whites and blacks in crashes than in the general driving population in the warning phase, and in the $25 citation phase. It is of interest to note the closing of the rather wide gap in belt usage differences between races from the baseline period to the citation phase, with a slightly higher usage rate in the black population rate in the most recent observational and crash data.

It should be noted in all of these comparisons that the accident-involved people are <u>covered</u> occupants (i.e., front seat occupants of covered vehicles), while the observational data represents corresponding covered occupants, namely, those front seat occupants of covered vehicles seen in the roadside surveys.

Figure 3.3 depicts the results by occupant sex for Highway Patrol investigated crashes versus the observational data by time period. In both the accident and observational data across each time period (with the lone exception of baseline crashes), belt usage among females exceeds that for males, which is consistent with previous experience. However, the wearing rates in accidents again show a dramatic reversal as one moves from the baseline period into the warning and then the citation phase, reaching a high of 90.1 and 85.8 percent in crashes for female and male occupants, respectively, versus 74.2 percent and 64.5 percent for female and male passengers in the roadside surveys.

In summary, as can be seen in Figure 3.1, the accident percentages exceed the observational percentages by a large margin, during both the warning ticket phase and the $25 citation phase, for not only all crashes but also the presumably better data provided by the Highway Patrol. This is likewise apparent in Figures 3.2 and 3.3 examining differences by race and sex, respectively.

In fact, the rate of growth in the percentage for accident-involved belted occupants is in the counter-intuitive direction. Due to proven belt effectiveness, as a larger percentage of the population is wearing belts, the rate seen in crashes for belted occupants should grow but not at the accelerated rate seen in each of the figures. In fact, due to this effectiveness, it should not grow as fast as the observed wearing rates.

The rising belt use across time periods within injury categories is depicted in Figure 3.4 for Highway Patrol-investigated crashes. The crash data

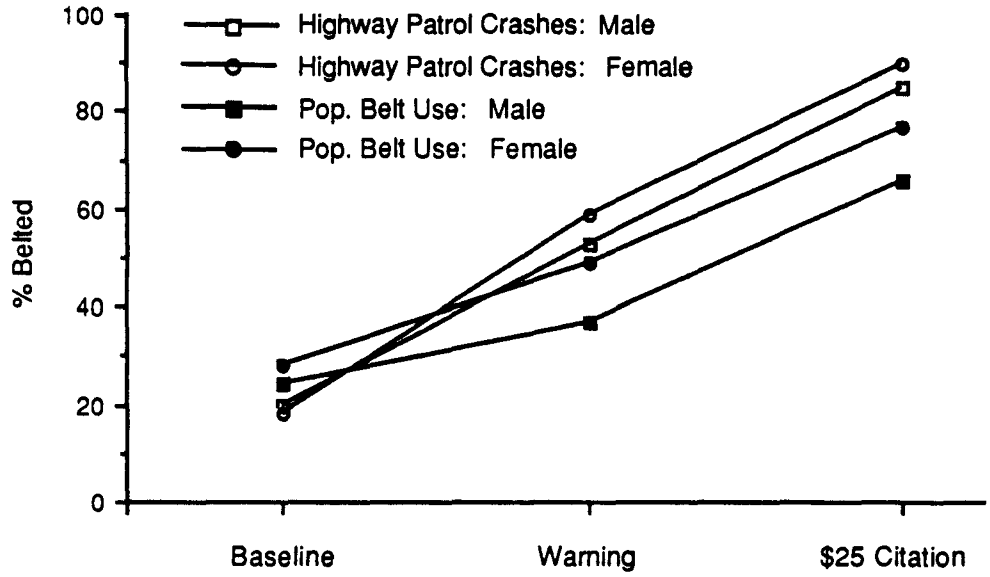

Figure 3.3. Accident vs population-at-risk belt usage by sex of covered occupant across time periods (NC).

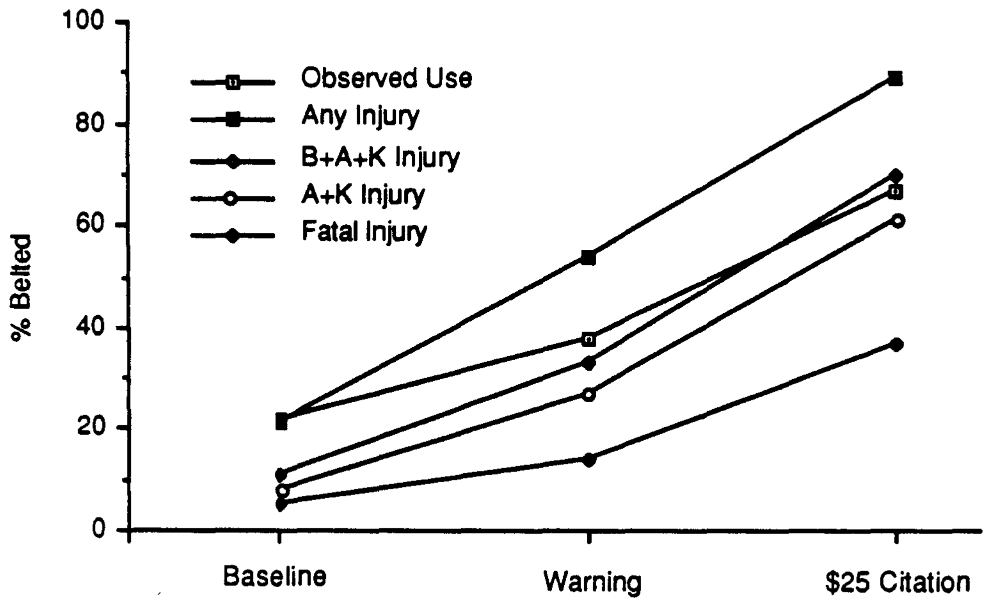

Figure 3.4. Accident belt usage by injury severity of covered occupant compared with population-at-risk usage across time periods (NC).

are consistent within time periods with respect to belt usage by level of injury, namely, lowest usage rate for the fatally injured and highest for the all injury category with moderate and severe injuries intermediate.

Also plotted are the population-at-risk belt usage rates for each of the three time periods. Note the increase in wearing rates (24.1 percent, 43.1 percent and 70.7 percent for the pre-law, warning and $25 citation periods, respectively) in the general driving population. However, the rates of increase in belt usage at each level of injury (as shown by their respective slopes) are consistently nearly as great as the population-at-risk and for the most part greater. This is contrary to what one would expect with reliable crash data due to the proven effectiveness of belts in reducing injuries and fatalities. Thus, for example, if the population belt usage doubled in the citation phase compared with the warning phase, belt usage among the fatally injured should not have increased by much more than about one and a half times (given that belts are 40-50 percent effective in reducing fatalities). This is clearly not the case here.

The bottom line with respect to the "lie factor" is that it is increasingly apparent in the citation phase compared to the warning phase. It cuts across both sex and race groups. It is prevalent not only for all crashes but also for the Highway Patrol investigated crashes, and it cuts across all levels of injury. For those populations and particular subgroups for which we also have the observational data, there are no special subsets where the "lie factor" appears to be unimportant. The analysis implication is that, unless there are mathematical adjustments that can be made with the data, the seat belt information provided by police officers in the presence of a seat belt law appears to be quite unreliable and thus not nearly as useful as in the past.

One final subpopulation of interest is for those fatally injured in crashes. It is generally held that the police crash data for fatal crashes is more reliable than for any other level. Table 3.1 gives the population-at-risk usage rates for each of the time periods as well as the wearing rates for fatally injured covered occupants. (Sample sizes precluded looking at the fatally injured non-covered occupants.) Presented in Table 3.1 are the overall comparisons as well as comparisons within urban and rural groups and by race and by sex for fatally injured occupants. Note the rise in wearing rates for fatally-injured covered occupants in crashes as opposed to the population-at-risk wearing rates. Whereas the population estimates do not even double as one moves from one period to the next, the wearing rates for fatally injured occupants more than double, as one moves from pre-law to warning phase to citation period. This is exactly the reverse of what should be expected due to the known effectiveness of seat belts.

It has been suggested that, as belt usage becomes more widespread, belts would be used more and more by the risk takers and hence the "true" proportion of belted crash-involved occupants would increase at the rate seen in Table 3.1. This would necessarily be true at usage rates above 90 percent but not at the level seen during the citation phase (70.7% overall). Males -- generally a high risk group -- did indeed increase their belt usage by 76 percent from the warning ticket phase to the citation phase. However, they apparently raised

Table 3.1. Belt use (%) for the population-at-risk vs. fatally injured covered occupants by time period.

		Time Period			Percentage Point Change	
		Baseline	Warning	$25 Citation	Warning vs Baseline	$25 Citation vs Warning
Overall*	Pop-at-Risk	24.1	43.1	70.7	19.0	27.6
	Accident Group	5.5	14.2	38.9	8.7	24.7
Urban	Pop-at-Risk	27.0	44.8	72.6	17.8	27.8
	Accident Group	9.8	13.6	50.9	3.8	37.3
Rural	Pop-at-Risk	21.2	38.3	65.6	17.1	27.3
	Accident Group	4.8	14.3	37.1	9.5	22.8
White	Pop-at-Risk	25.2	42.5	68.5	27.3	26.9
	Accident Group	5.4	14.2	38.4	8.8	24.2
Black	Pop-at-Risk	14.4	32.2	70.5	17.8	38.3
	Accident Group	6.2	14.1	40.0	7.9	25.9
Male	Pop-at-Risk	22.3	36.7	64.5	14.4	27.8
	Accident Group	4.7	9.8	31.9	5.1	22.1
Female	Pop-at-Risk	25.9	46.9	74.2	21.0	27.3
	Accident Group	7.1	23.8	53.1	16.7	29.3

*Overall rates are weighted by ADT (Average Daily Traffic) their usage in fatal accidents by 225 percent, which is inconsistent with the proven life-saving benefits of belts.

On the other side, it would appear that there is less of a "lie factor" in the fatal data than in the data for any injury or for moderate or worse (BAK) injuries (see Figure 3.4). As should be the case with population wearing rates no greater than 70 percent, the wearing rates for fatally injured occupants should be lower than in the population-at-risk. This is the case for all three time periods for both fatally (K) injured and seriously or fatally (A+K) injured occupants but not so for the other injury severities.

Finally, looking at the percentage point changes across time periods (see Table 3.1), these are generally most expectable for the population-at-risk and for the fatally injured occupants except for the urban strata and for females. Here the increases are inordinately great (comparing the citation phase with the warning ticket phase) yielding unlikely wearing rates of over 50 percent for crash-involved occupants in both strata!

In short, although the best usage data look better in the fatal data than in either the all injury data or the Highway Patrol data, there remain unexplainable discrepancies in police-reported belt usage data which render it much less useful than in the days prior to belt usage legislation.

Adjustment Procedures

Two analytical adjustment procedures were utilized to further examine the evident "lie factor" now present in accident-reported seat belt use. The first procedure assumed that the ratio of observed to accident belt usage was the same in the warning ticket phase as in the baseline phase and likewise the citation phase. Thus, in the following relationship

$$\frac{\text{observed use}_{\text{baseline}}}{\text{accident use}_{\text{baseline}}} = \frac{\text{observed use}_{\text{warning}}}{X}$$

where X = wearing rate in the warning phase accidents,

one solves for X which is the predicted accident wearing rate in the warning ticket phase. A similar expression would yield the corresponding predicted accident wearing rates in the citation phase.

Table 3.2 gives the results for the adjustment by phase for overall as well as within race and sex groups. Presented are the reported usage rates in

Table 3.2. Predicted vs. reported accident restraint usage rate by time period -- overall and within race and sex groups.

	Warning			Citation		
	Accident Report	Predicted	Pop-at Risk	Accident Report	Predicted	Pop-at Risk
Overall	54.7	38.1	43.1	87.5	62.5	70.7
White	54.3	34.1	42.5	86.9	54.9	68.5
Black	56.1	40.7	32.2	90.3	89.1	70.5
Male	52.6	32.4	36.7	85.8	57.0	64.5
Female	57.8	36.6	46.9	90.1	57.9	74.2

accidents, the predicted rates, and the usage rates seen in the population-at-risk. Except for the black subpopulation, the predicted rates are most reasonable. The cause for the unreasonable predicted rates in this subpopulation is that the observed baseline usage was lower than the corresponding accident baseline usage for the black population. Whatever the causes for this reversal, it does make this adjustment procedure less than ideal.

The second analytical procedure employed to further examine the extent of the apparent "lie factor" assumes that injury rates for restrained and for unrestrained occupants remain constant as the population of restraint users increases (and perhaps changes in other respects). It also assumes that the restraint usage data for the pre-law period are reliable. Given these assumptions, the <u>observed</u> injury by restraint usage distribution in the post-law period is then compared with the <u>predicted</u> distribution where the latter is derived from belt effectiveness estimates from the pre-law period.

The procedure is illustrated using actual Highway Patrol-reported crash data from North Carolina during the pre-law period (July-September 1985) and the post-law (or citation) period (July-September, 1987) (see Table 3.3). For simplicity, the observed totals have been proportionally scaled down to table totals of 1000 cases in each period (see Table 3.4).

For the required predicted table (see Table 3.5), the column totals are obtained from the observed post-law injury totals (Table 3.4) which assumes

Table 3.3. Observed restraint usage by injury severity by time period.

Pre-Law	Injured	Not Injured	Total
Restrained	1727	5258	6,985
Not Restrained	6831	11,516	18,347
Total	8558	16,774	25,332

Post-Law	Injured	Not Injured	Total
Restrained	7,233	17,682	24,915
Not Restrained	2,286	2,006	4,292
Total	9,519	19,688	29,207

Table 3.4. (Proportional) observed restraint usage by injury severity by time period.

Pre-Law	Injured	Not Injured	Total	Pr (Injured)
Restrained	68	208	276	0.246
Not Restrained	270	454	724	0.373
Total	338	662	1000	0.338

R_{pre} = restraint usage (Pre-Law) = 27.6%
E_{pre} = effectiveness (Pre-Law) = 34.1%

Post-Law	Injured	Not Injured	Total	Pr (Injured)
Restrained	248	605	853	0.291
Not Restrained	78	69	147	0.531
Total	326	674	1000	0.326

R_{post} = restraint usage (Post-Law) = 85.3%
E_{post} = effectiveness (Post-Law) = 45.2%

Table 3.5. Constraints for predicted post-law restraint usage by injury severity distribution.

Post-Law	Injured	Not Injured	Total	Pr (Injured)
Restrained	N_{11}^*	N_{12}^*	$N_{1.}^*$	0.246
Not Restrained	N_{21}^*	N_{22}^*	$N_{2.}^*$	0.373
Total	326	674	1000	0.326

that police [illegible]cers have not changed their determination of injury severity over time. [illegible]tain the row totals ($N_{i.}^*$), the following relationships are utilized:

(1) $N_{1.}^* + N_{2.}^* = 1000$

(2) $$\frac{N_{1.}^*(0.246) + N_{2.}^*(0.373)}{1000} = 0.326$$

Solving for $N_{1.}^*$ and $N_{2.}^*$ yields

$N_{1.}^* = 370$

$N_{2.}^* = 630$

Finally, assuming Pr (A+K|restrained) = 0.246, then the predicted value of N_{11}^* is derived from $N_{11}^*/N_{1.}^* = N_{11}^*/370 = 0.246$; thus, $N_{11}^* = 91$. Hence the predicted post-law injury distribution is given by Table 3.6, which is vastly

Table 3.6. Predicted post-law restraint usage by injury severity.

Post-Law	Injured	Not Injured	Total
Restrained	91	279	370
Not Restrained	235	395	630
Total	326	674	1000

$\hat{R}$ = predicted restraint usage (Post-Law) = 37.0%
$\hat{E}$ = predicted effectiveness (Post-Law) = 34.1% = E_{pre}

different from the observed distribution (Table 3.4). Note also the sizable discrepancy in the effectiveness estimates (45.2% observed post-law vs. 34.1% predicted post-law). In addition, the observed restraint usage percent in the post-law period (85.3% from Table 3.4) is clearly inconsistent with both the population-at-risk estimate of belt usage (58.3% for covered front seat occupants during the July-September, 1987 period) and historical data showing lower belt usage in crashes than in the general population. All of these results are clearly consistent with the presence of a "lie factor."

The Question of Unknown Belt Use

The final dimension to the investigation of the usefulness of post-law accident belt usage information deals with the question of unknown belt use. Here the analysis focuses on Highway Patrol-investigated crashes and covered occupants only. It is to be expected that with the stigma of not wearing a belt even though there is a law, the officer might tend to use "unknown" for belt use more in the citation phase than in either the warning or baseline phase.

As can be seen in Figures 3.5 for the overall population of covered occupants as well as Figure 3.6 by race and Figure 3.7 by sex, the rate of unknown belt usage in accidents increases slightly in the warning phase over that of the baseline phase and dramatically once the $25 citation phase is reached! This is true across all levels of injury as well as within each race and sex group -- again across all levels of injury. The rate of unknown belt usage rises directly as injury severity increases; that is, the rate is lowest for the any injury category and consistently highest in fatal crashes. For the most part, the unknown usage rates are higher for black occupants and for males in crashes.

The relatively high unknown belt usage rates in the citation phase provide further evidence of the lack of usefulness of police-reported belt data in post-law periods. Combining this with the "lie factor" results leads one to conclude that, at present, belt usage from belt law states in the post-law period is extremely tenuous at best and not to be recommended, provided the results in other states are similar to those seen in North Carolina.

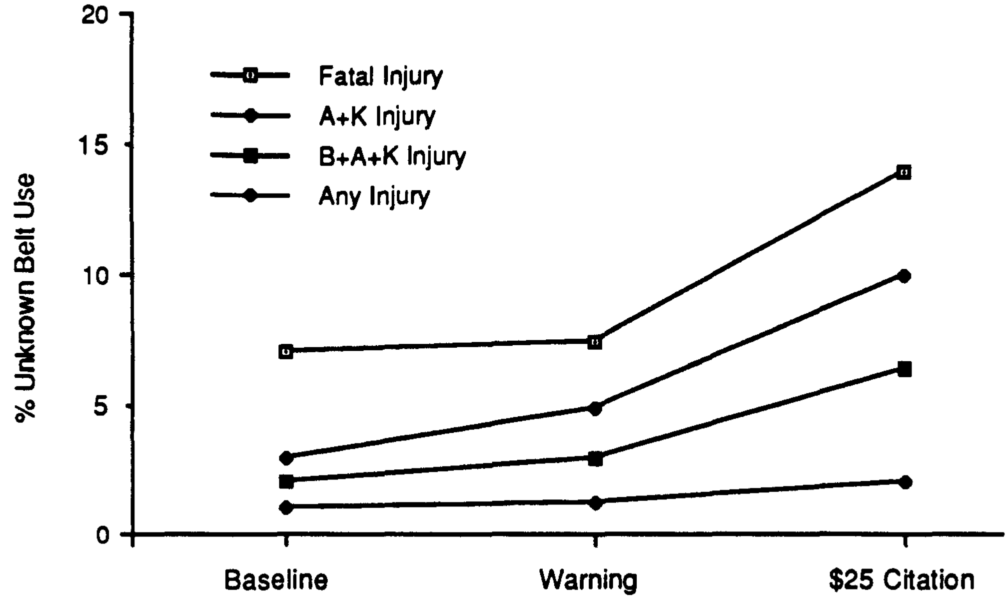

Figure 3.5. Percent unknown belt usage by injury severity of covered occupant across time periods (NC Highway Patrol).

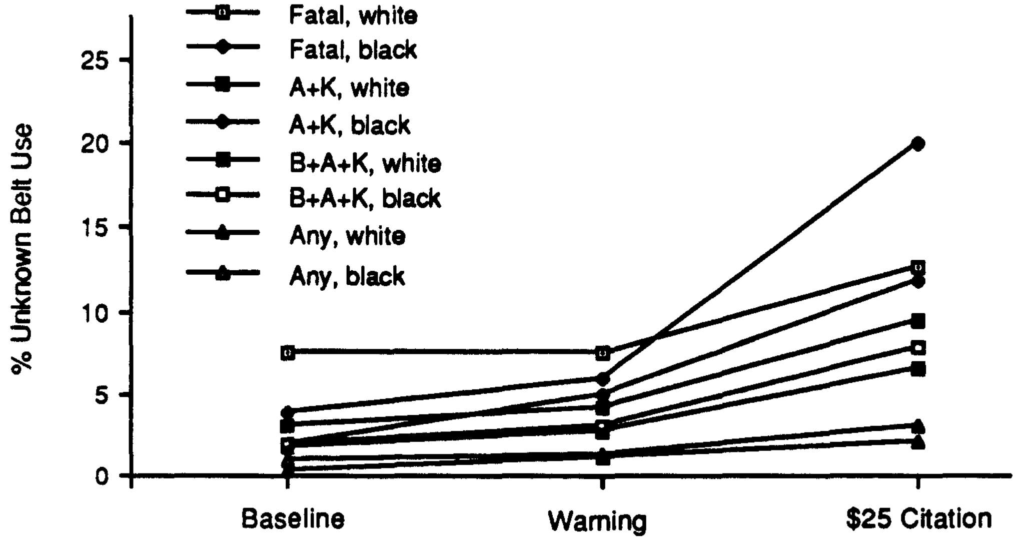

Figure 3.6. Percent unknown belt usage by race for covered occupant injury severity across time periods (NC Highway Patrol).

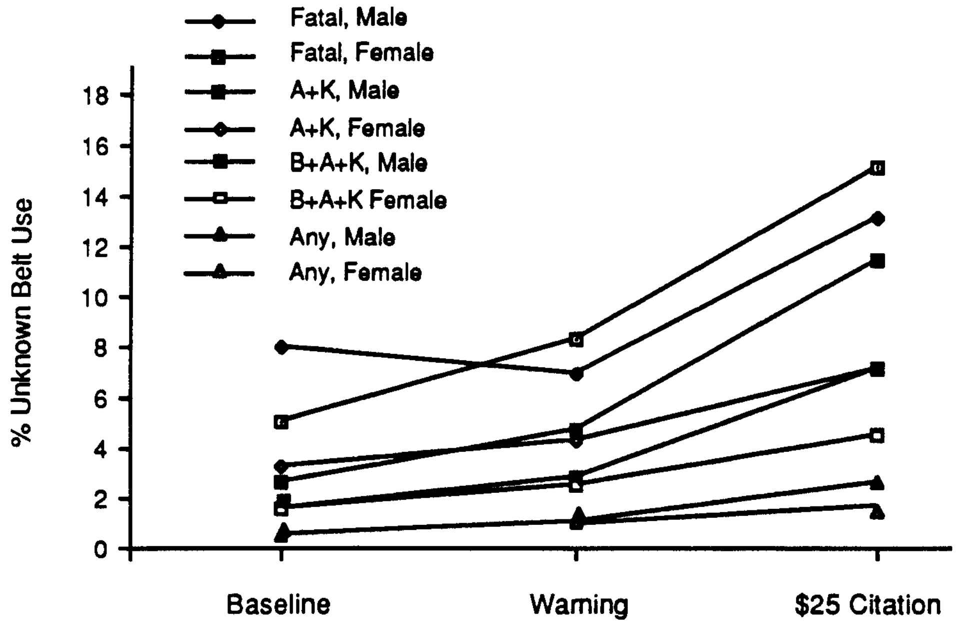

Figure 3.7. Percent unknown belt usage by sex for covered occupant injury severity across time periods (NC Highway Patrol).

Conclusions

Realizing these inadequacies in the data, current attempts at looking at mortality and morbidity reduction arising from seat belt laws tend to use time series analyses covering a long period prior to the passage of the law and examine injury fluctuations regardless of reported belt usage categories. This would appear to be the recommended procedure for the foreseeable future.

Another strategy, however, is to examine a variable such as ejection (or ejection rates) which is directly affected by belt use. Increases in belt usage rates in the population should yield decreases in ejections (or ejection rates), without having to examine the belt use category.

In short, the question, "How does a State law affect seat belt use?" can at best only approximately be described from the accident data and more appropriately can be gleaned from the various observational studies that are being carried out in the belt law states. Inferences can be made from changes in injury patterns over time but are especially difficult to quantify. Clearly, the accident belt usage data is flawed and hence does not provide adequate direct answers to the question.

CHAPTER 4. TIME SERIES ANALYSIS OF STATE INJURY DATA

Ohio Injury Data

In the last few years, the technique of time series analysis has been used to analyze the effectiveness of seat belt legislation. For example, in Campbell, Stewart, and Campbell (1988), injury data from five states were examined in this fashion. It was decided to use time series analysis on two states from the NHTSA data base that had not previously been analyzed by Campbell, Stewart, and Campbell, and the States of Ohio and Louisiana were selected.

For these analyses, six different monthly data series relating to occupant injury were prepared. Accident victims were first classified as either "covered occupants" or "not covered others". Covered occupants included drivers and front seat occupants of vehicles covered by the Ohio seat belt legislation, while not covered others included other occupants along with nonoccupants (e.g., pedestrians, motorcyclists). Injuries to these subjects resulting from motor vehicle accidents were then classified by three levels of severity: killed (K), killed or seriously injured (A or K), and moderately injured through killed (A, B, or K). Counts of injured covered and not covered subjects for each of the three severity levels were then accumulated by month over the time interval from January 1982 through December 1987. Finally, these counts were expressed as percentages of all accidents involving covered or not covered subjects. Thus, for May 1984, we have the percent of all accident-involved covered occupants who were killed, the percent who were killed or seriously injured, and the percent who were moderately injured or worse; similarly, for not covered others and for all other months.

If Ohio's seat belt law resulted in a substantial increase in seat belt usage, then we might expect to see a sharp reduction in the percentage of covered occupants who were injured at the various severity levels coinciding with the beginning of the law. For the not covered others, one might not expect to see such a shift. Population seat belt use for Ohio as noted in Campbell, et al. (1988) was

Date	Belt Use Rate	Comments
Early 1984	15%	Pre-law
Mid 1985	16%	Pre-law
June 1986	38%	Immediate post-law
September 1986	47%	Just after enforcement began July 1986
March 1987	48%	Post-law
June 1987	41%	Post-law
June 1988	34%	Post-law

Thus, the belt use rate tripled after enforcement, compared to pre-law, but then declined thereafter.

Structural time series models of the form used by Harvey and Durbin (1986) in their evaluation of seat belt legislation in Great Britain were used to analyze these data series. The computer routine, Structural Time Series Analysis and Modelling Package (STAMP) developed by ESRC Center in Economic Computing, was used to carry out the analyses. Structural time series models were formulated in terms of stochastic (randomly varying) levels, slope components, and seasonal effects, and a purely random or irregular component. These models can also include regression effects due to exogenous and intervention variables. The basic form of the model is

$$Y_t = \mu_t + \tau_t + \sum_{j=1}^{K} \alpha_j X_{jt} + \varepsilon_t \quad ,$$

where Y_t is the series being modelled, μ_t is the trend component, τ_t the seasonal component, X_{jt} represent independent variables including interventions, and ε_t is an error term.

The simplest such model contains only a stochastic level and an irregular component. It has the form $Y_t = \mu_t + \varepsilon_t$, where $\mu_t = \mu_{t-1} + \delta_t$. Both ε_t and δ_t are random terms each having mean zero and variances σ_ε^2 and σ_δ^2. Thus, the value of the series Y_t at time t is the level μ_t plus an error term ε_t. The value of the level μ_t is its value at time t-1, μ_{t-1} plus a second error term δ_t. Note that the only fixed parameters in this model are the variances, σ_ε^2 and σ_δ^2. Slopes, seasonals, etc. add other terms and variances to the equation.

Each model contained either one or two intervention variables indicating either the beginning of the law (May 1986) or the start of enforcement (July 1986) or both. These intervention variables consisted of a series of zeros from January 1982 up to the point of intervention, then a series of ones from that point onward. A statistically significant intervention effect, thus, is an indication that the series has undergone an overall shift in level beginning at the point of intervention. The algebraic sign of the estimated effect determines whether the shift is an increase (positive sign) or a decrease (negative sign).

Plots of the six data series are shown in Figures 4.1-4.6. Figure 4.1 shows the percent of the covered occupants with either an A, B, or K injury, while Figure 4.2 shows the percent of the covered occupants with either an A or K injury. Figure 4.3 is a plot of the percent of the covered occupants who were killed. Figures 4.4-4.6 cover the same sequence of injuries for the "not covered others."

These figures show that all of the series seem to contain a certain amount of seasonal variation, though this is more pronounced for the not covered series. The figures also show that there seems to be no major shifts in the level of the series associated with either of the intervention points. For the covered occupant series, models with autoregressive terms at lag 11 fit the data better than models with 12 month seasonal patterns.

For each series, models were fit which adequately accounted for the observed autocorrelational patterns and contained the intervention variables. Results of these analyses are presented in Table 4.1. The values in the first row of each cell of Table 4.1 are t-statistics for the two intervention effects when fit separately (i.e., from two models each containing a single intervention). The values in the second row are from a third model containing

Table 4.1. T-statistics for intervention effects.

	Covered Occupants			Not Covered		
	Interventions					
Injury Level	May 1986		July 1986	May 1986		July 1986
A, B, K	.37		.66	-.57		-.88
	.56	and	.78	-.18	and	-.74
A, K	-.44		.08	-.19		-.30
	-.68	and	.59	-.09	and	-.26
K	-.33		-.06	.91		1.33
	-.72	and	.65	.35	and	.88

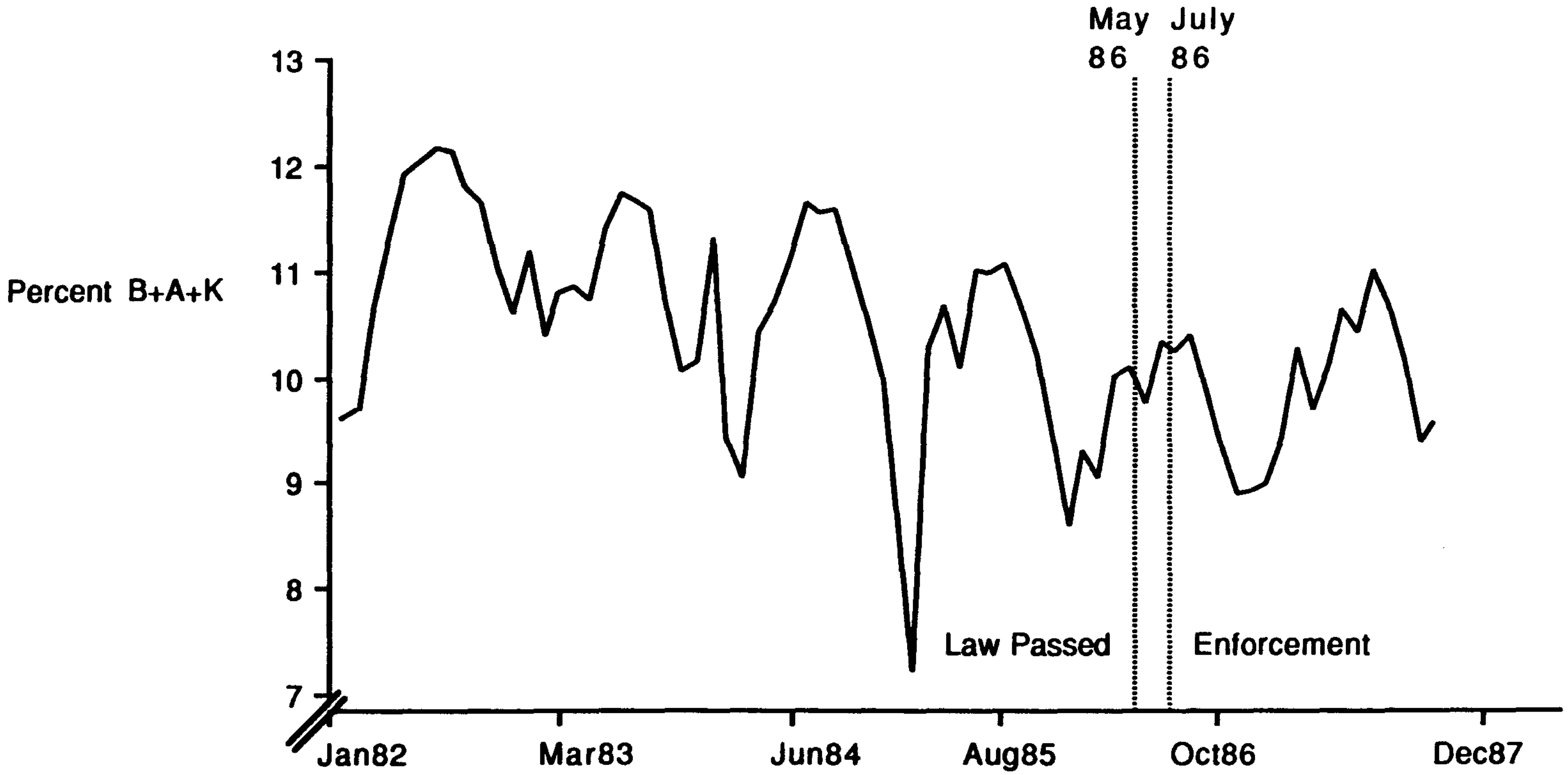

Figure 4.1. Percent of covered occupants with moderate or worse injuries (Ohio).

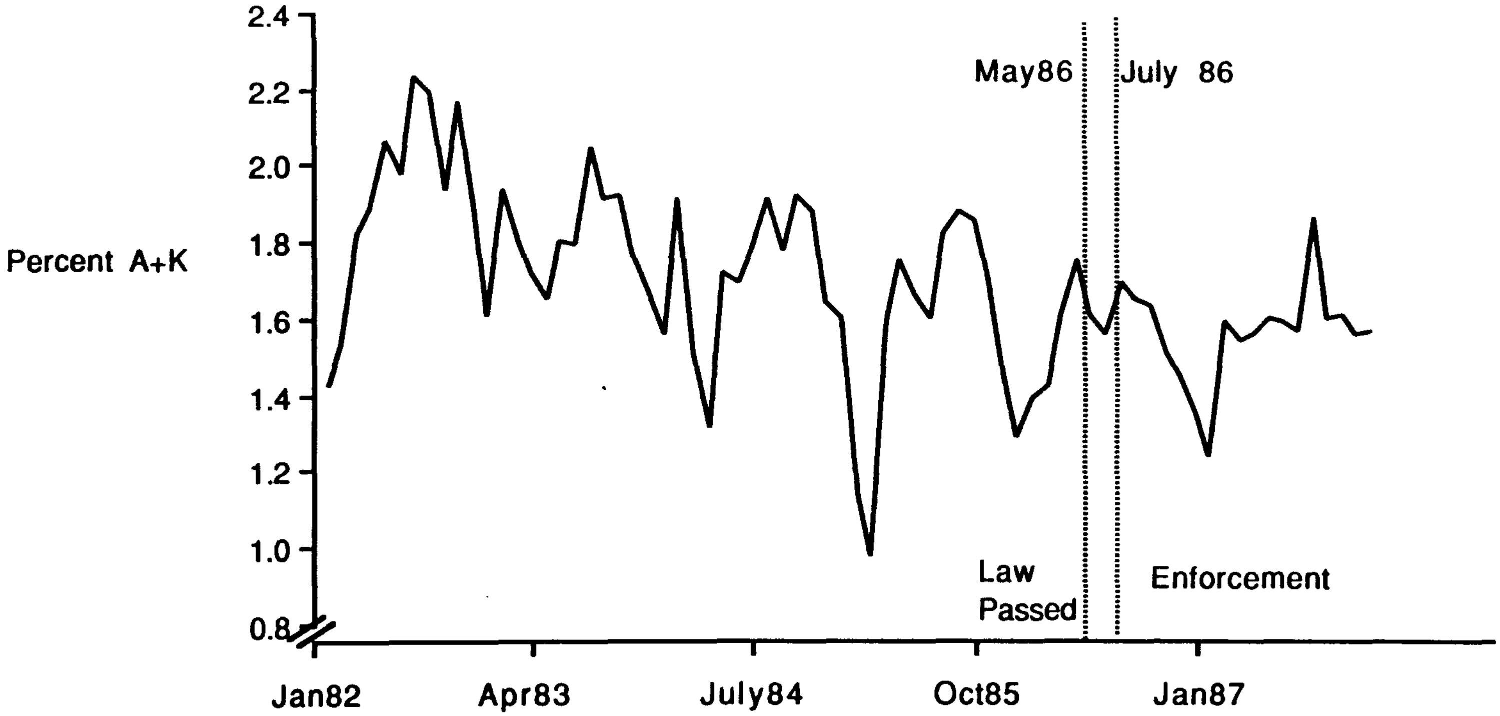

Figure 4.2. Percent of covered occupants seriously injured or killed (Ohio).

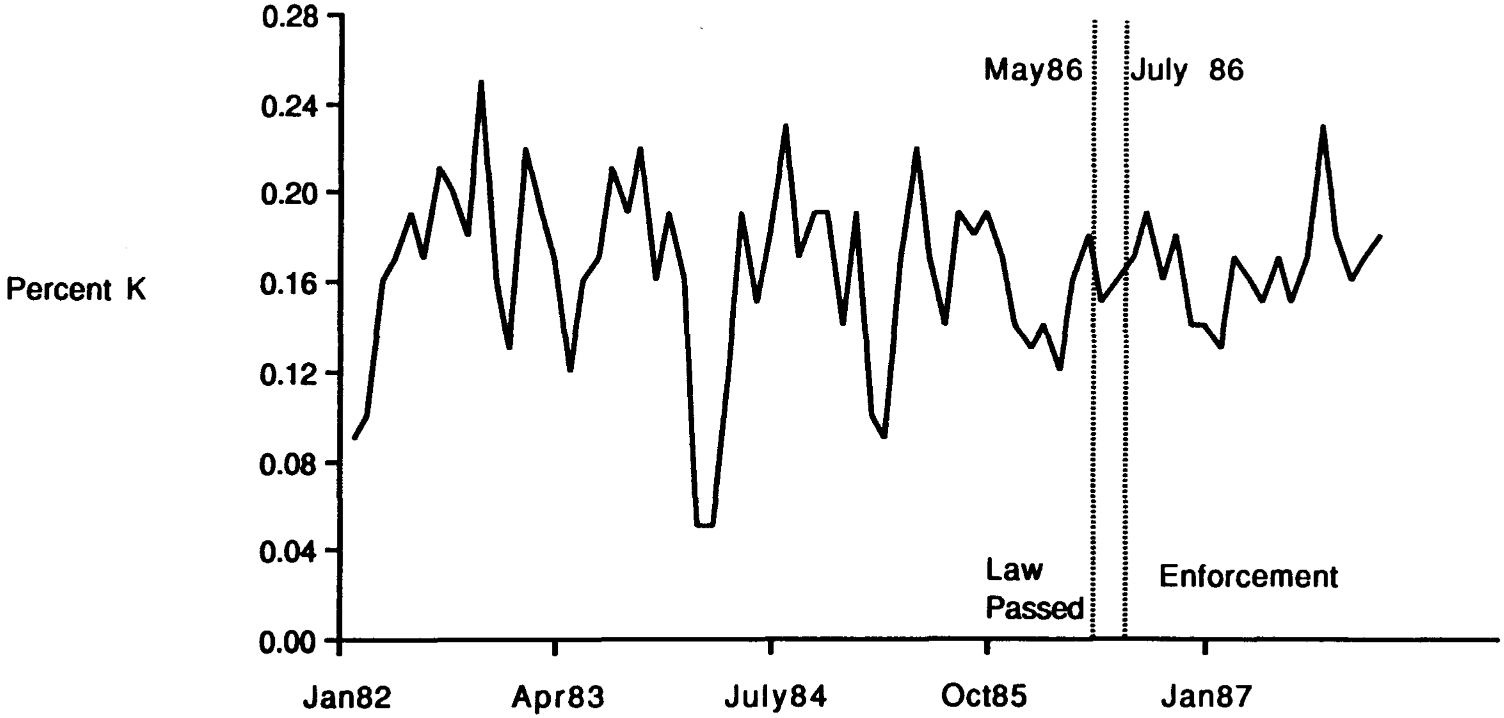

Figure 4.3. Percent of covered occupants with fatal injuries (Ohio).

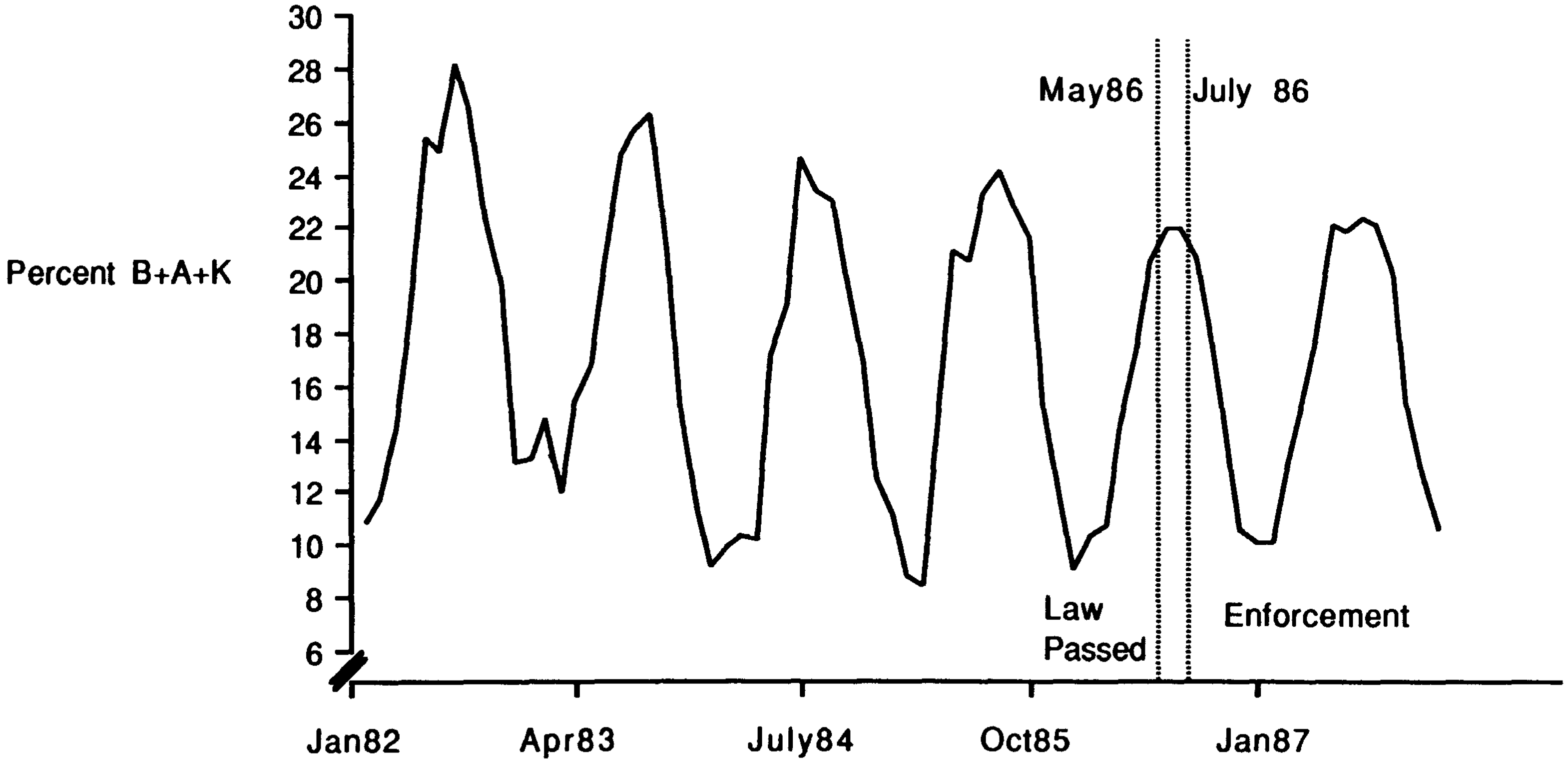

Figure 4.4. Percent of non-covered others with moderate or worse injuries (Ohio).

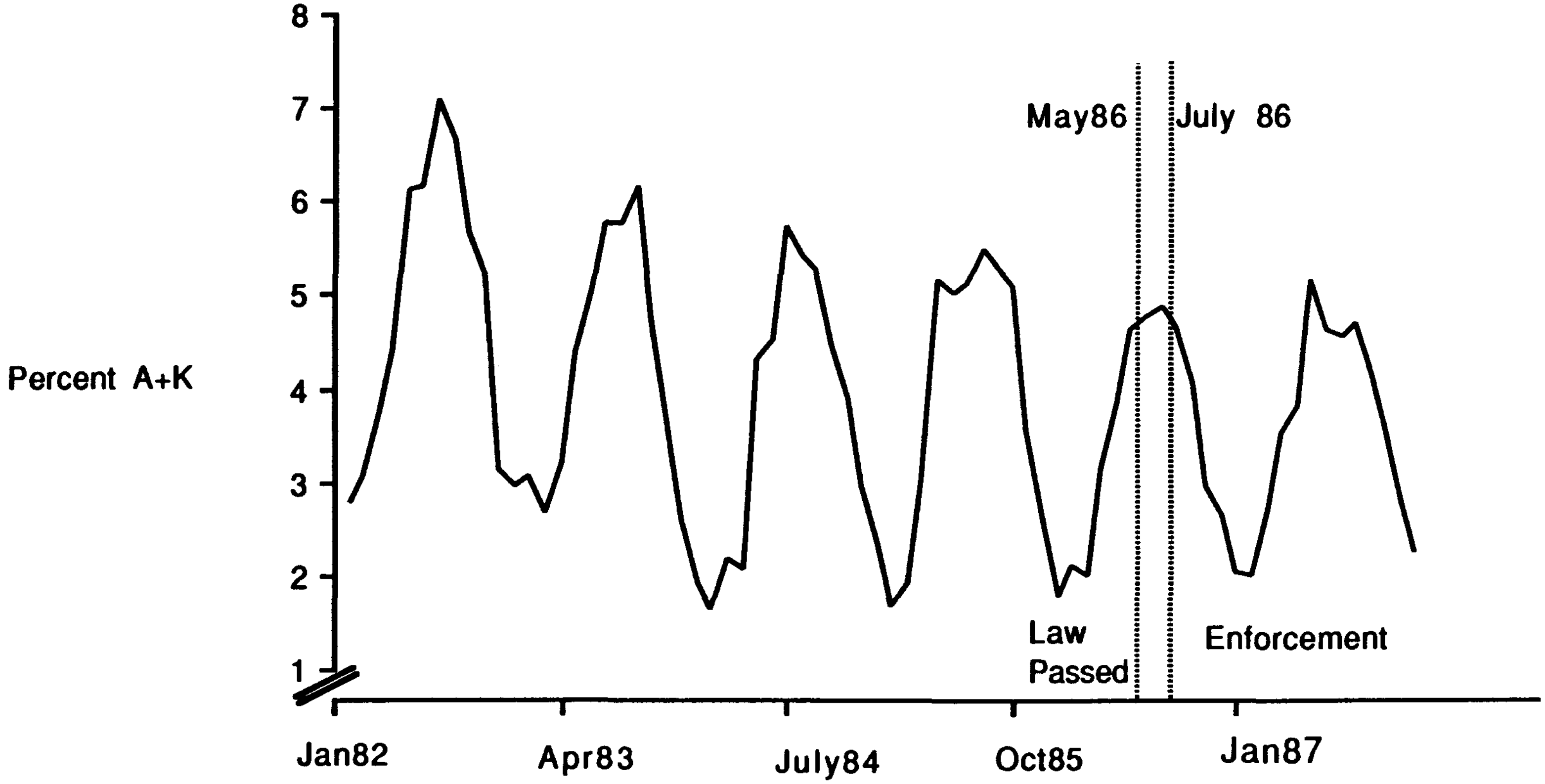

Figure 4.5. Percent of non-covered others seriously injured (Ohio).

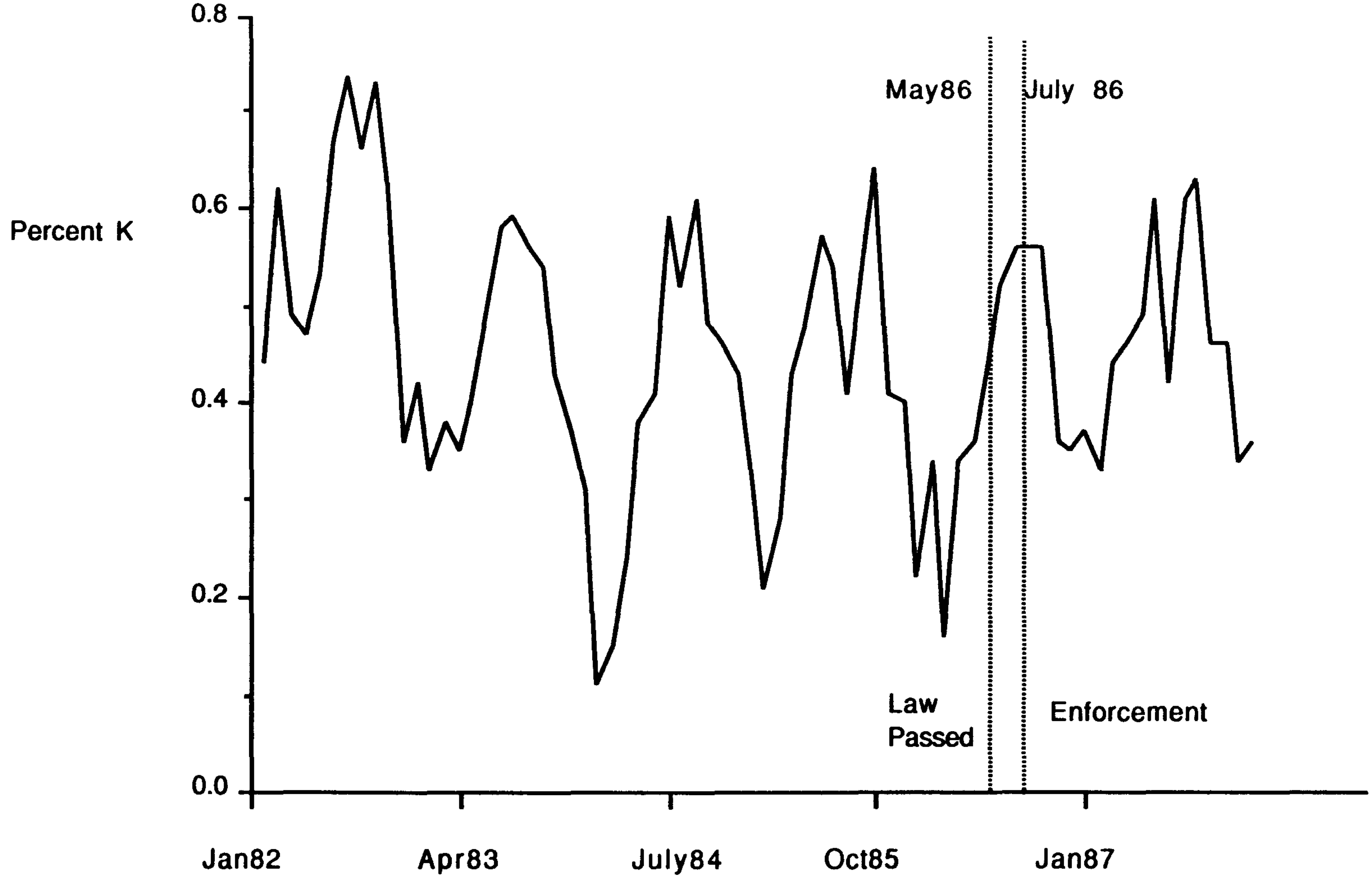

Figure 4.6. Percent of non-covered others with fatal injuries (Ohio).

two intervention variables. All t-statistics should be compared with a t-distribution with 60 degrees of freedom. For covered occupants, we would expect a negative effect (decrease) so that a one-tailed test would normally be used. For not covered others a two-tailed test would be used. None of the t-statistics of Table 4.1 was significant at a significance level of .10.

Thus, we see no evidence from the data of a reduction in motor vehicle related injuries at any severity level as a result of Ohio's seat belt law.

Louisiana Injury Data

Six monthly data series were developed using accident injury data from the state of Louisiana. Three of these series pertained to accident involved motor vehicle occupants who were covered by the state's mandatory seat belt law, which became effective in July 1986. These series consisted of the percent of these occupants who were killed, the percent who were killed or seriously injured, and the percent who were ejected from the vehicle. The other three series were developed similarly for occupants not covered by the law and non-occupants.

The population belt use for Louisiana as noted in Campbell, et al. (1988) was:

Date	Belt Use Rate	Comments
December 1985	12%	Pre-law
December 1986	35%	After enforcement began August 1986
January 1988	36%	Post-law

Thus, while the use rate tripled after enforcement of the law, still only about one-third of the occupants were restrained.

Louisiana does not use the KABCO injury severity scale, but serious injuries were designated to match as closely as possible A-level injuries. Thus, the killed or seriously injured series should be reasonably comparable to A+K series which we typically analyze.

Plots of the six data series are shown in Figures 4.7 through 4.12. Figure 4.7 shows the series for percent of covered occupants killed or seriously injured. The plot shows an abnormally high peak at the very beginning (i.e., Jan. - Feb. 1982) of the series which may reflect an error in either the numerator or denominator of this series. Although these data points

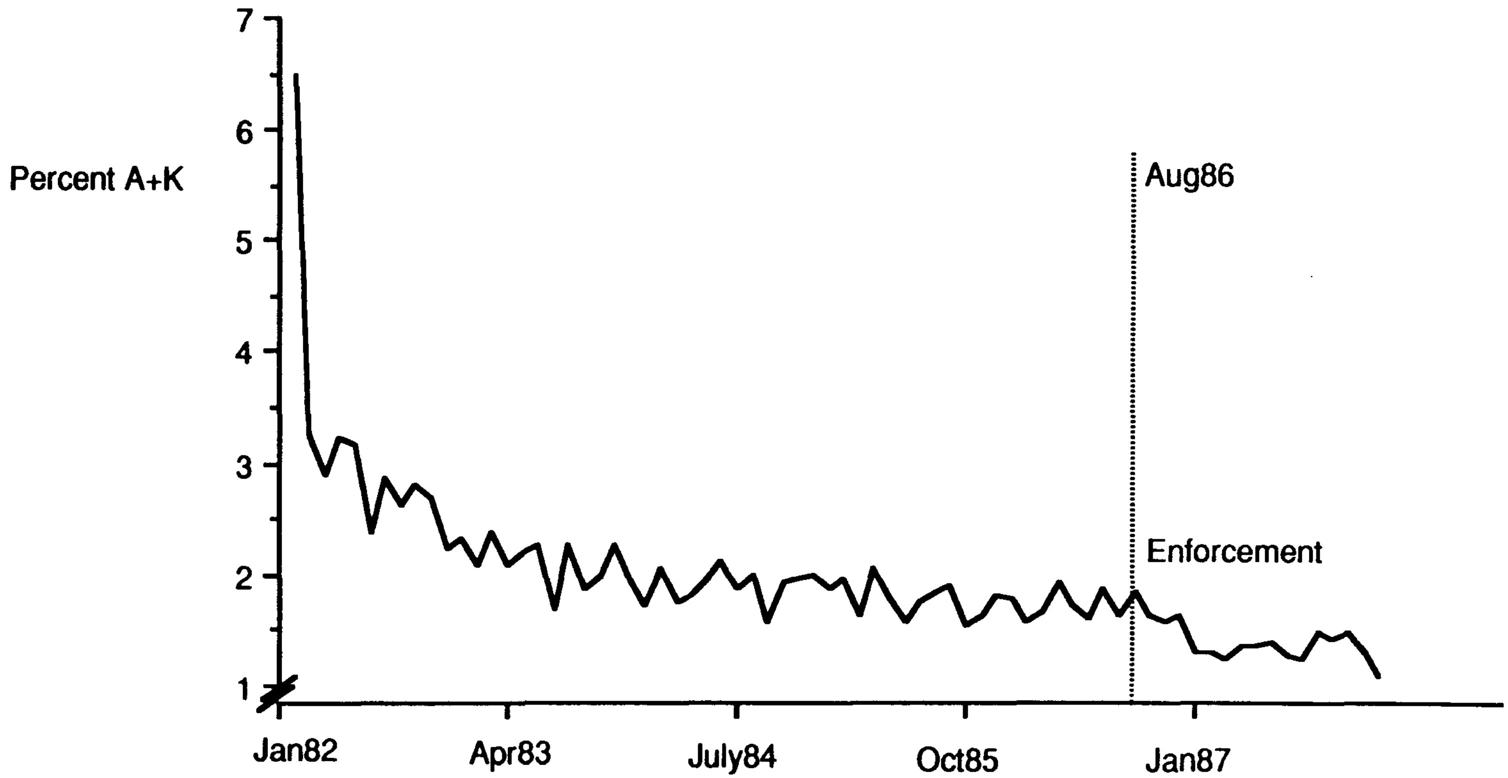

Figure 4.7. Percent of covered occupants seriously injured or killed (Louisiana).

are far removed (in time) from the onset of the seat belt law and should not affect the estimation of intervention parameters, the first two data points of this series were not used in any of the analyses. From March 1983 onward the series in Figure 4.7 shows a steady decrease in the percent killed or seriously injured, and a rather sudden drop late in 1986. Figures 4.8 and 4.9 show roughly similar patterns for the other covered occupant series.

As was done with the Ohio data, structural time series models were fit to each of these data series. These models contained trend and seasonal components, random components, and intervention variables to characterize the effect of the mandatory seat belt law on the subsequent data. In particular, since enforcement of the Louisiana seat belt law started in August 1986, an intervention variable having the value of zero for each month prior to August 1986 and the value one from that point onward was included in the models. When such a model was fit to the data of Figure 4.7, a negative but not significant ($p > .10$) intervention effect was estimated. If, however, the intervention point was shifted to December 1986, the estimated effect (decrease) was quite significant ($p < .025$). Thus, it seems that most of the sudden shift in level shown in Figure 4.7 comes some four months after the start of the seat belt law. While we know of no reason for this December 1986 shift, models containing such an intervention variable were also fit to the other data series. Figure 4.13 shows the same data as Figure 4.7, but beginning in March 1982. This figure also shows the estimated trend from a model containing the August 1986 intervention variable.

Table 4.2 gives the results of the intervention analyses for all six series (Figures 4.7-4.12). Table 4.2 shows that a statistically significant

Table 4.2. Intervention analysis results.

	August 1986		December 1986	
	Effect	P-Value	Effect	P-Value
Percent A+K, covered	-.11	>.10	-.27	<.025
Percent K, covered	-.06	<.025	-.08	<.005
Percent ejected, covered	-.11	>.20	-.03	>.25
Percent A+K, not covered	-.23	>.25	.50	>.20
Percent K, not covered	-.06	>.25	-.07	>.25
Percent ejected, not covered	-1.22	>.10	-1.27	>.10

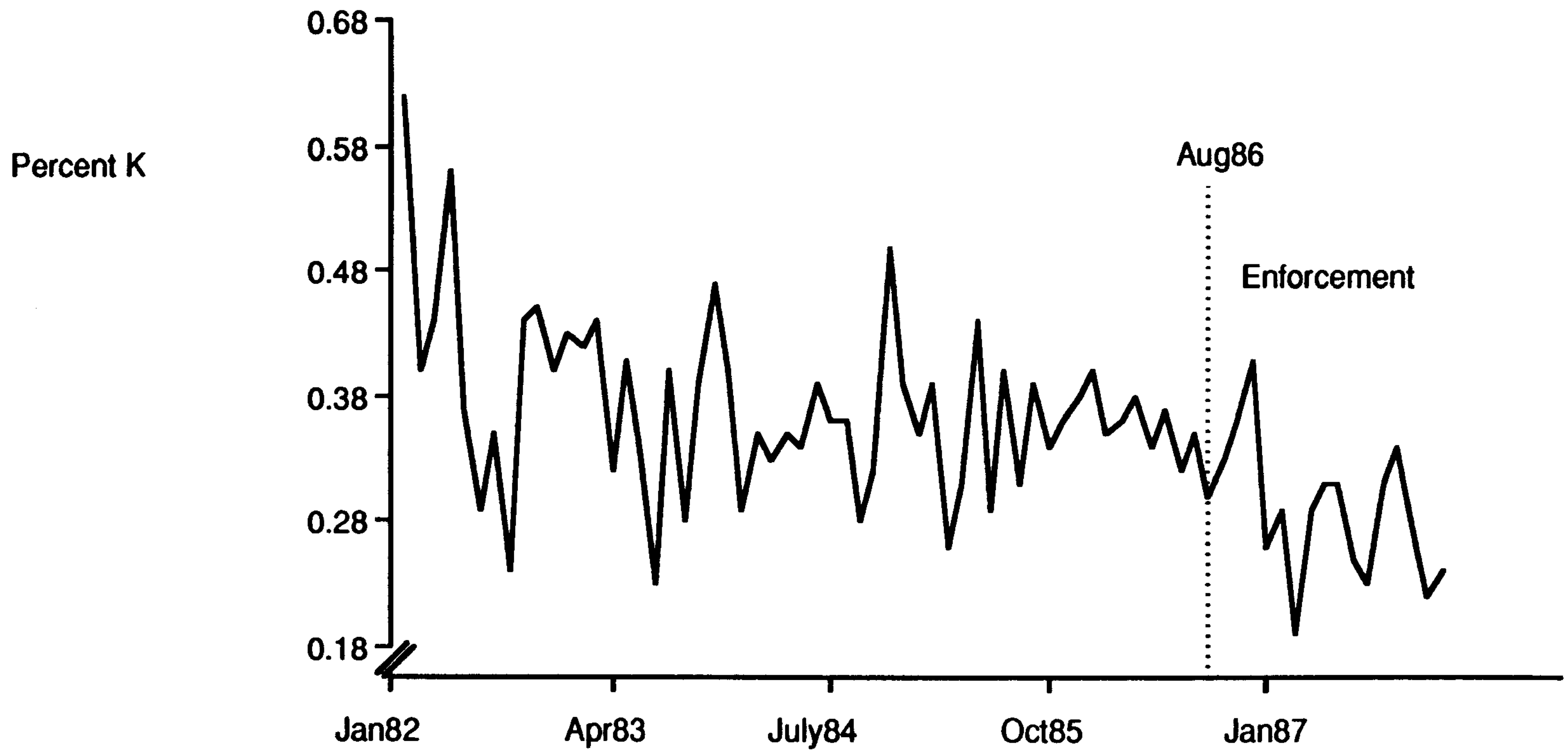

Figure 4.8. Percent of covered occupants with fatal injuries (Louisiana).

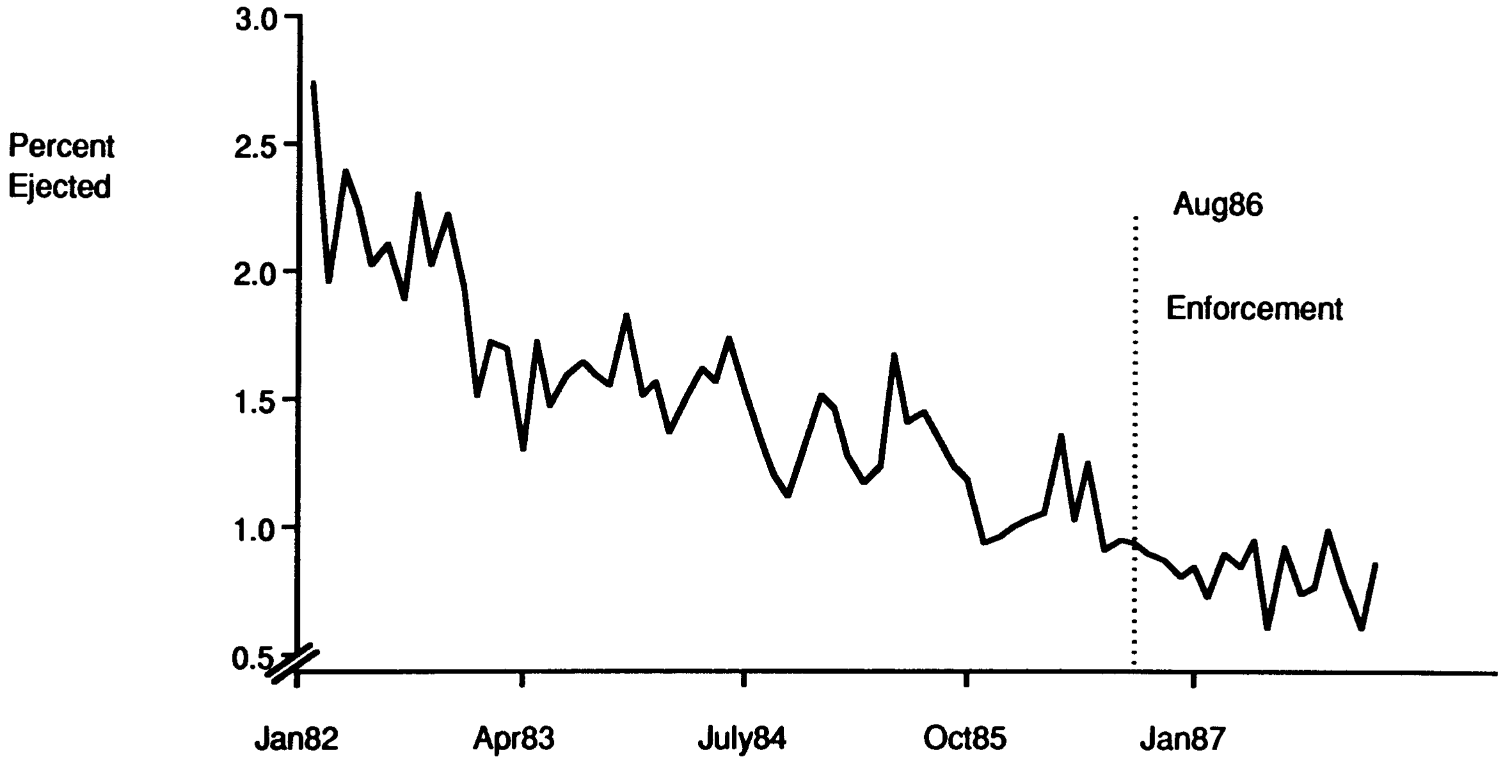

Figure 4.9. Percent of covered occupants ejected (Louisiana).

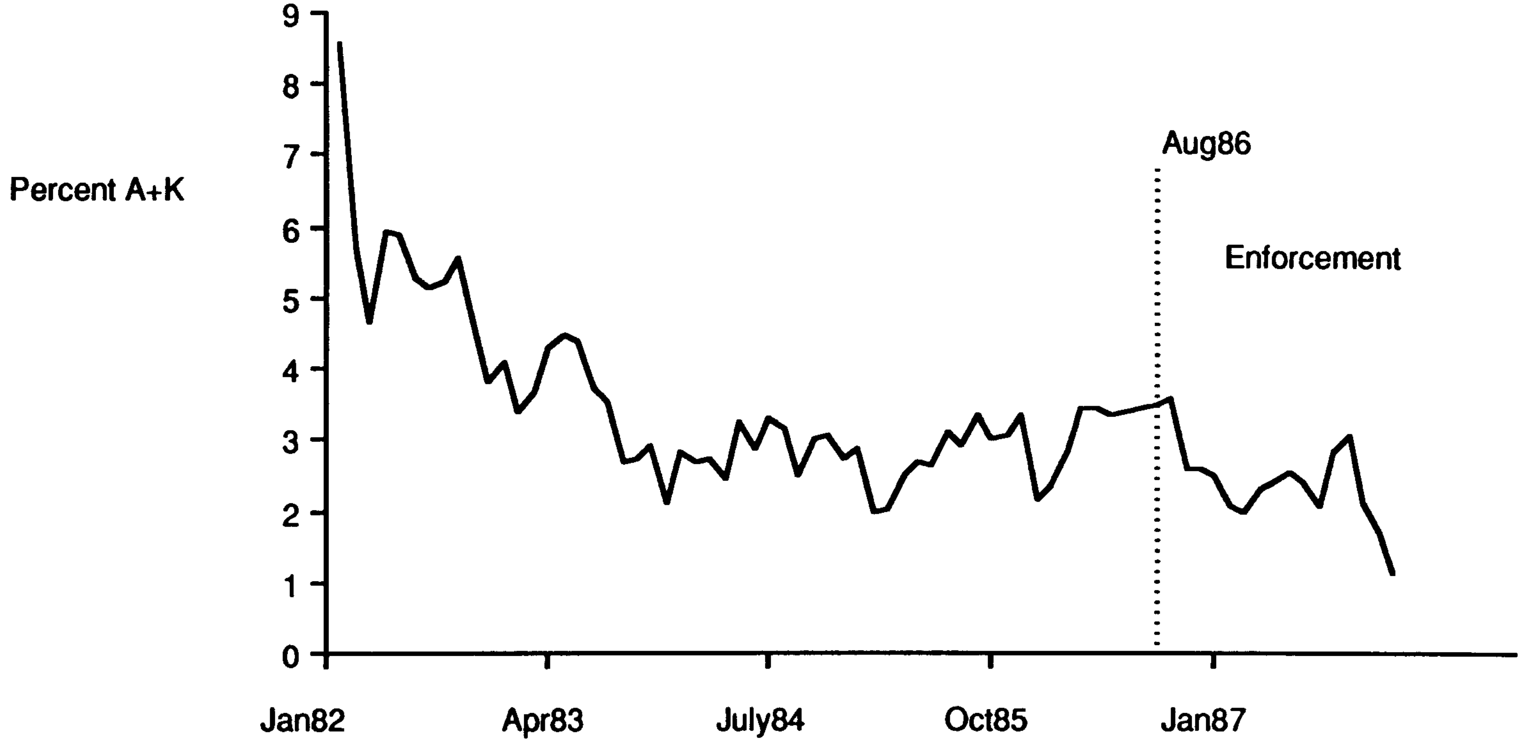

Figure 4.10. Percent of non-covered occupants seriously injured or killed (Louisiana).

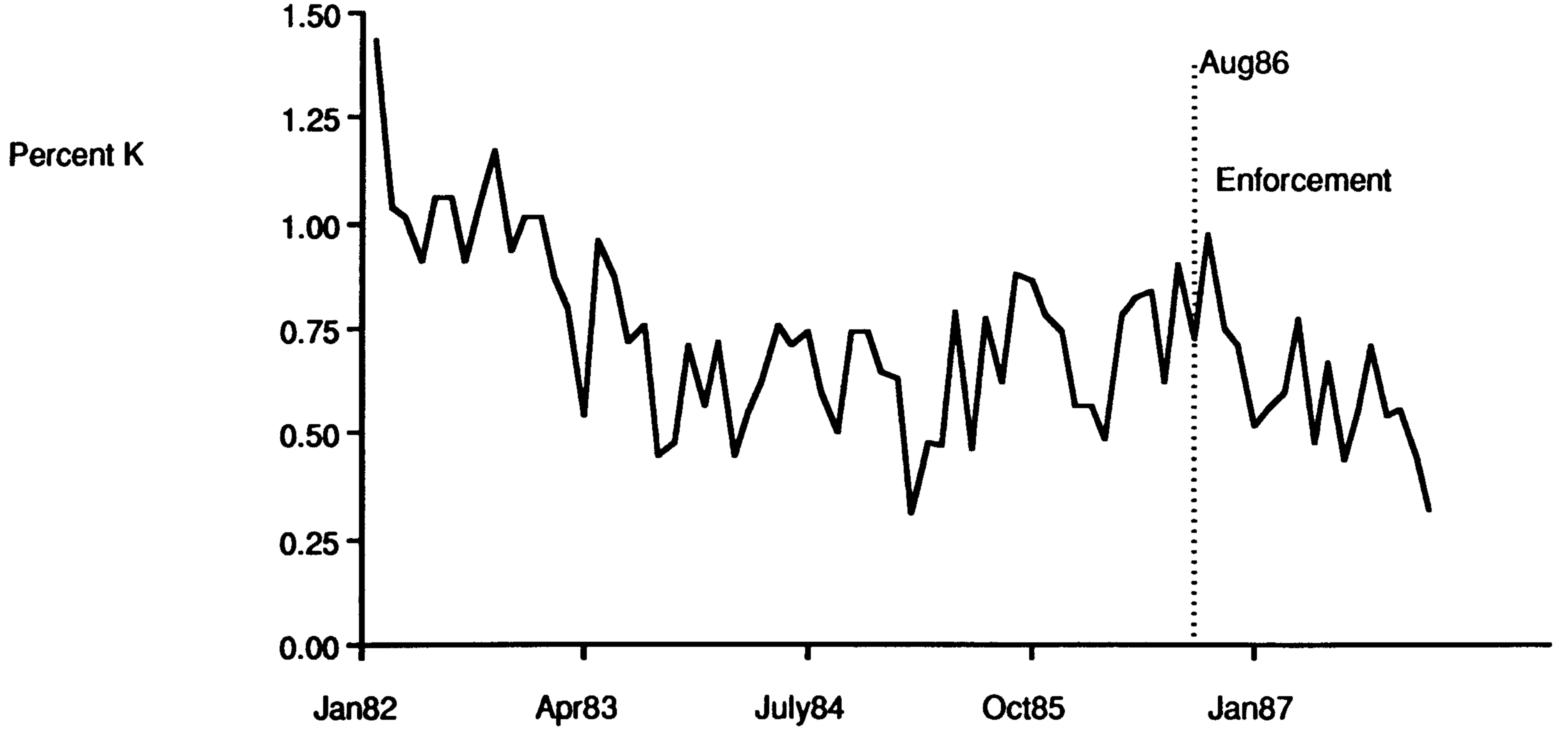

Figure 4.11. Percent of non-covered occupants with fatal injuries (Louisiana).

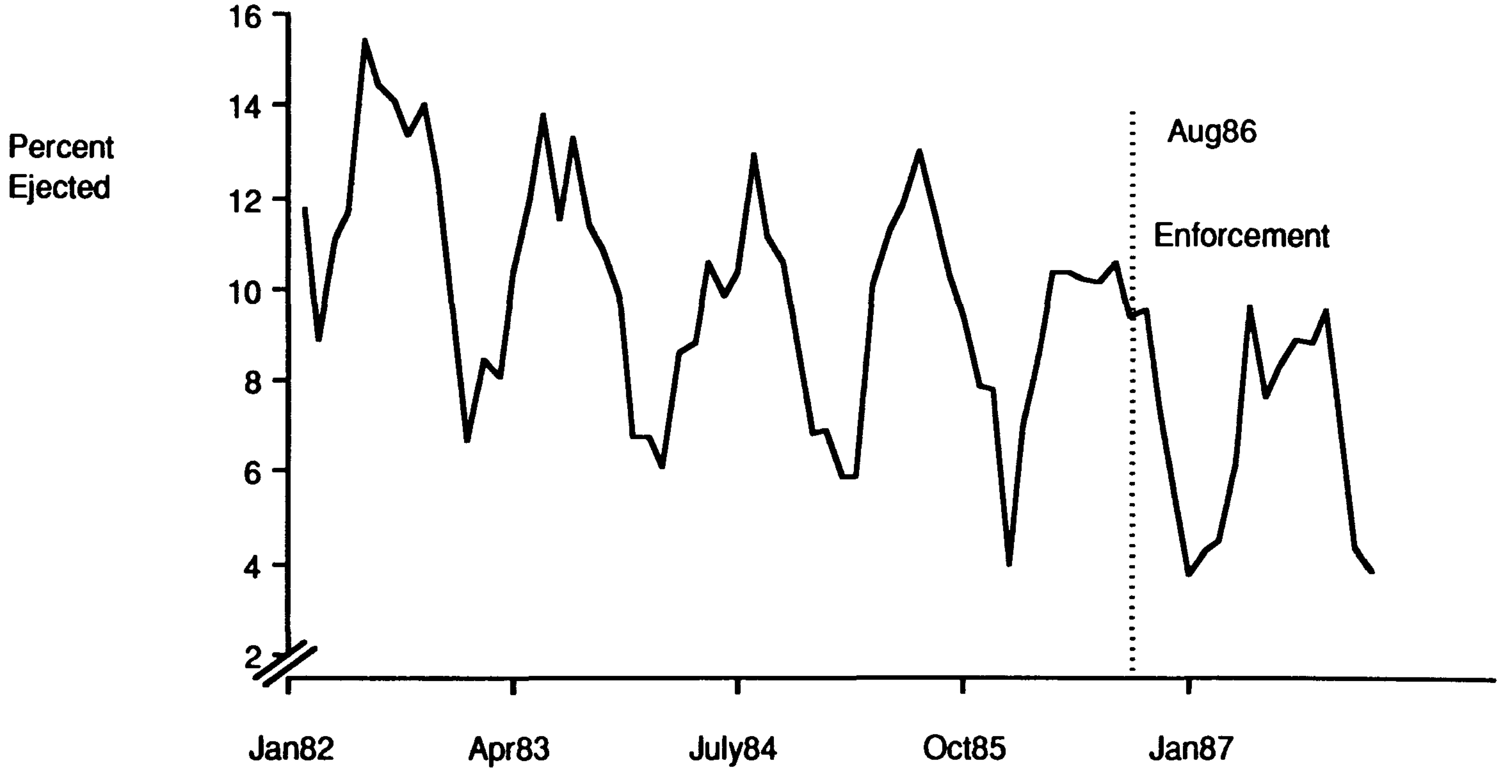

Figure 4.12. Percent of non-covered occupants ejected (Louisiana).

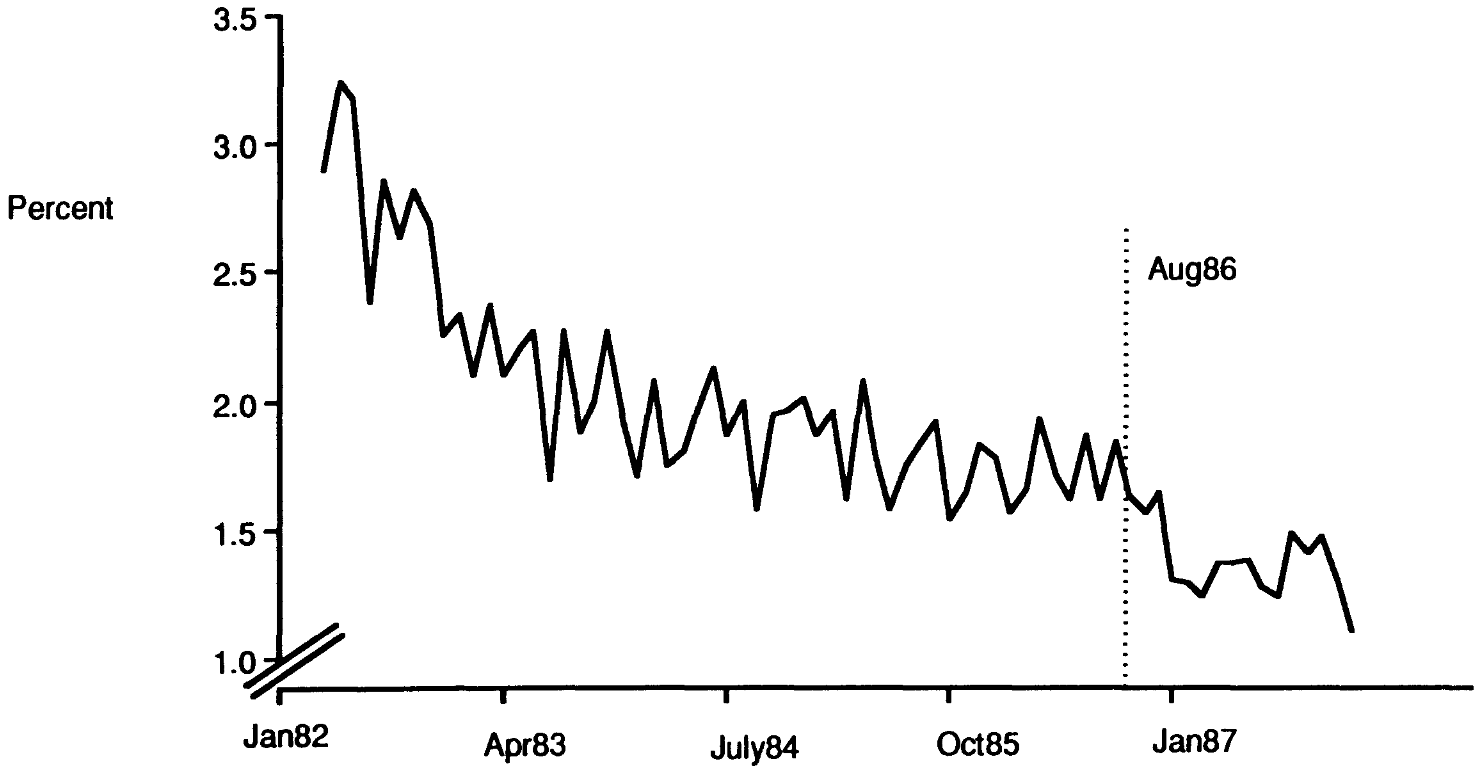

Figure 4.13. Observed percent (A+K) and trend component for percent seriously injured or killed for covered occupants.

decrease in the percent of covered occupants killed was estimated for the August 1986 intervention point. Both the percent killed and percent killed or seriously injured series for covered occupants exhibit larger decreases somewhat after the August 1986 start-up of seat belt law enforcement. In fact, when an intervention point of December 1986 is used in the models, both series are found to decrease significantly. No significant intervention effects were found for the not covered series, nor for either ejection series.

CHAPTER 5. EFFECTIVENESS OF A STATE MANDATORY BELT USE LAW IN REDUCING EJECTIONS IN MOTOR VEHICLE CRASHES

Background

Ejection was first identified as a major factor in fatal and serious injury automobile crashes in 1954 (Wolf, 1962). Initially, better designed safety door locks were implemented and only later were lap safety belts introduced. This early study by Wolf indicated that usage of safety belts had the potential to significantly reduce fatalities by at least 35 percent.

A subsequent study by Huelke, Marsh, and Sherman (1972) examined injuries associated with ejection in rollover crashes. They concluded that occupants involved in overturns have a nearly two-fold increase in fatal injuries compared with their counterparts in non-rollover crashes. Their data imply that this is due to higher ejection rates, in that 21 percent of the occupants of rolled vehicles were ejected, contrasted with a 3 percent ejection rate for occupants of non-rolled vehicles. Further, within the rolled vehicles, 49 percent of the ejected occupants were fatally injured, compared to 7 percent of those not ejected.

The National Highway Traffic Safety Administration has examined the ejection issue several times. Hedlund (1979) used National Crash Severity Study data to determine that the fatality rate given ejection in rollover crashes was about twice the fatality rate given ejection in frontal or side impacts. Bondy and Hart (1982) used National Center for Statistics and Analysis data to conclude that ejection increased the chance of death by a factor of 25, but without controlling for crash severity. In a 1986 NHTSA study, Sikora used the double pair method of Evans (1986) to account for crash severity and concluded that ejection increased the risk of death four times for ejected drivers compared to non-ejected drivers and 2 1/2 times for ejected right front passengers compared with non-ejected right front passengers.

One of the more recent studies of the risk of death associated with ejection was conducted by the Insurance Institute of Highway Safety (IIHS) (Esterlitz, 1989). Using paired comparison criteria, Fatal Accident Reporting System (FARS) data from 1982-1986 were used to examine trends in ejections resulting from various crash types (including single or multiple vehicle) and crash modes (including rollover, non-rollover, and other points of impact). The data included both passenger cars and "other vehicles", where the "other vehicle" category was stated to include pickups, vans, tractor-trailers, and so forth. Given an ejection, Esterlitz found that depending on these factors, the risk of death ranged from 1.5 to 8, with single vehicle rollover crashes having the highest increase in risk of death for both drivers and right front passengers. In single-vehicle rollover crashes, ejection increases the risk of death eight times to drivers and seven times for right front passengers.

Method

To evaluate the effectiveness of a state mandatory usage law (MUL) in reducing (the generally serious) ejections, accident data from Maryland were examined for the years 1981-1988. This interval spanned both the pre- and post-law periods, with the inception of the law on July 1, 1986. Thus, 1986 was a "mixed" year with six months of pre-law data and six months of post-law data. If Maryland drivers were similar to those in other states passing belt laws (e.g., North Carolina), it would have been reasonable for some to start wearing their belts (perhaps developing the habit) prior to the law actually becoming effective, or closer to the first part of 1986. Since the overall data for the year (labelled as 1986 in the tables and charts that follow) appeared to behave more like post-law activity, the 1986 year is treated as post-law in the analysis.

Since the federal requirement of front seat lap belt installation was mandated in the early 1960's, practically all cars on the road today are equipped with safety restraints (i.e., lap or lap/shoulder belts). While earlier studies (1970's) had shown that usage of these devices reduces the likelihood of certain injuries, the vast majority (nearly 90%) of drivers and front seat occupants elected not to restrain themselves. Now that 36 states plus the District of Columbia have mandatory use laws (MUL's), there has been a wholesale increase in belt use, with national use estimated at roughly 50 percent in NHTSA's 19-city survey (Bowman and Rounds, 1986). Coupled with MUL's is an increasingly present phenomenon referred to as the "lie factor", in which crash victims are telling the investigating officer that they are wearing their belts at higher rates than what would be predicted based on population observations (Hunter, Reinfurt, and Hirsh, 1988). These "lie factor" occurrences now make the measurement of the effectiveness of these laws more difficult. Therefore, for this analysis the alternative indirect approach of examining ejections was employed, since the rate of ejections should decrease as reported and observed belt usage increases (Figure 5.1).

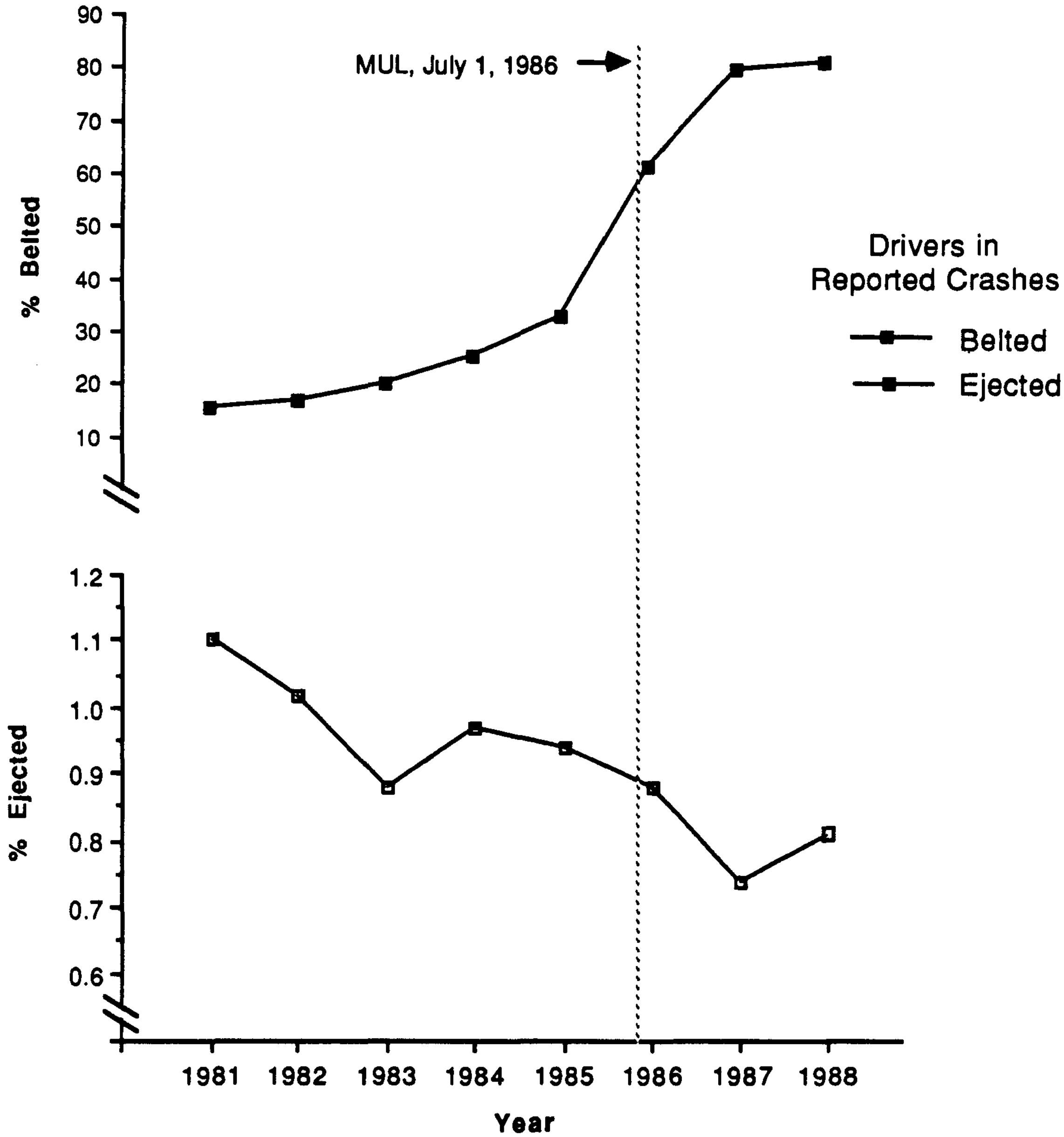

Figure 5.1. Percentage of reported belted drivers in crashes compared with the percentage of ejected drivers.

Due to the implications of the "lie factor", in order to get a sense of how belt usage in crashes compares with belt usage in the population, observational study results from a series of statewide surveys in Maryland were obtained from the Transportation Studies Center at the University of Maryland (average of 29 sites). Additionally, results of an independent study conducted by the Maryland Association of Women's Highway Safety Leaders were obtained (11 sites). Of the two studies, the Transportation Studies Center approach appeared to provide a more unbiased estimate of statewide belt use. Contrary to what would be expected but consistent with the effect a "lie factor" might have, belt usage rates in injury related crashes from the accident file were higher than the rates of the two observational studies (Figure 5.2). These comparisons are limited to the latter three years of the study period, since observational study data are not available for the earlier years (Tables 5.1a-5.1b).

Table 5.1a. Driver belt usage percentages.

Year	Injury Crashes	Transportation Studies Center	Women's Highway Safety
1986	62	-	52
1987	80	53	66
1988	81	51	73
1989	-	50	80

Table 5.1b. Right front passenger belt usage percentages.

Year	Injury Crashes	Transportation Studies Center	Women's Highway Safety
1986	56	-	53
1987	75	49	66
1988	77	41	74
1989	-	54	72

The analysis files consisted of all vehicles in crashes in which there was either an injured driver or an injured right front passenger. This subset of the overall accident file was selected in order to alleviate problems involved with reporting changes over the years. Beginning in 1985, an investigating

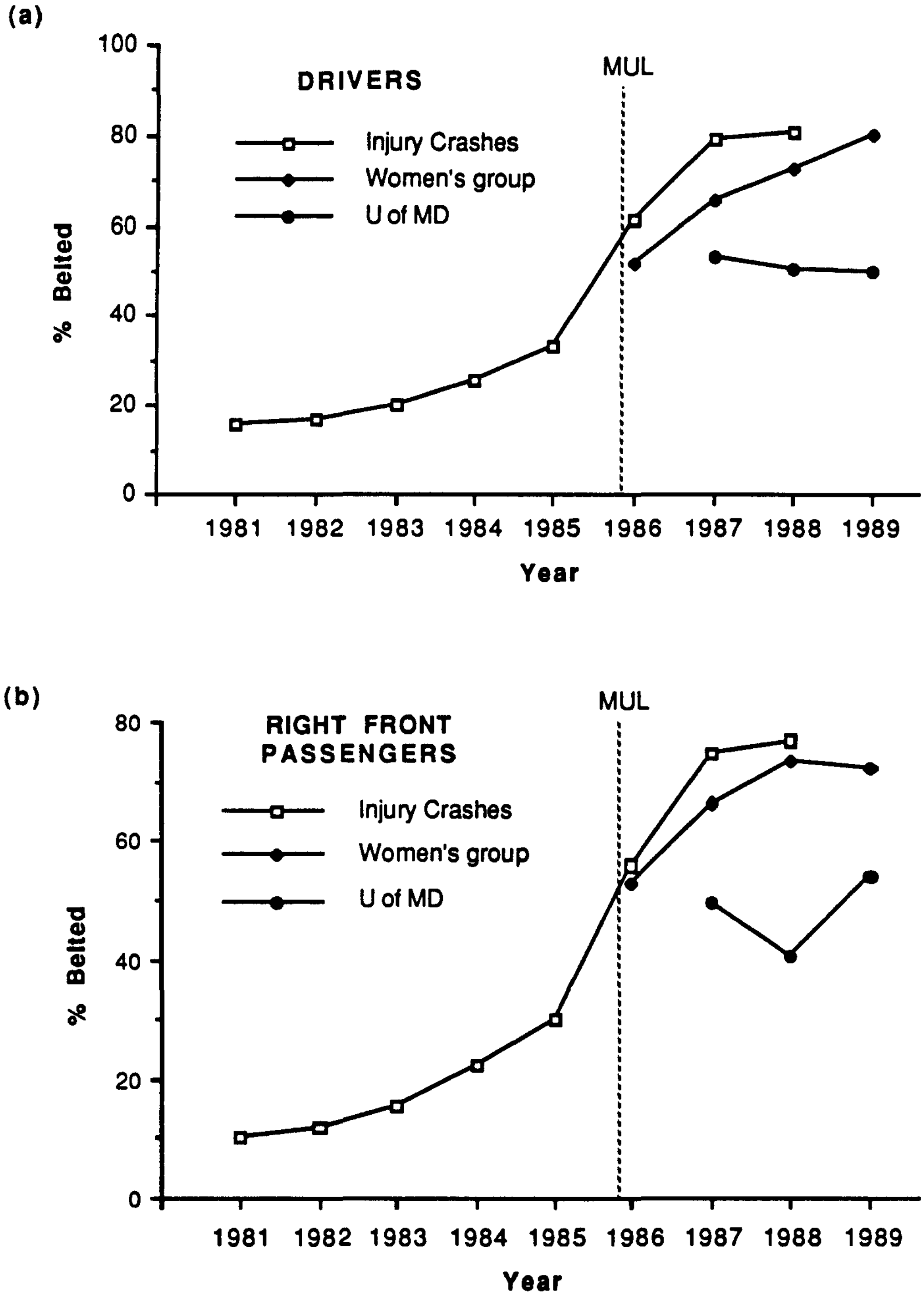

Figure 5.2. (a) Percentage of belted drivers in injury related crashes compared with observational study data;
(b) Percentage of belted right front passengers in injury related crashes compared with observational study data.

officer reported to the scene of an accident only in cases where there was an injured occupant. Nonetheless, examination of the total accident files for the years 1981-1988 showed very little variation in ejection rates.

Results

A variety of roadway and driving conditions were examined (i.e., straight and curved roadway sections, and wet weather and "good" dry weather) to determine if serious injury and ejection rates are higher under certain constraints. There was little evidence to show that ejections varied by any of these roadway or driving condition factors. However, since it is known that ejections are more likely to occur in overturns and in crashes involving fixed objects, these variables, as well as wheelbase (which is an indicator of the size of the vehicle) were analyzed.

Injury related crashes had an overall downward trend in ejection rates for drivers and right front passengers (Table 5.2). From 1981-1985 (pre-law), drivers experienced a reduction in ejections of approximately 15 percent. Extending into the post-law period, there was an even greater reduction in ejections for drivers (26% when 1981 is compared to 1988). The experience of

Table 5.2. Ejection percentages of drivers and right front passengers in injury related crashes.

		Drivers*	Right Front Passengers*
	Year	Percent Ejected	Percent Ejected
Pre-Law	1981	1.10	1.30
	1982	1.02	1.11
	1983	0.88	1.07
	1984	0.97	1.17
	1985	0.94	1.16
Post-Law	1986	0.88	1.00
	1987	0.74	1.00
	1988	0.81	1.02

*based on an average of 43,278 drivers/yr and 17,201 right front passengers/yr right front passengers followed a similar pattern. During the pre-law period, 1981-1985, ejections decreased by 11 percent. After the inception of the MUL, the rate of ejections was reduced even further (22% reduction between 1981 and 1988). Coinciding with the reduction of ejections of these front seat occupants, belt usage as reported on the accident form increased steadily (Table 5.3).

Table 5.3. Reported belt usage percentages of drivers and right front passengers in injury related crashes.

		Drivers*	Right Front Passengers*
	Year	Percent Reported Belted	Percent Reported Belted
	1981	16	10
Pre-Law	1982	17	11
	1983	20	14
	1984	25	21
	1985	33	27
Post-Law	1986	62	56
	1987	79	75
	1988	81	77

*based on an average of 40,400 drivers/yr and 16,093 right front passengers/yr

As expected, the ejection rates of drivers and right front passengers involved in overturn crashes is much higher than those involved in non-overturns (Figure 5.3). Based on the average of the pre- and post-law estimates, driver ejection in overturn crashes was reduced by nearly 17 percent with the law in effect. In contrast, the average estimates for right front passengers yielded a three percent decrease. While right front passengers had steady increases in terms of ejections during the pre-law phase, with the inception of the MUL in 1986, there was a substantial reduction of approximately 29 percent (when 1985 is compared to 1986).

Because wheelbase is a factor which influences vehicle overturns, it has an indirect relationship on the rate of ejections. Figure 5.4 shows that regardless of the size of the vehicle, the ejection rates decreased during the sample period. As expected, occupants in small cars (i.e., wheelbase less than

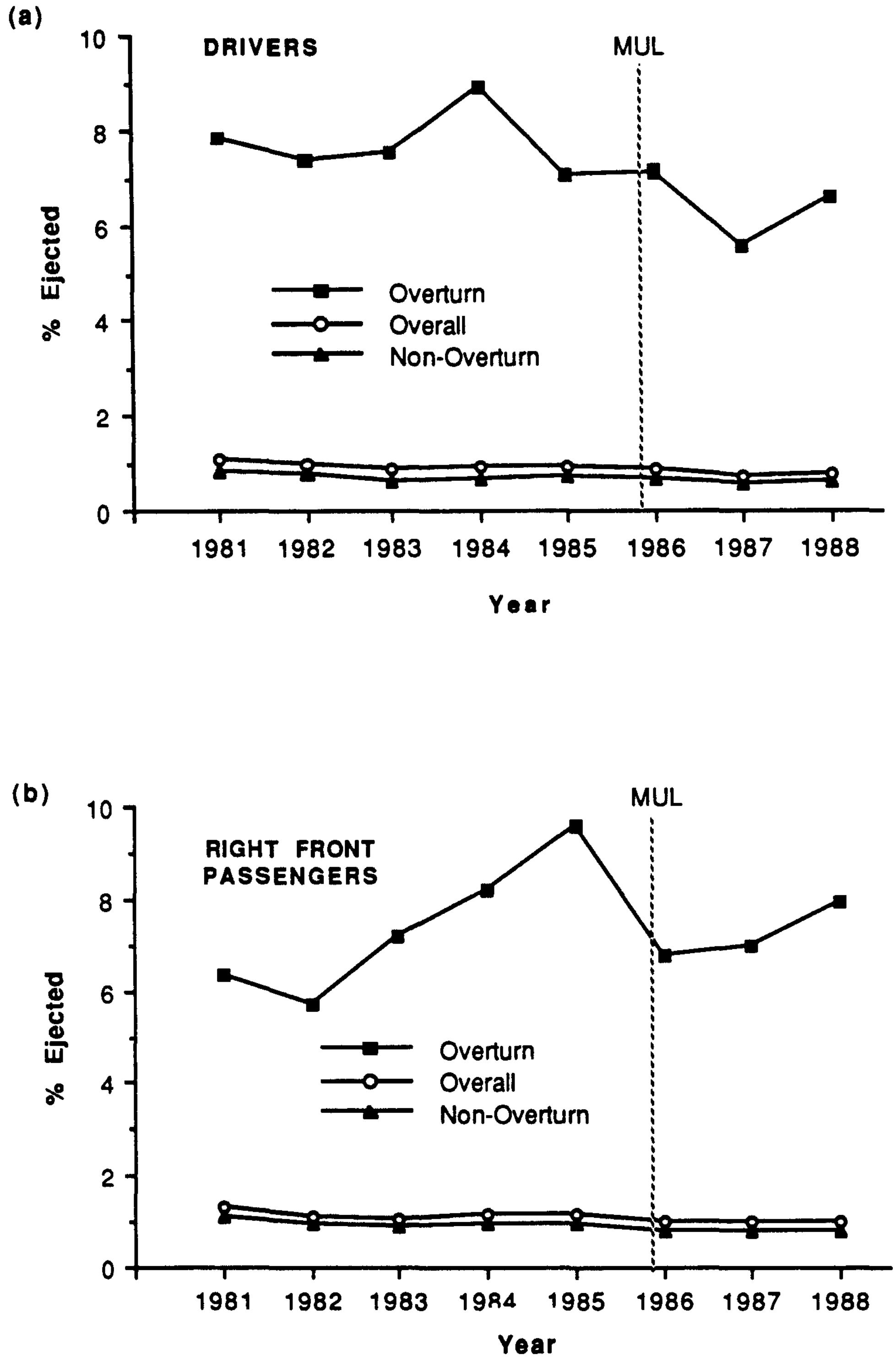

Figure 5.3. (a) Percentage of <u>drivers</u> ejected in overturn crashes vs non-overturn crashes;
(b) Percentage of <u>right front passengers</u> ejected in overturns vs. non-overturn crashes.

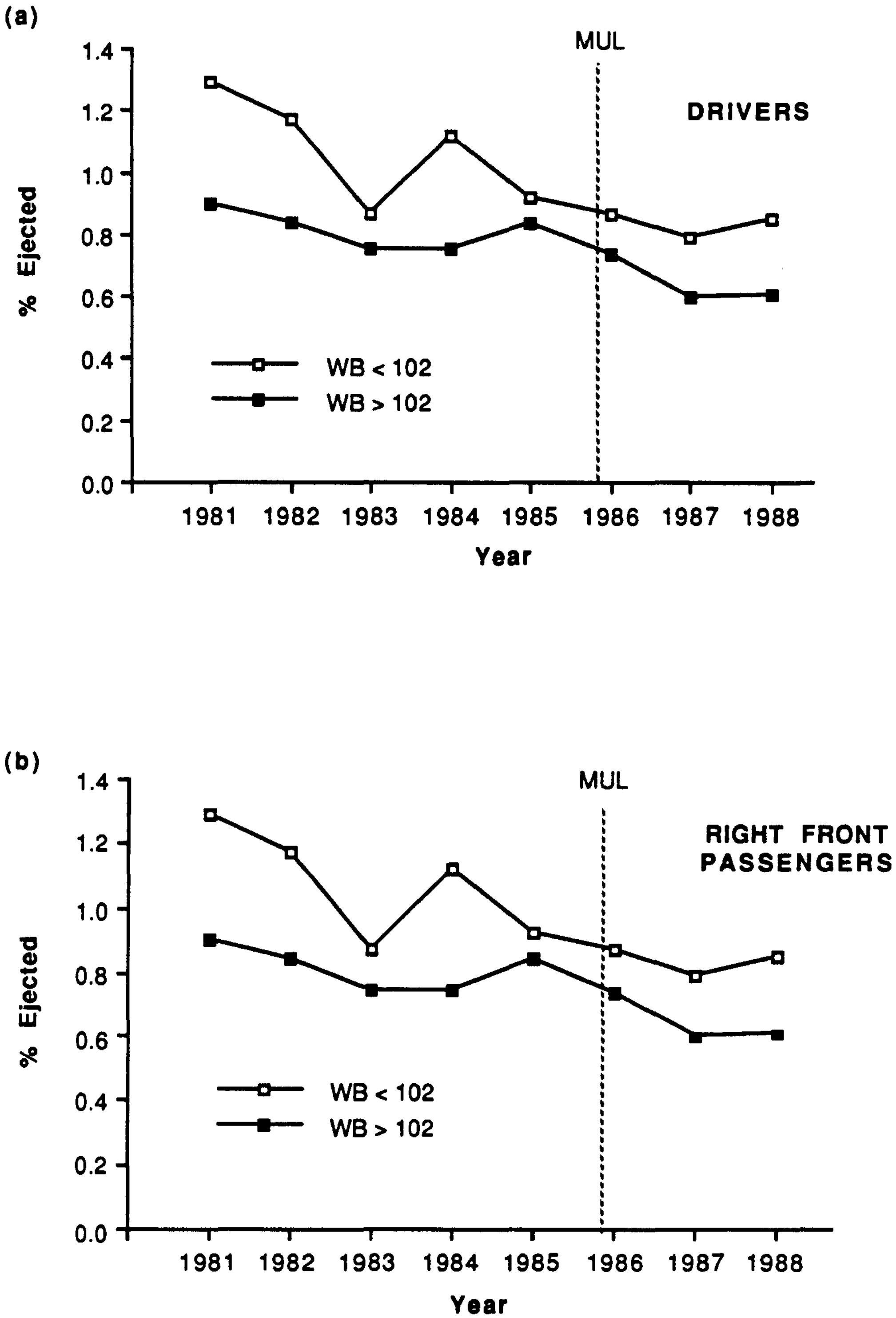

Figure 5.4. (a) Percentage of drivers ejected from cars with wheelbase less than 102 inches vs cars with wheelbase greater than or equal to 102 inches; (b) Percentage of right front passengers ejected from cars with wheelbase less than 102 inches vs cars with wheelbase greater than or equal to 102 inches.

102 inches) were more likely to be thrown from the vehicle than their counterparts in larger vehicles (i.e., wheelbase greater than or equal to 102 inches).

The final factor believed to affect the likelihood of being ejected is the fixed object crash (Figure 5.5). During the eight-year period, the percentages of both drivers and right front passengers ejected in fixed object crashes showed no clear trend. Examining the no-object crashes, there appeared to be a slight downward trend for both drivers and right front passengers. (Because of a coding change, the no-object data were unavailable for 1988.)

Conclusion

In conclusion, now that seat belt laws are in effect in 34 states (including Maryland) plus the District of Columbia, it has become increasingly difficult to measure the effectiveness of restraints. As reported by Hunter et. al., 1988, information on seat belt usage provided by police officers is unreliable when there is an existing mandatory usage law. Indications of this "lie factor" are evident in Maryland's accident data. During the period from 1981-1988, reported belt usage rates of front seat occupants in crashes increased steadily and exceeded the rates of two independent statewide observational studies.

Assessing ejections yielded indirect evidence that ejections may be decreasing overall in injury related crashes. For the most part, the ejection rates of front seat occupants remained lower in the post-law period from 1986-1988 than in the preceding years. These results indicate that since Maryland imposed a MUL there have been reductions in ejections and thus a decreased likelihood of serious or fatal injuries.

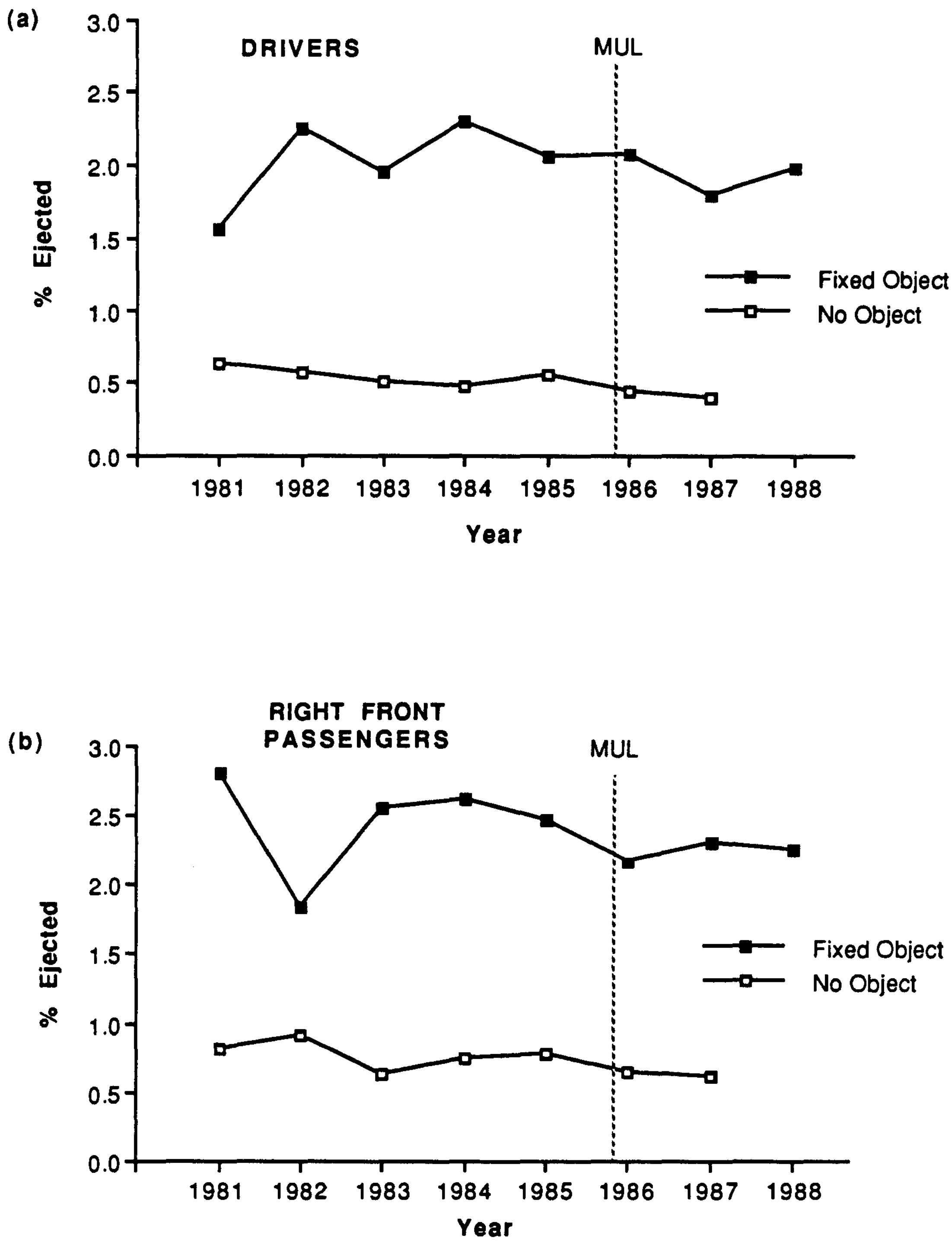

Figure 5.5. (a) Percentage of <u>drivers</u> ejected in fixed object crashes vs crashes in which there was no object struck;
(b) Percentage of <u>right front passengers</u> ejected in fixed object crashes vs crashes with no object struck.

CHAPTER 6. USAGE PATTERNS AND MISUSE RATES OF AUTOMATIC SEAT BELTS BY SYSTEM TYPE[1]

Background

Seat belts have now been required in passenger vehicles for over two decades; lap belts were required in 1966 and lap and shoulder belts in 1968. The early lap and shoulder belt systems were not connected (a four-point system), but interconnected lap/shoulder belts (a three-point system) became standard in 1974. Through the early 1980's, however, U.S. seat belt use rates were approximately 10-15 percent, so that the vast majority of motor vehicle occupants were electing not to use their available restraints.

In 1974 an ignition interlock system was required on all new cars, such that they would not start unless the driver lap/shoulder belt was engaged. However, this system was so unpopular that Congress also repealed the interlock rule effective February 1975.

The knowledge about design and implementation of air bags in motor vehicles has been available for several decades, yet movement to require these automatic devices has been quite slow. Many highway safety specialists feel that the protracted arguing between seat belt and air bag advocates over which system should be preferred was a major factor in holding down the seat belt use rate in the U.S. thus maintaining the status quo from around 1975 till 1984. This dichotomy did not exist in Europe and Australia, and many of these countries had high belt use rates in the 1970's and 1980's.

Tennessee became the first state to pass a child passenger safety law in 1977, and many states followed suit over the next few years. By 1985 all 50 states had such a law in place. This activity may have helped to initiate the movement that was to come in regard to adult belt laws.

In 1984, Federal Motor Vehicle Safety Standard (FMVSS) 208 was amended to promulgate the use of automatic protection in motor vehicles. A phase-in was set up such that all cars manufactured during the 1990 model year and later would be required to have some form of automatic protection that would meet federal crash test requirements. The four-year phase-in took place in the following manner: 10% of all 1987 model year cars sold in the U.S. were

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[1]This chapter is a revision of the paper that was presented at the 34th Annual Meeting of the Association for the Advancement of Automotive Medicine held October 1-3, 1990, in Scottsdale, Arizona.

required to have automatic protection; 25% of 1988 model year cars; 40% of 1989 model year cars; and 100% of all 1990 model year cars.

During the early-to-mid 1980's, the auto manufacturers began promoting the passage of mandatory belt use laws (MUL's), no doubt aided by the prospect of possibly not having to meet the automatic protection phase-in schedule if two-thirds of the U.S. population were covered by adequate MUL's. In 1984, New York became the first state to require belt use by drivers and front seat occupants. By the end of 1985, fifteen additional states plus the District of Columbia had passed mandatory use laws. Although there have been repeals of MUL's by four states, as of April 1990 there were belt laws in 33 states plus the District of Columbia that covered more than 85 percent of the U.S. population.

Although much of the U.S. population was covered by belt laws, the federal government on other grounds declined to overturn the amendment to FMVSS 208 that required the automatic protection phase-in. Initially the majority of vehicles with automatic restraints were equipped with automatic seat belts. Now there is an increased production of driver air bags which will eventually also include right front-seat passenger air bag systems. These air bag restraint systems are supplemental systems designed to activate in frontal and frontal oblique collisions only. Therefore, it is important for the three-point manual seat belts to be used by air bag-equipped automobile drivers.

Relatively little is known about the usage of automatic seat belts by the population-at-risk or the effectiveness of these systems in crashes. The same can be said with respect to the effectiveness of the supplemental air bag systems in reducing deaths and injuries. In 1981, Chi and Reinfurt reported on a study involving some 10,336 Volkswagen Rabbits involved in crashes. The dataset consisted of both manual restraint system Rabbits as well as automatic shoulder belt/knee bolster restraint Rabbits. They concluded that the automatic belt Rabbits experienced between 20 and 30 percent fewer serious and fatal injuries than their counterparts in Rabbits with conventional three-point belt systems. The overriding factor for this reduction was the increase (at least two-fold) in the belt usage rates in the automatic belt Rabbits. This study concluded that, when used, the two belt systems are equally effective in reducing serious injuries.

More recently, Nash (1989) reports on the effectiveness of automatic belts in reducing fatality rates in Toyota Cressidas. Comparing Toyota Cressidas equipped with motor-driven automatic belts since 1981 with similar Nissan Maxima's equipped with three-point manual belts and using data from the Fatal Accident Reporting System, he concluded that the fatality reduction effectiveness for the Toyota automatic belts is approximately 40 percent. This is consistent with the existing estimates of the effectiveness of manual restraint systems in fatality reduction (Partyka, 1988).

Automatic seat belts are available in three basic designs. VW produced the first automatic belts in its 1975 Rabbit models. These consisted of two-point shoulder belts attached to the upper rear of the front door and connected to a take-up reel located between the front seats. Lower body restraint was provided by a knee bolster since no lap belts were provided. These belts were detachable but an ignition interlock was installed to encourage usage.

With the 1981 Cressida, Toyota introduced a second design which is a two-point motorized automatic belt system. The belt is a motor-driven, non-detachable automatic shoulder harness. Also included are manual lap belts along with a knee bolster.

The third type of automatic belt, used extensively by General Motors and Honda, is a three-point non-motorized belt mounted near the upper and lower rear edge of the front door of the vehicle. There are variations on these basic systems, such as the two-point automatic shoulder belt along with a manual lap belt found in all 1990 VW's.

Again, as the majority of automatic belt systems are detachable and also are not accompanied with ignition interlock systems, relatively little is known about the acceptance of these systems by the motoring public. The usage in crashes reported by Chi and Reinfurt (1981) suggested usage rates for the automatic belts roughly two-fold that of the manual belts -- at least in VW Rabbits. The estimates ranged from 17 to 42 percent for manual belts versus 43 to 74 percent for automatic belts based on crash data from New York, North Carolina, Maryland and Colorado.

With respect to belt usage in the population-at-risk, a study conducted by Williams, Wells, Lund and Teed (1989) showed significantly higher belt usage rates for drivers with automatic restraints compared with manual belts. Additionally, there were differences with regard to lap belt use among the various automatic systems. The data were comprised of 1987 model year vehicles observed in different suburban areas of Washington, D.C., Chicago, Los Angeles, and Philadelphia. The authors concluded that some manufacturers were indeed more successful than others in providing automatic belt systems that result in high usage rates.

The most extensive study to date was conducted in conjunction with the NHTSA's annual belt survey in 19 cities (Bowman and Rounds, 1989). As an add-on to their regular national survey of belt usage across the United States, information was collected during 1987 and 1988 on a total of 21,308 drivers in automatic belt passenger cars. The results from this study provide usage rates by type of automatic belt systems by manufacturer and make/ model. Comparisons are made with manual belt usage and also by model year groups. Results are limited to shoulder belt usage only because the cars observed were not necessarily stopped. In addition, these results are strictly for urban vehicles and do not include information on driver characteristics such as age, race, and sex.

To close some of these gaps in the data, the Highway Safety Research Center collected belt use data in cars equipped with automatic belts, along with air bag and manual belt vehicles (as a baseline). The goal was to provide knowledge about whether some belt systems were more acceptable (i.e., used) than others, and whether drivers with air bags actually use their available belts. Comparisons are made with the U.S. DOT 19-city survey where appropriate.

Method

To obtain data on the use of restraints in cars equipped with automatic restraints (lap/shoulder belts and/or air bags), supplemental data were collected as part of an on-going statewide belt use survey for North Carolina. Data were collected in January-February, 1989, June-July, 1989, and January-March, 1990. Observers were sent to signal- or stop-controlled intersections scattered across the State, both in rural and in urban locations. The requirement for signal- or stop-controlled intersections was to enable the data collectors to correctly ascertain lap belt use -- an essential ingredient of this survey.

Starting with model year 1986, passenger cars have been required to have center, high-mounted rear brake lights. And starting with the 1987 model vehicles, some of the new cars were also required to have automatic restraints -- either air bags or automatic seat belts. Thus, the observers focused on cars with the center, high-mounted brake lights with the exception of VW

Rabbits, which have had a portion of their vehicles equipped with automatic belts since model year 1975. Since only 10 percent of the 1987 model year cars were required to have automatic restraints and 25 percent of the 1988 models, the data collectors were trained to recognize the various makes and models likely to be equipped with automatic restraints by visiting automobile dealer showrooms and studying the available literature. However, the data were not restricted only to air bag or automatic seat belt vehicles, as information was needed for new model vehicles equipped only with manual belts which would serve as baseline data.

The data collectors worked in pairs at these various controlled intersections. One observer recorded age, (under 25, 25-54, 55 and older), race (white, non-white), and sex of the driver; belt type (e.g., motorized automatic shoulder belt vs. manual three-point system); and usage of the lap and of the shoulder belt. In addition, this observer recorded misuse which included the belt being unhooked from the mounting position, excessive slack, or the shoulder belt placed under the arm of the driver.

The second observer, positioned toward the rear of the vehicle, first determined that there was a center, high-mounted brake light present or else that the vehicle was a VW Rabbit and hence an eligible vehicle, recorded the license plate number for cars with North Carolina license plates and provided a description of the car, namely, the make and model as well as body style (e.g., two-door vs. four-door vs. station wagon). The description of the vehicle was necessary to confirm the subsequent match with the North Carolina vehicle registration data since, when there is a vehicle transfer, the license plate stays with the owner. Thus, there is a period of time after this transfer when the old plate is on the new vehicle but the registration file information has not yet been updated. Therefore, to guarantee that the observed license plate corresponds to the vehicle data on the registration file, this additional description of the car was required. Data on belt use for a total of 4820 cars were collected during these three sampling periods.

To determine the type of restraint system installed in the vehicle, it was necessary to obtain the vehicle identification number (VIN). This is available on the North Carolina registration file for all cars registered in the State. Thus, each of the observed license plate numbers was checked against the vehicle registration file. If the description of the vehicle agreed with that on the registration file, then the VIN from the file was recorded for that vehicle. Otherwise it was necessary to exclude that vehicle from the study. Of the initial 4820 cars observed, some 4225 vehicles (or 87.7%) matched the data on the registration file, and hence had appropriate VIN's.

Using VINDICATOR, the VIN-decoding software package developed by the Insurance Institute for Highway Safety (IIHS), the sample VIN's were decoded to obtain restraint type. The resulting levels of restraint type provided by this program are manual three-point belts, air bags, or automatic seat belts. Some 4151 VIN's were decoded using the VINDICATOR package (i.e., 86.1% of the original sample).

As with the U.S. DOT study, there was particular interest in the types of automatic seat belts -- the motorized two-point belts, the non-motorized shoulder belt only, and the non-motorized three-point (i.e., automatic shoulder/automatic lap combination) belt. In order to provide this level of detail, the make/model and model year information from the VINDICATOR program was used, along with detailed documentation on specific type of automatic belt system provided annually by NHTSA, IIHS, and also Geico Automobile Insurance Company.

Thus, the final study sample consisted of belt usage by system type for 831 drivers with manual three-point belts, 230 with air bags (along with three-point manual belts), and 3,090 with automatic seat belts. Of these 3,090, there were 413 motorized automatic shoulder/manual lap belts, 148 non-motorized automatic shoulder belts, 2,518 non-motorized automatic shoulder/automatic lap belts, and an additional 11 non-motorized belt with type unknown.

Results

The distribution of the study sample of 4,151 drivers of late model passenger cars is shown in Table 6.1 by restraint type system. The majority (74.4%) of the sampled vehicles had automatic seat belts, 5.5 percent had air bags with manual three-point belts and the remaining 20.1 percent had manual three-point belts without air bags. As there were only 21 cars with a non-motorized automatic shoulder/manual lap belt system (e.g., 1990 model VW Jetta), they were combined with the more common automatic shoulder belt only system (e.g., VW Rabbit). The column identified as "Shoulder Belted %" represents drivers where the shoulder belt was in use. The next column, labeled "Full System Usage %" indicates that the entire system was being used appropriately. As will be seen, the main instance of misuse was when there was a manual lap belt that was not buckled. The final column presents the results from the US DOT 19-city survey of driver automatic belt use rates (see Bowman and Rounds, 1988).

Table 6.1. Percent shoulder belted and percent full system usage by restraint type.

Restraint Type	Total	Shoulder Belted %	Full System Usage %	19 City Shoulder Belted %
Auto Belt	3090	79.6	68.8	88.7
Motorized:				
Auto S/Manual L	413	94.2	28.6	97.2
Non-Motorized:				
Auto S	148*	83.8	75.7	81.3
Auto S/Auto L	2518	76.9	74.9	76.9
Type Unknown	11	90.9	81.8	--
Air Bag	230	73.9	73.5	
Manual Belt	831	76.3	73.8	
Overall	4151	78.6	70.0	

*148 = 127 (Auto S) + 21 (Auto S/Manual L)

It should be noted that in both the air bag cars and the manual belt cars, shoulder belt usage percentages correspond to usage of three-point manual belts provided by these vehicles.

For the full sample, there was at least a shoulder belt used in 78.6 percent of the cases. When looking at "Full System Usge," the percentage drops to 70.0 percent. This rather high usage is partly due to the observations focusing on new model cars (basically 1986 and later model years) and also the sampling being carried out in North Carolina where belt usage in the population has been approximately 60 percent for the last several years.

Results of applying Pearson's Chi-square test indicate that there is a significant difference in "shoulder belted" usage rates among drivers of vehicles equipped with automatic belts, manual belts, or air bags (Chi-square = 7.5, df = 2, p = 0.02). Shoulder belt usage is highest for drivers with automatic belts (79.6%) compared with 76.3 percent for manual belts and 73.9 percent for air bags. Within the automatic belt systems, there is also a significant difference in "shoulder belted" usage rates (Chi-square = 67.7, df = 3, p < .001). The generally non-detachable motorized systems have the highest usage rates, namely 94.2 percent. This was followed by the automatic shoulder belt system with 83.8 percent, and, somewhat lower at 76.9 percent, the three-point automatic shoulder belt combined with the automatic lap belt as is commonly found in General Motors and Honda vehicles.

A special feature of this study was the determination of not only shoulder belt usage but also lap belt use. This is particularly important in cases where the lap belt must be fastened separately, such as in the Toyota Camry and Cressida and the Ford Tempo and Escort. As is seen in Table 6.1, in the case of the non-motorized automatic shoulder/automatic lap belt, generally when the shoulder belt is used, the lap belt is also utilized (76.9% vs 74.9%, respectively). For the non-motorized automatic shoulder belt systems, the drop from 83.8 percent shoulder-belted to 75.7 percent fully restrained is mainly attributable to the 21 vehicles for which the lap belt must be buckled manually (e.g., 1990 model VW Jetta).

For the increasingly popular motorized automatic belts where the shoulder belt is motor-driven and a separate lap belt must be manually attached, there is a 70 percent reduction going from 94.2 percent shoulder belt usage down to 28.6 percent where the lap belt is also manually attached. Often motorists would tell the data collectors that "they just forget to buckle the lap belt" or that "they didn't know that they had a lap belt." For whatever the reason, it is clear that the drivers with the motorized shoulder belts are most often neglecting to use the important manual lap belt. See Figure 6.1 for usage rate comparisons across restraint types.

Comparing the second and final columns of Table 6.1, it is of interest to note that the results from the urban DOT study are relatively similar to those found in North Carolina. Again, highest shoulder belt use rates (97.2% DOT vs 94.2% N.C.) were seen with the motorized automatic belts and lowest for the non-motorized automatic shoulder/ automatic lap belt combination (identical at 76.9%).

Note was made by the observers of obvious misuse of the shoulder belt portion. Categories of misuse included (1) belts that were unhooked from the door mounting, (2) shoulder belts with obvious excessive slack (i.e., being

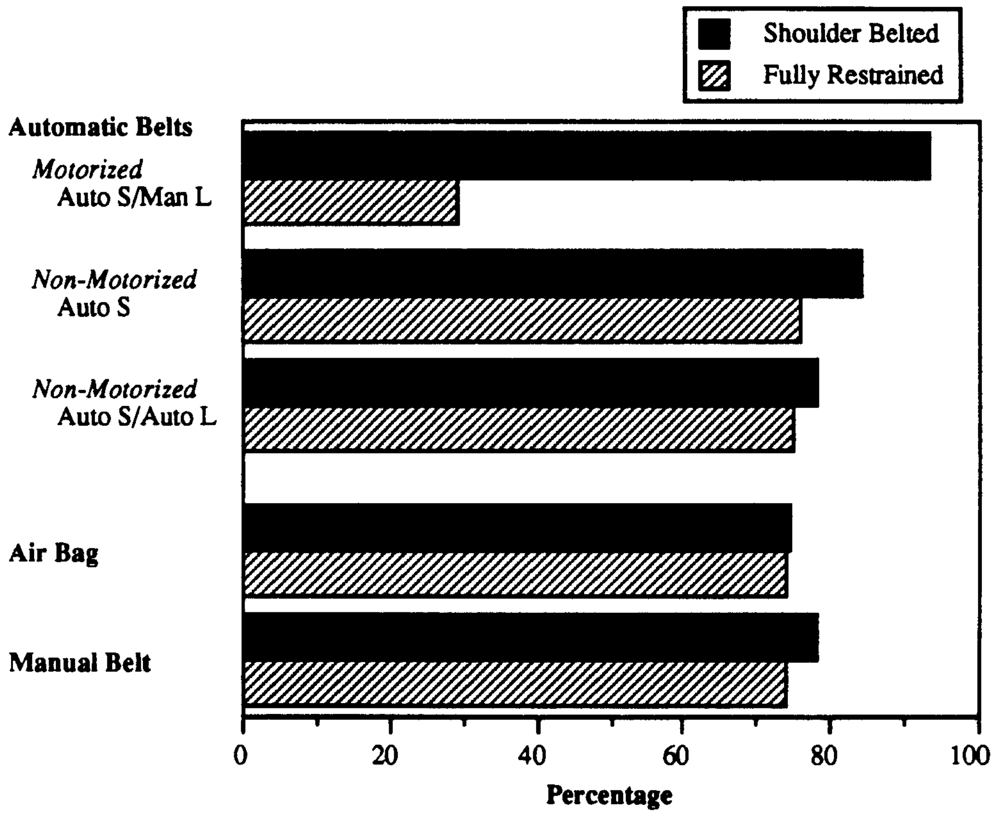

Figure 6.1. Percent Shoulder Belted vs. Percent Fully Restrained by Restraint Type

"too loose" with at least six inches of extra belt webbing) and (3) shoulder belts worn under the arm. The most common form of misuse was the shoulder belt being "too loose." In 3.0 percent of the cases (i.e., 126 drivers), there was obvious excessive slack in the shoulder belt. In an additional 1.5 percent of the cases, the driver was wearing the shoulder belt underneath the arm. And in another 1.3 percent of the cases, the driver had detached the shoulder belt from the door mounting. Thus, overall nearly six percent of the drivers observed in this survey were wearing their shoulder belt incorrectly.

The next two tables deal with belt use by car manufacturer and by make and model within automatic belt type. For the most part results are limited to those subgroups with reasonable sample sizes.

Table 6.2 displays belt usage by restraint type across manufacturer. First, for each manufacturer, the percent- age distribution by restraint type is given. For example, in our survey 21.6 percent of the Chrysler products had automatic belts and 19.8 percent had air bags with the remaining 58.6 percent having only manual belts. Consistent with the previous table, the first three listed automatic belt manufacturers (i.e., Chrysler, Ford and Toyota) have high shoulder belt use rates ranging from 83 percent to 97 percent. However, too often the manual lap belt is not being used resulting in a sizable decline to a "Full System Usage %" ranging from 26 percent to 37 percent.

Although the shoulder belt usage rate for the non-motorized automatic belt is lower than that for the motorized system, these systems are much more likely to be fully used. Here the range in usage of the shoulder belt is from 77 percent to 88 percent with little decline for full system usage, namely 75 percent to 88 percent.

For the air bag cars as well as the manual belt cars, the usage rates of the manual three-point belts are somewhat lower but there is very little difference between the percentage indicated as shoulder belted versus having the entire belt system being used.

Table 6.3 gives a further breakdown for the automatic belt systems for various make/model combinations and compares the results of the North Carolina study with that done by U.S. DOT. Note the similarity in the results between the belted percent in North Carolina and the indicated belted percent for the 19-city survey. Except for the VW Rabbit/Golf and the Honda Prelude, the percentages are most comparable between the two surveys. Part of the reason

Table 6.2. Belt usage by restraint type across manufacturer.

Restraint Type	Manufacturer (%)*	Total	Shoulder Belted %	Full System Usage %
Auto Belt				
Motorized	Chrysler (21.6)	35	82.9	37.1
	Ford (61.1)	181	94.5	26.0
	Toyota (93.1)	122	96.7	28.7
Non-Motorized	VW (97.0)	98	87.8	87.8
	GM (91.8)	2337	76.9	74.8
	Honda (72.6)	193	77.7	76.7
Air Bag				
	Chrysler (19.8)	32	68.8	68.8
	Ford (9.5)	28	78.6	78.6
	Honda (3.8)	10	50.0	50.0
	Mercedes (80.2)	93	68.8	68.8
	Volvo (21.9)	40	90.0	90.0
Manual Belt				
	Chrysler (58.6)	95	71.6	70.5
	Ford (29.4)	87	72.4	69.0
	Toyota (6.1)**	--	--	--
	VW (3.0)**	--	--	--
	GM (8.2)	208	80.3	76.0
	Honda (23.7)	63	77.8	76.2
	Mercedes (19.8)	23	69.6	69.6
	Volvo (78.1)	143	80.4	79.7

*Restraint type percent within manufacturer.
**Cell size < 10

Table 6.3. Belt usage by type of automatic belt sy tem for various make/model combinations.

Restraint Type	Make	Model	Total	Shoulder Belted %	Full System Usage %	19 City Should. Belted %
Motorized:	Ford	Escort	105	93.3	27.6	97.7
		Tempo	40	97.5	27.5	97.7
	Toyota	Camry	78	98.7	24.3	99.3
		Cressida	42	92.9	35.7	99.6
Non-Motorized:						
Auto S	VW	Jetta	47	95.7	95.7	93.9
		Rabbit/ Golf	49	79.6	79.6	96.2
Auto S/ Auto L	Buick	LeSabre	315	85.4	83.8	76.9
		Regal	114	73.7	71.1	81.2
		Skylark	98	78.6	74.5	81.0
	Chev.	Beretta	150	67.3	62.7	76.9
		Corsica	87	71.3	70.1	81.8
	Olds.	Calais	170	70.6	68.2	67.7
		Cutlass	99	77.8	74.7	81.3
		Delta 88	254	81.5	80.3	77.0
	Pont.	Bonneville	195	81.0	80.5	79.4
		Grand AM	446	72.2	70.2	74.4
		Grand Prix	123	74.8	67.5	84.0
	Honda	Accord	110	72.7	71.8	75.3
		Prelude	68	83.8	83.8	67.0

for this difference is that older model Rabbits with lower use rates are included in the North Carolina sample. Again all four motorized shoulder belt make/models show high shoulder belt usage, namely 92.9 percent to 98.7 percent, but with a dramatic decline when accounting for full system usage. In contrast, for the non-motorized systems, when the shoulder belt is used, the lap belt is generally also in use.

The final three tables deal with driver characteristics such as age, sex, and race. With respect to belt usage by type of system, overall frequencies and usage percentages by restraint type are given in the first row of each section of the table to serve as a baseline for comparison.

Belt use by driver age is shown in Table 6.4. As can be seen, the percentage of drivers of cars with automatic seat belts using at least the

Table 6.4. Belt use by restraint type by age of driver.

Restraint Type	Age	Total	Shoulder Belted %	Full System Usage %
Auto Belts		3090	79.6	68.8
	Under 25	343	74.6	57.4
	25-54	2016	79.9	69.1
	55 and over	731	81.3	73.2
Air Bags		230	73.9	73.5
	Under 25	9	66.7	66.7
	25-54	162	75.3	75.3
	55 and over	59	71.2	69.5
Manual Belts		831	76.3	73.8
	Under 25	55	83.6	78.2
	25-54	562	74.4	72.2
	55 and over	214	79.4	76.6

shoulder belt (i.e., "Shoulder Belted %") is lowest for the youngest drivers. For air bags and manual belts, the small sample sizes limit drawing conclusions for the younger drivers. Within restraint type, the range of percentage of drivers buckled up among the various age groups is from seven to nine percent for automatic belts and manual belts, respectively. The decline in percentages when accounting for full system usage is generally greater for the younger drivers, dropping to below 60 percent for those younger drivers in automatic belt cars.

Table 6.5 provides results of belt usage by restraint type according to driver sex. The sample is split 44/56 by sex (male/female driver). Shoulder belt usage is higher for female drivers in both the air bag cars with three-point manual belts and in the manual belt cars -- namely some six to 12 percentage points higher. This is consistent with many surveys dealing with belt usage by driver sex. Similar comments apply to the "Full System Usage" percentages by driver sex. For the automatic belt category, both the percentage of drivers using at least shoulder belt as well as the percentage of

Table 6.5. Belt use by restraint type by sex of driver.

Restraint Type	Sex	Total	Shoulder Belted %	Full System Usage %
Auto Belts		3090	79.6	68.8
	Male	1371	79.4	69.3
	Female	1719	79.8	68.4
Air Bags		230	73.9	73.5
	Male	125	71.2	70.4
	Female	105	77.1	77.1
Manual Belts		831	76.3	73.8
	Male	413	70.2	68.8
	Female	418	82.3	78.7

drivers using the full system are about the same for both male and female drivers.

Finally, Table 6.6 examines belt use by driver race. In North Carolina, since the seat belt law with a $25 citation went into effect in January 1987,

Table 6.6. Belt use by restraint type by race of driver.

Restraint Type	Race	Total	Shoulder Belted %	Full System Usage %
Auto Belts		3090	79.6	68.8
	White	2737	79.4	69.6
	Non-white	353	81.3	62.0
Air Bags		230	73.9	73.5
	White	217	74.2	73.7
	Non-white	13	69.2	69.2
Manual Belts		831	76.3	73.8
	White	719	77.1	74.5
	Non-white	112	71.4	68.8

the wearing rates of non-white drivers has consistently been slightly greater than that for their white counterparts. In this survey of new model cars, the wearing rates for the non-white driver are lower in both the air bag cars and the manual belt cars. They are slightly higher, however, in the automatic belt vehicles. For all three restraint types, the percentage of drivers using the full belt system is higher for the white driver ranging from nearly five to eight percentage points higher.

Discussion

Since all 1990 model year cars are required to be equipped with passive restraints (e.g., automatic seat belts or air bags) following a gradual phase-in which started in 1987, and since relatively little is known about public acceptance of these new devices, an opportunity was seized upon to capture data on driver belt usage for new model cars in North Carolina. This survey was carried out in conjunction with our periodic statewide survey of belt use being done to help evaluate our mandatory use law.

For the most part, the sample of 4,151 drivers were driving 1986 and later model year cars selected on the basis of having center, high-mounted brake lights. Some 74.5 percent of the sample were in automatic belt cars with 20.0 percent in cars equipped with manual three-point belts and the remaining 5.5 percent in air bag cars with manual three-point belts.

Shoulder belt usage rates for all systems (automatic belts 79.6 percent, air bags 73.9 percent, manual belts 76.3 percent) considerably exceeded the statewide average of approximately 60 percent largely because these vehicles are nearly all new model cars. Within the automatic belt group, usage was highest (94.2 percent) for the motorized automatic shoulder/manual lap belt system, intermediate (83.8%) for the non-motorized system with automatic shoulder belts and lowest (76.9%) for the non-motorized automatic shoulder/automatic lap belt system.

The results seen in North Carolina are quite consistent with the 19-city U.S. DOT survey rates of 97.2 percent, 81.3 percent, and 76.9 percent, respectively. There are several features of this survey which are unique. First, data were collected on two types of automatic belt system misuse. The first type consisted of drivers not fully utilizing the restraint system available. The second kind of misuse dealt with misuse of the shoulder belt falling into categories of (1) belt being detached from the door mounting, (2) excessive slack in the belt, and (3) shoulder belt being placed underneath the arm. The other area in which this survey is unique is that it compares usage rates by various driver characteristics, namely, age, sex and race.

With respect to the first type of misuse, that is, failing to utilize the full restraint system provided, this problem was primarily experienced by drivers in vehicles equipped with motorized shoulder belts and manual lap belts such as the Ford Escort and Tempo and the Toyota Camry and Cressida. Here, there was a 70 percent decrease in "usage" (from 94.2% "Shoulder Belted" to 28.6% "Fully Restrained"). The corresponding drop in percent- ages for the other systems (non-motorized automatic belts as well as three-point systems available in both the air bag cars and in the manual belt cars) was relatively minor -- generally, only several percentage points.

The most common form of incorrect usage was having too much slack in the shoulder belt (3.0% of the sample) followed equally by the belt being detached from the door mounting (1.3%) and the shoulder belt being placed underneath the arm (1.5%). These rates of misuse totaling nearly six percent are very consistent with that which has been observed in the North Carolina statewide surveys of all cars regardless of belt system or model year.

With respect to driver age, the younger driver (under 25) had lower usage rates than other age groups except for the case of manual belts. The lower rates for the younger driver are certainly consistent with past seat belt surveys conducted in the U.S. The decline accounting for full system usage is likewise greatest for the under 25 year old dropping to 57.4 percent.

As has been seen in other surveys, females tended to wear manual three-point belts more frequently than males ranging from six to 12 percentage points higher. Female usage of automatic belts is most comparable with that of the male drivers. Likewise, their usage of the full restraint system (i.e., "Full System Usage %") is higher in the air bag cars and in the manual belt cars than that of male drivers.

In our North Carolina surveys covering cars of model years 1968 and newer, belt usage has consistently been higher for non-white drivers than for white drivers since implementation of the North Carolina seat belt law in January 1987. In this survey involving newer model cars, belt usage for non-white drivers was generally somewhat lower in the air bag and manual belt cars. For all three restraint systems, "Full System" usage rates for non-white drivers were lower than that for their white counterparts.

Several points bear mentioning. First, more and more cars are being produced with motorized shoulder belt systems. However, even though the shoulder belt was nearly always in use (94.2%), fewer than 30 percent of the drivers observed in this survey were getting the full protection available which included buckling the lap belt. Sometimes this was likely a result of ignorance while perhaps more often it was the result of not developing the special habit required. Evidently, having the motorized belt fall into place gives drivers of these cars the feeling of being buckled up. Clearly, additional educational efforts are warranted in this situation.

Secondly, the three-point non-motorized automatic belt systems were defeated nearly 25 percent of the time. Motorists indicate that it is very easy to disconnect these systems and often if they elect to use them, they use them as manual belts; in other words, they disconnect them as they get out of the car and reconnect them once they have entered the car for the next trip. It would seem clear that usage rates of approximately 75 percent for these non-motorized automatic shoulder/automatic lap belt systems is below what was anticipated.

On an encouraging side, it is good to see relatively high usage of the three-point manual belts in air bag cars (namely, 73.9%). Clearly air bags are designed to be supplemental systems in that they do not protect the occupant in many crash modes such as side impacts or rollovers. From data collectors talking with many drivers in air bag-equipped cars, it was clear that many did appreciate the fact that they needed to use the manual three-point belts. However, some drivers were not even aware that their car was equipped with air bags. Clearly, as more and more air bag cars are produced, public information and education with respect to utilizing the manual belts will become increasingly important.

CHAPTER 7. AN EMPIRICAL EXAMINATION OF THE DOUBLE PAIR COMPARISON METHOD FOR EXAMINING SEAT BELT EFFECTIVENESS

Background and Data

One of the basic questions posed for analysis in this project dealt with effectiveness of existing manual restraints. As has been addressed previously in this report, this question cannot be answered directly from recent state level crash data because of the unreliability of the information provided by the investigating officer.

However, there does exist a national data set that contains reliable data on seat belt use by occupants of towed vehicles involved in 12,050 crashes between January 1977 and March 1979. This data collected in the National Crash Severity Study (NCSS) was intended to provide a data base on the crash conditions of towaway passenger vehicle crashes, which was sufficiently large and representative to provide an overall picture of these conditions while detailed enough to support in-depth analysis of such issues as seat belt effectiveness controlling for such factors as crash severity. For a detailed description of the history of NCSS along with an explanation and description of the sample frame, sampling plan, and automated data file (accident level variables, vehicle level variables, and occupant level variables), see NHTSA (1981).

This data file was used to investigate belt effectiveness comparing two different methods: (1) double pair comparison (Evans, 1986) -- a method being used increasingly by NHTSA and the research community in general -- and (2) traditional estimates controlling for crash severity as measured by the joint effect of extent and region of principal vehicle damage (Partyka, 1988).

As a proportional sampling scheme was utilized in NCSS, the data utilized in both procedures were weighted data, where the weights were the inverse of the sampling proportions. To obtain more data on the more serious crashes, the following sampling strata according to the most severe injury consequence were utilized:

(1) 100%: fatality or overnight hospitalization

(2) 25%: transported to a hospital or emergency treatment facility (but no overnight hospitalization)

(3) 10%: not transported and not Team 6 (Southwest Research Institute) in the post-March 1978 period

(4) 5%: not transported, Team 6 in the post-March 1978 period

The variables utilized in the analysis included the following:

Occupant belt use	=	yes if L and S, L only, S only, air bag and L no if not used
Occupant Injury	=	AIS (Abbreviated Injury Scale) for most severe injury
Primary damage area of car	=	front side (left or right) rear top undercarriage
Extent of primary damage to the car	=	1 minimum damage 2 3 4 5 6+7 8+9 maximum damage

The highest damage levels were combined due to sample size limitations. The final data set consisted of complete information on 11,692 drivers, 5376 right front seat occupants, 675 left rear seat occupants, and 826 right rear seat occupants. As will be seen, sample size limitations precluded using rear seat occupants in the double pair comparison investigation.

Double Pair Comparison

Method. This procedure was utilized by Evans (1986) to determine how occupant characteristics affect fatality risk in traffic crashes. The method, which originally used data from the Fatal Accident Reporting System (FARS), compares pairs of occupants -- the "subject" occupant and an "other" occupant. The probabilities of a fatality to the subject occupant when that occupant has one of two characteristics (e.g., restrained by a seat belt) are compared. Since the "other" occupant is in the same vehicle, many vehicle and roadway factors are controlled for when comparing the fatality risk of the "subject" occupant with the "other" occupant. Such factors would include vehicle size, crash severity, roadside hazard, etc. Thus, the "other" occupant serves in an exposure estimating role.

Areas of applicability of this procedure have included car occupant fatality risk as a function of sex, age, or alcohol use; motorcycle fatality risk as a function of helmet use; potential fatality reductions through eliminating occupant ejection from cars; and relative fatality risk in different seating positions versus car model year.

Griffin (In Press) presents a very intuitive and clear description of the method and relates it to earlier work by Woolf (1955) where he applies this weighted average logs odds ratio statistical technique to the problem of estimating the relationship between blood group and disease. In addition, Griffin raises the possibility of three potential problems in Evans' application of log odds ratio methodology and suggests several modifications to the method.

As the details of the procedure are well described in both Evans (1986) and Griffin (In Press), they will not be repeated herein. Rather, the sample calculations will be illustrated in the next section for examining driver belt effectiveness at AIS $\geq$ 2 when compared with the right front seat occupant (the "other" occupant).

Results. In this analysis, the effectiveness of occupant restraint use (lap and/or shoulder) was restricted to driver and to right front seat occupants due to sample size limitations for the rear seat occupants. Injury criteria used included the following:

Moderate	AIS $\geq$ 2
Serious	AIS $\geq$ 3
Severe	AIS $\geq$ 4

Thus, for comparing the driver (subject) with the right front seat occupant (other), the double pairs and corresponding injury (AIS $\geq$ 2 vs. AIS = 1) given in Table 7.1 were involved:

Table 7.1. Double pair (belt use x injury) distribution.

		D^1F^2	D^2F^2	D^2F^1	D^1F^1	Total
(1)	D_uF_u	577	421	422	1689	3109
	D_rF_u	16	4	2	44	66
(2)	D_uF_r	0	6	3	19	28
	D_rF_r	7	14	17	67	105
						3308

where

D_u = unrestrained driver

D_r = restrained driver

D^1 = uninjured (AIS=1) driver

D^2 = injured (AIS $\geq$ 2) driver

and similarly for F, the right front seat occupant.

The odds ratio, U, for the driver with an unrestrained "other" occupant (section (1) of Table 7.1) is calculated from the following:

	AIS $\geq$ 2 F	AIS $\geq$ 2 D
D_uF_u	998	843
D_rF_u	20	6

Thus

$U_{(1)}$ = odds ratio for driver vs unbelted "other"

= (998/20) ÷ (843/6) = 0.355

Likewise

$U_{(2)}$ = (6/21) ÷ (9/31) = 0.984

Now since the distribution of U is rather skewed, we utilize a log transformation as follows:

$L_{(1)}$ = ln (odds ratio) = ln ($U_{(1)}$) = ln (0.355) = -1.036

$L_{(2)}$ = ln ($U_{(2)}$) = -0.016

Then to combine the log odds ratios, $L_{(1)}$ and $L_{(2)}$, use $w_{(i)} = 1/(L_{se(i)})^2$ where an approximate estimate of the standard error of $L_{(1)}$ (assuming initial simple random sampling) is given by

$$L_{se(1)} = (1/998 + 1/20 + 1/843 + 1/6)^{\frac{1}{2}}$$

$$= 0.468$$

and similarly, $L_{se(2)} = 0.598$. Thus, $w_{(1)} = 4.57$ and $w_{(2)} = 2.80$, and the overall log odds ratio is given by

$$\bar{L} = \Sigma\, w_{(i)}\, L_{(i)} \,/\, \Sigma\, w_{(i)}$$

$$= [(4.57)(-1.036) + (2.80)(-0.016)]/(4.57 + 2.80)$$

$$= -0.648$$

Therefore,

$$\bar{U} = e^{\bar{L}} = 0.523$$

and the desired effectiveness estimate for reducing driver AIS $\geq$ 2 injuries is given by

$$\bar{E} = (1-\bar{U})100 = 47.7\%$$

Ordinarily, as indicated in Evans (1986), we would derive estimates of effectiveness for the driver comparing with the left rear occupant, then the right rear occupant, and finally obtain an overall weighted estimate that combines the three separate estimates. However, the NCSS data limitations preclude deriving estimates for either of the rear seating positions. Thus, the double pair comparison estimate for belt effectiveness in reducing driver AIS $\geq$ 2 injuries is given by 47.7 percent.

In similar manner, double pair comparison estimates are derived for serious (AIS $\geq$ 3) and severe (AIS $\geq$ 4) injuries for the driver along with corresponding estimates for the right front seat passenger. These estimates are presented in Table 7.2 below.

Table 7.2. Double pair comparison effectiveness estimates for the weighted NCSS data.

Seat Position	Injury Threshold		Effectiveness Estimate (%)
Driver	Moderate	AIS$\geq$2	47.7
	Serious	AIS$\geq$3	36.3
	Severe	AIS$\geq$4	40.2
Right Front Passenger	Moderate	AIS$\geq$2	65.7
	Serious	AIS$\geq$3	60.6
	Severe	AIS$\geq$4	46.1

Traditional Estimates of Effectiveness

Method. Estimates of belt effectiveness were derived both without making any adjustments -- "overall" -- as well as adjusting for vehicle damage severity -- "adjusted". Extent of primary damage to the car (1 = minimum, 9 = maximum) combined with primary damage area of car (front, side, rear, top, undercarriage) was utilized to define vehicle damage severity.

Overall estimates. Here the traditional estimate is derived for AIS $\geq$ 2 from the table of weighted driver (injury x belt use) frequencies

		AIS$\geq$2	AIS=1	Total
Belt	Yes	150	686	836
	No	3624	8712	12336

as follows:

$$E_o = \left(1 - \frac{\text{proportion of belted drivers with AIS} > 2}{\text{proportion of unbelted drivers with AIS} \geq 2}\right) 100$$

$$= \left(1 - \frac{150/836}{3624/12336}\right) 100$$

$$= 38.9\ \%$$

Adjusted estimates. To the extent that belted drivers are involved in less serious crashes than unbelted drivers -- and there is evidence that such is the case (Hunter, et al., 1988) -- crash severity should be controlled for in calculations of overall belt effectiveness. Partyka (1988) illustrates one such adjustment procedure using a combination of NCSS and NASS (National Accident Sampling System) data.

As was illustrated by Partyka (1988), the weighted NCSS data in this analysis are adjusted in three ways: (1) adjust damage type (extent x impact site) of unrestrained drivers to mirror the damage type for restrained drivers; (2) adjust damage type of restrained and unrestrained drivers to reflect the overall crash conditions for all drivers; and (3) adjust damage type of restrained drivers to reflect the crash conditions of unrestrained drivers. These estimates are then compared among themselves as well as with both the overall estimates and the estimates from the double pair comparison procedure.

To illustrate, consider the damage type adjustment of the unrestrained NCSS drivers to reflect the damage type experienced by the restrained drivers. The basic damage distribution is given for restrained drivers as follows:

Damage Area

Extent	Front	Side	Rear	Top	Under	Total
1						
2						
3						
4			r_{ij}			
5						
6+7						
8+9						
Total						R

where

r_{ij} = no. restrained drivers with vehicle extent = i and area = j, $i = 1,\ldots,7$; $j = 1,\ldots,5$

e.g., r_{11} = minimal damage primarily to the front

R = total no. restrained drivers

Similarly, let

u_{ij} = no. unrestrained drivers with vehicle extent, i and area, j

t_{ij} = no. drivers (restrained or unrestrained) with vehicle extent, i and area, j

$= r_{ij} + u_{ij}$

The actual damage type (injury AIS $\geq$ 2) distributions for restrained ($r_{ij}(r_{Iij})$) and unrestrained (u_{ij} (u_{Iij})) drivers are given in Tables 7.3 and 7.4, respectively.

Table 7.3. Damage type (injury AIS $\geq$ 2) distribution for restrained drivers.

	Area				
Extent	Front	Side	Rear	Top	Undercarriage
1	145 (22)*	16 (0)	34 (0)	1 (1)	4 (0)
2	142 (19)	67 (2)	12 (0)	5 (0)	6 (1)
3	94 (33)	95 (22)	8 (0)	20 (4)	0 (0)
4	18 (0)	27 (10)	5 (0)	9 (5)	0 (0)
5	2 (2)	2 (0)	4 (0)	2 (2)	0 (0)
6+7	6 (4)	1 (1)	10 (0)	5 (5)	0 (0)
8+9	22 (3)	0 (0)	5 (1)	0 (0)	0 (0)
					767 (137)

* 145 (22): 145 drivers in cars with minor frontal damage of which 22 had AIS $\geq$ 2

Table 7.4. Damage type (injury AIS $\geq$ 2) distribution for unrestrained drivers.

	Area				
Extent	Front	Side	Rear	Top	Undercarriage
1	1406 (221)	135 (13)	107 (2)	4 (0)	46 (4)
2	3026 (748)	614 (105)	149 (18)	25 (2)	56 (16)
3	1345 (548)	1655 (518)	96 (11)	258 (84)	15 (5)
4	400 (233)	376 (199)	78 (4)	112 (38)	1 (1)
5	199 (109)	92 (59)	45 (12)	82 (39)	0 (0)
6+7	231 (103)	33 (27)	76 (20)	52 (24)	0 (0)
8+9	194 (89)	8 (6)	6 (5)	3 (2)	0 (0)
					10,925 (3265)

Then the damage type distribution for injured (AIS $\geq$ 2) unrestrained drivers adjusted for the damage type of restrained drivers (adjustment (1)) is given by

$$u^*_{ij} = r_{ij} \left(\frac{u_{Iij}}{u_{ij}} \right)$$

where

$$u_{Iij} = \text{no. injured (AIS} \geq 2\text{) unrestrained drivers in cell } (i,j)$$

Note that the adjusted u^*_{ij} is the product of the injury rate for the unrestrained occupant and the severity distribution of the restrained occupant. Then the traditional effectiveness estimate, with the unrestrained driver data adjusted to mirror the damage distribution of the restrained drivers (1), is given by

$$E_{(r)} = 1 - \left(\frac{\text{proportion of belted drivers with AIS} > 2}{\text{proportion of "unrestrained" drivers with AIS} \geq 2} \right) 100$$

$$= 1 - \left(\frac{\Sigma r_{Iij} \;/\; R}{\Sigma u^*_{Iij} \;/\; \Sigma u^*_{ij}} \right) 100 \qquad (1)$$

Similar calculations yield the other adjustments, namely,

(2) Adjusting for total drivers

$$r^*_{ij} = t_{ij} \left(\frac{r_{Iij}}{r_{ij}} \right)$$

$$u^*_{ij} = t_{ij} \left(\frac{u_{Iij}}{u_{ij}} \right)$$

(2) Adjusting for unrestrained drivers

$$r^*_{ij} = u_{ij} \left(\frac{r_{Iij}}{r_{ij}} \right)$$

The effectiveness estimates, $E_{(t)}$ and $E_{(u)}$, follow as in equation (1).

Results. The overall estimates along with the three estimates adjusting for damage type differences are provided in Table 7.5. For comparison purposes, the corresponding estimates derived using the double pair procedure are also shown in the table.

Table 7.5. Belt effectiveness for traditional method (overall and adjusted for damage type) and double pair comparison method.

	Belt Effectiveness (%) Moderate AIS $\geq$ 2	Serious AIS $\geq$ 3	Severe AIS $\geq$ 4
DRIVER:			
Traditional			
Overall	38.9	28.0	52.6
Adjusted for			
(1) Restrained	33.5	17.1	42.6
(2) Total	29.5	9.8	30.3
(3) Unrestrained	29.2	9.4	29.6
Double Pair Method	47.7	36.3	40.2
RIGHT FRONT:			
Traditional			
Overall	38.2	41.5	3.27*
Double Pair Method	65.7	60.6	46.1

*only 9 belted, injured cases

Discussion.

This chapter has examined belt effectiveness in reducing moderate (AIS $\geq$ 2), serious (AIS $\geq$ 3), and severe (AIS $\geq$ 4) injuries using the weighted National Crash Severity Study data. This file was used because it contains reliable restraint usage data by seating position along with information on crash severity as indicated by the combination of extent of damage (minor = 1 to maximum = 9) and area of principal damage (front, side, rear, top, undercarriage). Only occupants of cars required to be towed from the scene were used in the analysis.

As can be seen from Table 7.5, the estimates from the double pair comparison method generally exceed those from the traditional estimates, which, in turn, are generally higher than those for any of the estimates adjusted for damage type.

Among the latter estimates, adjusting for the damage type distribution of the unrestrained drivers (3) has the greatest effect on the effectiveness estimates across all injury levels; adjusting for the restrained drivers (1) has the least impact.

Sample size limitations of the weighted NCSS data precluded a full analysis of belt effectiveness using the double pair comparison method with a weighted combination of log odds ratios (i.e., comparing driver (D) with right front (F), with left rear (L), and with right rear (R), and then combining the results to obtain an overall belt effectiveness estimate for the driver and likewise for the other seating positions).

Likewise sample size limitations posed problems with the traditional overall and adjusted estimates. For example, for severely injured (AIS $\geq$ 4) right front seat occupants, there were only 9 belted cases. Similarly in the adjustment procedure (especially adjusting for the restrained damage distribution), there were a number of empty cells even when combining the upper extent categories. Indeed, it would have been helpful to have had data adequate for making additional adjustments such as by driver age and sex.

Nevertheless, it was helpful to see the relative consistency of the estimates from both procedures at each injury level.

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APPENDIX A

Data for New Jersey and Pennsylvania

Table A.1. Number and percent of covered occupants in all accidents with moderate, major or fatal injuries across time periods (data for Figure 2.1).

PENNSYLVANIA

	1984				1985				1986			
	Jan-Mar	Apr-Jun	July-Sept	Oct-Dec	Jan-Mar	Apr-Jun	July-Sept	Oct-Dec	Jan-Mar	Apr-Jun	July-Sept	Oct-Dec
Injury Severity												
Killed	228 (0.58)	206 (0.54)	243 (0.61)	243 (0.56)	186 (0.51)	253 (0.62)	259 (0.64)	253 (0.54)	229 (0.60)	271 (0.64)	293 (0.64)	290 (0.59)
Major	902 (2.31)	891 (2.33)	903 (2.27)	1006 (2.31)	816 (2.22)	1009 (2.47)	953 (2.35)	1081 (2.31)	846 (2.22)	1103 (2.60)	1110 (2.43)	1127 (2.31)
Moderate	5396 (13.80)	5454 (14.26)	5618 (14.09)	6321 (14.53)	5150 (14.03)	5859 (14.36)	5732 (14.15)	6332 (13.51)	5405 (14.17)	6005 (14.17)	6483 (14.22)	7204 (14.75)

NEW JERSEY

	1984				1985				1986			
	Jan-Mar	Apr-Jun	July-Sept	Oct-Dec	Jan-Mar	Apr-Jun	July-Sept	Oct-Dec	Jan-Mar	Apr-Jun	July-Sept	Oct-Dec
Injury Severity												
Killed	65 (0.10)	94 (0.12)	107 (0.14)	113 (0.13)	107 (0.15)	119 (0.15)	108 (0.13)	107 (0.11)	102 (0.13)	104 (0.11)	131 (0.14)	124 (0.12)
Major	921 (1.41)	1148 (1.47)	1114 (1.46)	1207 (1.42)	946 (1.35)	1071 (1.35)	1148 (1.41)	1222 (1.29)	974 (1.27)	1047 (1.14)	1245 (1.33)	1276 (1.28)
Moderate	4879 (7.50)	5599 (7.18)	5667 (7.44)	6142 (7.25)	5067 (7.21)	5457 (6.88)	5395 (6.65)	6019 (6.33)	4990 (6.51)	5864 (6.38)	6203 (6.64)	6223 (6.22)

Table A.2. Number and percent of covered occupants in all accidents with certain injury types across time periods - Pennsylvania data (data for Figures 2.2a and 2.3a).

PENNSYLVANIA

	1984				1985				1986			
	Jan-Mar	Apr-Jun	July-Sept	Oct-Dec	Jan-Mar	Apr-Jun	July-Sept	Oct-Dec	Jan-Mar	Apr-Jun	July-Sept	Oct-Dec
Injury Type												
Bleeding	2338 (5.98)	2271 (5.94)	2426 (6.09)	2558 (5.88)	2036 (5.54)	2417 (5.92)	2383 (5.88)	2634 (5.62)	2157 (5.65)	2487 (5.87)	2640 (5.79)	2799 (5.73)
Broken Bones	736 (1.88)	707 (1.85)	720 (1.81)	802 (1.84)	638 (1.74)	747 (1.83)	736 (1.82)	799 (1.70)	666 (1.75)	767 (1.81)	902 (1.98)	907 (1.86)
Concussion	296 (0.76)	263 (0.69)	245 (0.61)	301 (0.69)	271 (0.74)	256 (0.63)	255 (0.63)	254 (0.54)	251 (0.66)	265 (0.63)	293 (0.64)	321 (0.66)
Complaint of Pain	2146 (5.49)	2160 (5.65)	2259 (5.67)	2677 (6.15)	2260 (6.16)	2562 (6.28)	2435 (6.01)	2745 (5.86)	2397 (6.28)	2724 (6.43)	2861 (6.27)	3293 (6.74)

Table A.3. Number and percent of covered occupants in all accidents with certain injury across time periods - New Jersey (data for Figures 2.2b and 2.3b).

NEW JERSEY

	1984				1985				1986			
	Jan-Mar	Apr-Jun	July-Sept	Oct-Dec	Jan-Mar	Apr-Jun	July-Sept	Oct-Dec	Jan-Mar	Apr-Jun	July-Sept	Oct-Dec
Injury Type												
Concussion	177 (0.27)	178 (0.23)	187 (0.25)	231 (0.27)	176 (0.25)	156 (0.20)	178 (0.22)	196 (0.21)	184 (0.24)	199 (0.22)	186 (0.20)	235 (0.24)
Internal	151 (0.23)	239 (0.31)	224 (0.29)	221 (0.26)	172 (0.24)	234 (0.30)	246 (0.30)	283 (0.30)	206 (0.27)	231 (0.25)	300 (0.32)	299 (0.30)
Bleeding	3488 (5.36)	4006 (5.14)	3924 (5.15)	4352 (5.14)	3545 (5.05)	3739 (4.72)	3850 (4.74)	4144 (4.36)	3532 (4.61)	3807 (4.14)	4185 (4.48)	4265 (4.27)
Fracture/ Dislocation	318 (0.49)	345 (0.44)	371 (0.49)	405 (0.48)	337 (0.48)	355 (0.45)	338 (0.42)	394 (0.41)	319 (0.42)	390 (0.42)	452 (0.48)	421 (0.42)
Complaint of Pain	10190 (15.66)	12652 (16.23)	12514 (16.43)	14588 (17.22)	11750 (16.73)	13948 (17.59)	13822 (17.03)	16717 (17.59)	13199 (17.21)	16025 (17.44)	16058 (17.18)	16935 (16.94)

Table A.4. Number and percent of covered occupants in all accidents with certain injury locations across time periods - Pennsylvania data (data for Figure 2.4a).

PENNSYLVANIA

	1984				1985				1986			
	Jan-Mar	Apr-Jun	July-Sept	Oct-Dec	Jan-Mar	Apr-Jun	July-Sept	Oct-Dec	Jan-Mar	Apr-Jun	July-Sept	Oct-Dec
Injury Location												
Face	1426 (3.65)	1307 (3.42)	1336 (3.35)	1524 (3.50)	1264 (3.44)	1341 (3.29)	1217 (3.00)	1545 (3.30)	1266 (3.32)	1373 (3.24)	1462 (3.21)	1646 (3.37)
Head	1967 (5.03)	1969 (5.15)	1974 (4.95)	2309 (5.31)	1892 (5.15)	2074 (5.08)	2001 (4.94)	2259 (4.82)	1956 (5.13)	2105 (4.97)	2189 (4.80)	2555 (5.23)
Neck	721 (1.84)	785 (2.05)	820 (2.06)	886 (2.04)	738 (2.01)	882 (2.16)	893 (2.20)	960 (2.05)	820 (2.15)	1053 (2.48)	1084 (2.38)	1159 (2.37)
Back	434 (1.11)	445 (1.16)	471 (1.18)	498 (1.14)	409 (1.11)	510 (1.25)	525 (1.30)	501 (1.07)	477 (1.25)	527 (1.24)	580 (1.27)	606 (1.24)
Chest/ Stomach	527 (1.35)	468 (1.22)	487 (1.22)	565 (1.30)	463 (1.26)	503 (1.23)	469 (1.16)	587 (1.25)	479 (1.26)	516 (1.22)	600 (1.32)	658 (1.35)

Table A.5. Number and percent of covered occupants in all accidents with certain injury locations across time periods - New Jersey data (data for Figure 2.4b)

	NEW JERSEY											
	1984				1985				1986			
	Jan-Mar	Apr-Jun	July-Sept	Oct-Dec	Jan-Mar	Apr-Jun	July-Sept	Oct-Dec	Jan-Mar	Apr-Jun	July-Sept	Oct-Dec
Injury Location												
Head	6357 (9.77)	6910 (8.86)	6765 (8.88)	8103 (9.57)	6296 (8.96)	6303 (7.95)	6246 (7.70)	7962 (8.38)	6756 (8.81)	7296 (7.94)	7397 (7.92)	8194 (8.20)
Face	2224 (3.42)	2365 (3.03)	2199 (2.89)	2796 (3.30)	2266 (3.23)	2093 (2.64)	2096 (2.58)	2547 (2.68)	2123 (2.77)	2221 (2.42)	2220 (2.38)	2633 (2.63)
Neck	2614 (4.02)	3998 (5.13)	4164 (5.51)	4371 (5.16)	3471 (4.94)	4820 (6.08)	4944 (6.09)	5277 (5.55)	4041 (5.27)	5510 (6.00)	5695 (6.09)	5665 (5.67)
Back	1487 (2.28)	1724 (2.21)	1802 (2.37)	2043 (2.41)	1739 (2.48)	2047 (2.58)	2105 (2.59)	2560 (2.69)	1925 (2.51)	2417 (2.63)	2516 (2.69)	2428 (2.43)
Chest/Abd. Pelvis	1867 (1.33)	1026 (1.31)	1000 (1.32)	1232 (1.45)	1115 (1.59)	1346 (1.70)	1333 (1.65)	1557 (1.63)	1235 (1.61)	1405 (1.53)	1535 (1.64)	1656 (1.65)

Table A.6. Number and percent of covered occupants in rollover accidents with bleeding or serious (A+K) injuries across time periods (data for Figure 2.5).

PENNSYLVANIA

	1984				1985				1986			
	Jan-Mar	Apr-Jun	July-Sept	Oct-Dec	Jan-Mar	Apr-Jun	July-Sept	Oct-Dec	Jan-Mar	Apr-Jun	July-Sept	Oct-Dec
Injury												
A+K	110 (8.54)	147 (12.78)	133 (11.08)	134 (9.29)	82 (7.21)	166 (13.13)	147 (11.81)	124 (8.12)	113 (7.86)	177 (12.67)	185 (12.19)	129 (7.57)
Bleeding	117 (9.09)	175 (15.22)	196 (16.32)	208 (14.41)	122 (10.73)	199 (15.73)	206 (16.55)	156 (10.22)	161 (11.20)	208 14.89))	244 (16.07)	189 (11.10)

NEW JERSEY

	1984				1985				1986			
	Jan-Mar	Apr-Jun	July-Sept	Oct-Dec	Jan-Mar	Apr-Jun	July-Sept	Oct-Dec	Jan-Mar	Apr-Jun	July-Sept	Oct-Dec
Injury												
A+K	15 (4.79)	25 (9.16)	15 (5.02)	26 (8.00)	8 (2.91)	18 (5.55)	15 (4.92)	10 (2.97)	10 (3.06)	12 (4.11)	19 (5.69)	16 (4.64)
Bleeding	43 (13.74)	32 (11.72)	41 (13.71)	55 (16.92)	44 (16.00)	49 (15.12)	50 (16.39)	53 (15.73)	43 (13.15)	39 (13.36)	51 (15.27)	42 (12.17)

Table A.7. Number and percent of covered occupants in non-rollover accidents with bleeding or serious (A+K) injuries across time periods (data for Figure 2.6).

PENNSYLVANIA

	1984				1985				1986			
	Jan-Mar	Apr-Jun	July-Sept	Oct-Dec	Jan-Mar	Apr-Jun	July-Sept	Oct-Dec	Jan-Mar	Apr-Jun	July-Sept	Oct-Dec
Injury												
A+K	751 (2.86)	712 (2.91)	758 (3.01)	827 (2.93)	676 (2.80)	811 (3.12)	792 (3.07)	907 (2.98)	720 (2.85)	903 (3.34)	923 (3.16)	936 (2.95)
Bleeding	1747 (6.65)	1664 (6.79)	1752 (6.96)	1851 (6.56)	1513 (6.26)	1735 (6.68)	1718 (6.67)	1947 (6.40)	1586 (6.29)	1811 (6.69)	1892 (6.48)	2041 (6.44)

NEW JERSEY

	1984				1985				1986			
	Jan-Mar	Apr-Jun	July-Sept	Oct-Dec	Jan-Mar	Apr-Jun	July-Sept	Oct-Dec	Jan-Mar	Apr-Jun	Jul-Sept	Oct-Dec
Injury												
A+K	971 (1.50)	1217 (1.57)	1206 (1.59)	1294 (1.53)	1045 (1.49)	1172 (1.49)	1241 (1.53)	1319 (1.39)	1066 (1.39)	1139 (1.24)	1357 (1.46)	1384 (1.39)
Bleeding	3445 (5.32)	3974 (5.12)	3883 (5.12)	4297 (5.09)	3501 (5.00)	3690 (4.67)	3800 (4.70)	4091 (4.32)	3489 (4.57)	3768 (4.11)	4134 (4.44)	4223 (4.24)

Table A.8. Number and percent of uninjured covered occupants in rollover and non-rollover accidents across time periods (data for Figure 2.7).

PENNSYLVANIA

	1984				1985				1986			
	Jan-Mar	Apr-Jun	July-Sept	Oct-Dec	Jan-Mar	Apr-Jun	July-Sept	Oct-Dec	Jan-Mar	Apr-Jun	July-Sept	Oct-Dec
Uninjured												
Non-Rollover Uninjured	21652 (82.43)	20143 (82.18)	20666 (82.12)	23185 (82.17)	20019 (82.84)	21381 (82.32)	21147 (82.05)	25245 (82.94)	20745 (82.22)	22207 (82.00)	23848 (81.71)	25935 (81.86)
Rollover Uninjured	912 (70.86)	648 (56.35)	684 (56.95)	903 (62.58)	779 (68.51)	679 (53.68)	695 (55.82)	1028 (67.32)	938 (65.23)	789 (56.48)	840 (55.34)	1126 (66.12)

NEW JERSEY

	1984				1985				1986			
	Jan-Mar	Apr-Jun	July-Sept	Oct-Dec	Jan-Mar	Apr-Jun	July-Sept	Oct-Dec	Jan-Mar	Apr-Jun	July-Sept	Oct-Dec
Uninjured												
Non-Rollover Uninjured	47428 (73.22)	56525 (72.76)	54808 (72.23)	60610 (71.83)	50778 (72.57)	56978 (72.16)	58741 (72.66)	68961 (72.82)	55715 (72.96)	66753 (72.89)	67801 (72.82)	73265 (73.54)
Rollover Uninjured	161 (51.44)	127 (46.52)	130 (43.48)	149 (45.85)	117 (42.55)	146 (45.06)	133 (43.61)	178 (52.82)	160 (48.93)	130 (44.52)	137 (41.02)	168 (48.70)

Table A.9. Number and percent of covered occupants in rollover accidents with certain injury locations across time periods - Pennsylvania data (data for Figures 2.8a and 2.9a).

PENNSYLVANIA

	1984				1985				1986			
	Jan-Mar	Apr-Jun	July-Sept	Oct-Dec	Jan-Mar	Apr-Jun	July-Sept	Oct-Dec	Jan-Mar	Apr-Jun	July-Sept	Oct-Dec
Injury Location												
Face	50 (3.89)	62 (5.39)	80 (6.66)	93 (6.44)	51 (4.49)	81 (6.40)	77 (6.18)	67 (4.39)	64 (4.45)	77 (5.51)	84 (5.53)	90 (5.28)
Head	109 (8.47)	145 (12.61)	146 (12.16)	173 (11.99)	109 (9.59)	175 (13.83)	156 (12.53)	146 (9.56)	158 (10.99)	171 (12.24)	177 (11.66)	155 (9.10)
Neck	38 (2.95)	38 (3.30)	33 (2.75)	38 (2.63)	35 (3.08)	47 (3.72)	47 (3.78)	49 (3.21)	55 (3.82)	50 (3.58)	54 (3.56)	58 (3.41)
Back	28 (2.18)	31 (2.70)	42 (3.50)	33 (2.29)	35 (3.08)	52 (4.11)	42 (3.37)	42 (2.75)	39 (2.71)	57 (4.08)	44 (2.90)	55 (3.23)
Chest/ Stomach	29 (2.25)	37 (3.22)	30 (2.50)	39 (2.70)	21 (1.85)	37 (2.92)	28 (2.25)	25 (1.64)	28 (1.95)	34 (2.43)	47 (3.10)	36 (2.11)

Table A.10. Number and percent of covered occupants in rollover accidents with certain injury locations across time periods - New Jersey data (data for Figures 2.8a and 2.9a).

	NEW JERSEY											
	1984				1985				1986			
	Jan-Mar	Apr-Jun	July-Sept	Oct-Dec	Jan-Mar	Apr-Jun	July-Sept	Oct-Dec	Jan-Mar	Apr-Jun	July-Sept	Oct-Dec
Injury Location												
Head	39 (12.46)	33 (12.09)	37 (12.37)	52 (16.00)	36 (13.09)	47 (14.51)	42 (13.77)	45 (13.35)	49 (14.98)	40 (13.70)	39 (11.68)	46 (13.33)
Face	13 (4.15)	15 (5.49)	10 (3.34)	17 (5.23)	16 (5.82)	8 (2.47)	12 (3.93)	10 (2.97)	12 (3.67)	6 (2.05)	12 (3.59)	13 (3.77)
Neck	11 (3.51)	11 (4.03)	13 (4.35)	18 (5.54)	17 (6.18)	19 (5.86)	20 (6.56)	14 (4.15)	15 (4.59)	20 (6.85)	22 (6.59)	19 (5.51)
Back	13 (4.15)	14 (5.13)	10 (3.34)	13 (4.00)	19 (6.91)	11 (3.40)	14 (4.59)	12 (3.56)	10 (3.06)	12 (4.11)	26 (7.78)	14 (4.06)
Chest/Abd. Pelvis	9 (2.88)	10 (3.66)	7 (2.34)	12 (3.69)	6 (2.18)	7 (2.16)	8 (2.63)	9 (2.67)	6 (1.84)	7 (2.39)	3 (0.90)	10 (2.90)

Table A.11. Number and percent of covered occupants in non-rollover accidents with certain injury locations across time periods - Pennsylvania data (data for Figures 2.10a and 2.11a).

PENNSYLVANIA

	1984				1985				1986			
	Jan-Mar	Apr-Jun	July-Sept	Oct-Dec	Jan-Mar	Apr-Jun	July-Sept	Oct-Dec	Jan-Mar	Apr-Jun	July-Sept	Oct-Dec
Injury Location												
Face	1130 (4.30)	1025 (4.18)	1029 (4.09)	1145 (4.06)	987 (4.08)	1009 (3.88)	937 (3.64)	1211 (3.98)	993 (3.94)	1066 (3.94)	1139 (3.90)	1266 (4.00)
Head	1379 (5.25)	1303 (5.32)	1305 (5.19)	1546 (5.48)	1259 (5.21)	1320 (5.08)	1345 (5.22)	1516 (4.98)	1302 (5.16)	1392 (5.14)	1447 (4.96)	1681 (5.31)
Neck	353 (1.34)	349 (1.42)	390 (1.55)	433 (1.53)	349 (1.44)	402 (1.55)	438 (1.70)	453 (1.49)	434 (1.72)	498 (1.84)	504 (1.73)	567 (1.79)
Back	219 (0.83)	220 (0.90)	234 (0.93)	243 (0.86)	204 (0.84)	222 (0.85)	261 (1.01)	225 (0.74)	244 (0.97)	236 (0.87)	299 (1.02)	283 (0.89)
Chest/ Stomach	371 (1.41)	296 (1.21)	322 (1.28)	371 (1.31)	296 (1.22)	329 (1.27)	317 (1.23)	389 (1.28)	309 (1.22)	344 (1.27)	392 (1.34)	450 (1.42)

Table A.12. Number and percent of covered occupants in non-rollover accidents with certain injury locations across time periods - New Jersey data (data for Figures 2.10b and 2.11b).

	NEW JERSEY											
	1984				1985				1986			
	Jan-Mar	Apr-Jun	July-Sept	Oct-Dec	Jan-Mar	Apr-Jun	July-Sept	Oct-Dec	Jan-Mar	Apr-Jun	July-Sept	Oct-Dec
Injury Location												
Head	6318 (9.75)	6877 (8.85)	6728 (8.87)	8051 (9.54)	6260 (8.95)	6256 (7.92)	6204 (7.67)	7917 (8.36)	6707 (8.78)	7256 (7.92)	7358 (7.90)	8148 (8.18)
Face	2211 (3.41)	2350 (3.02)	2189 (2.88)	2779 (3.29)	2250 (3.22)	2085 (2.64)	2084 (2.58)	2537 (2.68)	2111 (2.76)	2215 (2.42)	2208 (2.37)	2620 (2.63)
Neck	2603 (4.02)	3987 (5.13)	4181 (5.51)	4353 (5.16)	3454 (4.94)	4801 (6.08)	4924 (6.09)	5263 (5.56)	4026 (5.27)	5490 (5.99)	5673 (6.09)	5646 (5.67)
Back	1474 (2.28)	1710 (2.20)	1792 (2.36)	2030 (2.41)	1720 (2.46)	2036 (2.58)	2091 (2.59)	2548 (2.69)	1915 (2.51)	2405 (2.63)	2490 (2.67)	2414 (2.42)
Chest/Abd. Pelvis	858 (1.33)	1016 (1.31)	993 (1.31)	1220 (1.45)	1109 (1.59)	1339 (1.70)	1325 (1.64)	1548 (1.64)	1229 (1.61)	1398 (1.53)	1532 (1.64)	1646 (1.65)

Table A.13. Number and percent of covered occupants in head-on accidents with bleeding or serious (A+K) injuries across time periods (data for Figure 2.12).

PENNSYLVANIA

	1984				1985				1986			
	Jan-Mar	Apr-Jun	July-Sept	Oct-Dec	Jan-Mar	Apr-Jun	July-Sept	Oct-Dec	Jan-Mar	Apr-Jun	July-Sept	Oct-Dec
Injury												
A+K	222 (5.06)	211 (6.19)	232 (6.30)	230 (5.98)	218 (5.38)	219 (6.38)	187 (6.39)	266 (6.74)	212 (6.50)	239 (7.56)	212 (6.38)	243 (6.37)
Bleeding	410 (9.35)	356 (10.43)	374 (10.16)	410 (10.67)	349 (8.61)	363 (10.58)	283 (9.67)	404 (10.23)	314 (9.62)	334 (10.56)	365 (11.00)	411 (10.78)

NEW JERSEY

	1984				1985				1986			
	Jan-Mar	Apr-Jun	July-Sept	Oct-Dec	Jan-Mar	Apr-Jun	July-Sept	Oct-Dec	Jan-Mar	Apr-Jun	July-Sept	Oct-Dec
Injury												
A+K	154 (3.21)	181 (4.89)	176 (5.11)	203 (5.00)	182 (3.90)	194 (5.11)	210 (5.55)	235 (4.82)	179 (4.10)	142 (3.71)	232 (5.52)	234 (5.07)
Bleeding	393 (8.20)	369 (9.98)	337 (9.78)	443 (10.90)	382 (8.19)	358 (9.43)	372 (9.85)	423 (8.66)	399 (9.15)	312 (8.14)	400 (9.51)	412 (8.93)

Table A.14. Number and percent of covered occupants in non-head-on accidents with bleeding or serious (A+K) injuries across time periods (data for Figure 2.13).

PENNSYLVANIA

	1984				1985				1986			
	Jan-Mar	Apr-Jun	July-Sept	Oct-Dec	Jan-Mar	Apr-Jun	July-Sept	Oct-Dec	Jan-Mar	Apr-Jun	July-Sept	Oct-Dec
Injury												
A+K	908 (2.61)	886 (2.54)	914 (2.52)	1019 (2.57)	784 (2.40)	1043 (2.79)	1025 (2.72)	1068 (2.49)	863 (2.48)	1135 (2.89)	1191 (2.81)	1174 (2.61)
Bleeding	1928 (5.55)	1915 (5.50)	2052 (5.67)	2148 (5.41)	1687 (5.16)	2054 (5.49)	2100 (5.59)	2230 (5.20)	1843 (5.28)	2153 (5.49)	2275 (5.38)	2388 (5.31)

NEW JERSEY

	1984				1985				1986			
	Jan-Mar	Apr-Jun	July-Sept	Oct-Dec	Jan-Mar	Apr-Jun	July-Sept	Oct-Dec	Jan-Mar	Apr-Jun	July-Sept	Oct-Dec
Injury												
A+K	439 (0.89)	633 (0.99)	645 (1.04)	668 (0.98)	488 (0.90)	597 (0.92)	634 (0.96)	694 (0.90)	552 (0.91)	666 (0.87)	701 (0.91)	764 (0.94)
Bleeding	1738 (3.53)	2332 (3.64)	2289 (3.67)	2426 (3.54)	1720 (3.19)	2114 (3.26)	2153 (3.25)	2318 (3.00)	1853 (3.06)	2330 (3.04)	2441 (3.17)	2445 (3.00)

Table A.15. Number and percent of uninjured covered occupants in head-on and non-head-on accidents across time periods (data for Figure 2.14).

PENNSYLVANIA

	1984				1985				1986			
	Jan-Mar	Apr-Jun	July-Sept	Oct-Dec	Jan-Mar	Apr-Jun	July-Sept	Oct-Dec	Jan-Mar	Apr-Jun	July-Sept	Oct-Dec
Uninjured												
Non-Head-On Uninjured	28893 (83.21)	28877 (82.89)	30072 (83.11)	32918 (82.98)	27241 (83.40)	30926 (82.73)	31133 (82.85)	35947 (83.75)	28922 (82.89)	32346 (82.46)	34854 (82.44)	37172 (82.58)
Head-On Uninjured	3336 (76.09)	2514 (73.68)	2751 (74.74)	2766 (71.96)	3063 (75.57)	2496 (72.73)	2146 (73.32)	2889 (73.12)	2386 (73.10)	2272 (71.81)	2349 (70.77)	2706 (70.95)

NEW JERSEY

	1984				1985				1986			
	Jan-Mar	Apr-Jun	July-Sept	Oct-Dec	Jan-Mar	Apr-Jun	July-Sept	Oct-Dec	Jan-Mar	Apr-Jun	July-Sept	Oct-Dec
Uninjured												
Non-Head-On Uninjured	37399 (75.88)	47617 (74.30)	45894 (73.58)	50220 (73.28)	40441 (74.91)	47776 (73.59)	48896 (73.92)	57139 (73.98)	45085 (74.49)	56599 (73.79)	57052 (74.19)	60756 (74.55)
Head-On Uninjured	3192 (66.58)	2359 (63.77)	2139 (61.84)	2459 (60.51)	3029 (64.97)	2326 (61.28)	2406 (63.68)	3042 (62.31)	2812 (64.48)	2440 (63.67)	2553 (60.73)	2905 (62.95)

Table A.16. Number and percent of occupants in head-on accidents with certain injury locations across time periods - Pennsylvania data (data for Figures 2.15a and 2.16a).

PENNSYLVANIA

	1984				1985				1986			
	Jan-Mar	Apr-Jun	July-Sept	Oct-Dec	Jan-Mar	Apr-Jun	July-Sept	Oct-Dec	Jan-Mar	Apr-Jun	July-Sept	Oct-Dec
Injury Location												
Face	231 (5.27)	210 (6.15)	219 (5.95)	228 (5.93)	230 (5.67)	202 (5.89)	145 (4.95)	239 (6.05)	185 (5.67)	172 (5.44)	191 (5.75)	236 (6.19)
Head	321 (7.32)	262 (7.68)	272 (7.39)	338 (8.79)	291 (7.18)	264 (7.69)	218 (7.45)	313 (7.92)	265 (8.12)	269 (8.50)	267 (8.04)	339 (8.89)
Neck	76 (1.73)	60 (1.76)	63 (1.71)	80 (2.08)	73 (1.80)	72 (2.10)	71 (2.43)	85 (2.15)	61 (1.87)	71 (2.24)	88 (2.65)	98 (2.57)
Back	36 (0.82)	32 (0.94)	26 (0.71)	31 (0.81)	43 (1.06)	27 (0.79)	40 (1.37)	33 (0.84)	39 (1.19)	27 (0.82)	33 (0.99)	35 (0.92)
Chest/ Stomach	67 (1.53)	83 (2.43)	68 (1.85)	91 (2.37)	96 (2.37)	76 (2.21)	57 (1.95)	93 (2.35)	78 (2.39)	62 (1.96)	95 (2.86)	74 (1.94)

Table A.17. Number and percent of occupants in head-on accidents with certain injury locations across time periods - New Jersey data (data for Figures 2.15b and 2.16b).

NEW JERSEY

	1984				1985				1986			
	Jan-Mar	Apr-Jun	July-Sept	Oct-Dec	Jan-Mar	Apr-Jun	July-Sept	Oct-Dec	Jan-Mar	Apr-Jun	July-Sept	Oct-Dec
Injury Location												
Head	607 (12.66)	460 (12.44)	464 (13.46)	577 (14.20)	602 (12.91)	465 (12.25)	410 (10.85)	611 (12.52)	579 (13.28)	461 (12.03)	539 (12.82)	543 (11.77)
Face	233 (4.86)	187 (5.06)	152 (4.41)	234 (5.76)	203 (4.35)	199 (5.24)	195 (5.16)	223 (4.57)	181 (4.15)	152 (3.97)	207 (4.92)	245 (5.31)
Neck	145 (3.02)	134 (3.62)	156 (4.53)	160 (3.94)	155 (3.32)	163 (4.29)	170 (4.50)	245 (5.02)	159 (3.65)	162 (4.23)	202 (4.80)	224 (4.85)
Back	99 (2.07)	75 (2.03)	84 (2.44)	92 (2.26)	103 (2.21)	87 (2.29)	87 (2.30)	99 (2.03)	88 (2.02)	83 (2.17)	97 (2.31)	96 (2.08)
Chest/Abd. Pelvis	99 (2.07)	96 (2.59)	92 (2.67)	130 (3.20)	134 (2.88)	118 (3.10)	117 (3.09)	166 (3.40)	131 (3.00)	115 (3.00)	151 (3.59)	132 (2.86)

Table A.18. Number and percent of occupants in non-head-on accidents with certain injury locations across time periods - Pennsylvania data (data for Figures 2.17a and 2.18a).

PENNSYLVANIA

	1984				1985				1986			
	Jan-Mar	Apr-Jun	July-Sept	Oct-Dec	Jan-Mar	Apr-Jun	July-Sept	Oct-Dec	Jan-Mar	Apr-Jun	July-Sept	Oct-Dec
Injury Location												
Face	1195 (3.44)	1097 (3.15)	1117 (3.09)	1296 (3.27)	1034 (3.17)	1139 (3.05)	1072 (2.85)	1306 (3.04)	1081 (3.10)	1201 (3.06)	1271 (3.01)	1410 (3.13)
Head	1646 (4.74)	1707 (4.90)	1702 (4.70)	1971 (4.97)	1601 (4.90)	1810 (4.84)	1783 (4.74)	1946 (4.53)	1691 (4.85)	1836 (4.68)	1922 (4.55)	2216 (4.92)
Neck	645 (1.86)	725 (2.08)	757 (2.09)	806 (2.03)	665 (2.04)	810 (2.17)	822 (2.19)	875 (2.04)	759 (2.18)	982 (2.50)	996 (2.36)	1061 (2.36)
Back	398 (1.15)	413 (1.19)	445 (1.23)	467 (1.18)	366 (1.12)	483 (1.29)	485 (1.29)	468 (1.09)	438 (1.26)	501 (1.28)	547 (1.29)	571 (1.27)
Chest/ Stomach	460 (1.32)	385 (1.11)	419 (1.16)	474 (1.19)	367 (1.12)	427 (1.14)	412 (1.10)	494 (1.15)	401 (1.15)	454 (1.16)	505 (1.19)	584 (1.30)

Table A.19. Number and percent of occupants in non-head-on accidents with certain injury locations across time periods - New Jersey data (data for Figures 2.17b and 2.18b).

NEW JERSEY

Injury Location	1984 Jan-Mar	1984 Apr-Jun	1984 July-Sept	1984 Oct-Dec	1985 Jan-Mar	1985 Apr-Jun	1985 July-Sept	1985 Oct-Dec	1986 Jan-Mar	1986 Apr-Jun	1986 July-Sept	1986 Oct-Dec
Head	4209 (8.54)	5242 (8.18)	5084 (8.15)	6022 (8.79)	4169 (7.72)	4649 (7.16)	4608 (6.97)	5942 (7.69)	4803 (7.94)	5659 (7.38)	5563 (7.23)	6268 (7.69)
Face	1110 (2.25)	1364 (2.13)	1318 (2.11)	1605 (2.34)	1139 (2.11)	1182 (1.82)	1147 (1.73)	1460 (1.89)	1168 (1.93)	1350 (1.76)	1270 (1.65)	1511 (1.85)
Neck	2250 (4.57)	3662 (5.71)	3832 (6.14)	3980 (5.81)	3030 (5.61)	4392 (6.76)	4512 (6.82)	4744 (6.14)	3563 (5.89)	5058 (6.59)	5164 (6.72)	5085 (6.24)
Back	1186 (2.41)	1510 (2.36)	1599 (2.56)	1778 (2.59)	1455 (2.69)	1805 (2.78)	1838 (2.81)	2249 (2.91)	1663 (2.75)	2160 (2.82)	2221 (2.89)	2117 (2.60)
Chest/Abd. Pelvis	580 (1.18)	742 (3.28)	717 (1.15)	881 (1.29)	756 (1.40)	996 (1.54)	973 (1.47)	1153 (1.49)	853 (1.41)	1077 (1.41)	1126 (1.46)	1264 (1.56)

Table A.20. Number and percent of covered occupants in single vehicle accidents with bleeding and serious (A+K) injuries across time periods (data for Figure 2.19).

PENNSYLVANIA

	1984				1985				1986			
Injury	Jan-Mar	Apr-Jun	July-Sept	Oct-Dec	Jan-Mar	Apr-Jun	July-Sept	Oct-Dec	Jan-Mar	Apr-Jun	July-Sept	Oct-Dec
A+K	486 (4.41)	449 (5.19)	468 (5.27)	524 (4.99)	375 (4.14)	516 (5.83)	463 (5.26)	548 (4.96)	411 (4.12)	578 (6.21)	613 (6.06)	528 (4.60)
Bleeding	1039 (9.44)	956 (11.05)	1044 (11.77)	1106 (10.52)	848 (9.38)	955 (10.78)	984 (11.17)	1071 (9.70)	925 (9.27)	1059 (11.37)	1116 (11.04)	1141 (9.94)

NEW JERSEY

	1984				1985				1986			
Injury	Jan-Mar	Apr-Jun	July-Sept	Oct-Dec	Jan-Mar	Apr-Jun	July-Sept	Oct-Dec	Jan-Mar	Apr-Jun	July-Sept	Oct-Dec
A+K	380 (3.60)	417 (4.25)	385 (3.85)	434 (3.73)	364 (3.29)	381 (3.76)	385 (3.59)	382 (3.12)	328 (2.92)	331 (3.05)	422 (3.59)	369 (2.81)
Bleeding	1322 (12.51)	1284 (13.08)	1271 (12.70)	1444 (12.43)	1398 (12.63)	1223 (12.07)	1274 (11.89)	1355 (11.05)	1237 (11.00)	1120 (10.32)	1292 (10.98)	1349 (10.26)

Table A.21. Number and percent of covered occupants in multi-vehicle accidents with bleeding and serious (A+K) injuries across time periods (data for Figure 2.20).

PENNSYLVANIA

	1984				1985				1986			
	Jan-Mar	Apr-Jun	July-Sept	Oct-Dec	Jan-Mar	Apr-Jun	July-Sept	Oct-Dec	Jan-Mar	Apr-Jun	July-Sept	Oct-Dec
Injury												
A+K	644 (2.29)	648 (2.19)	678 (2.18)	725 (2.20)	627 (2.27)	746 (2.33)	749 (2.36)	786 (2.19)	664 (2.35)	796 (2.40)	790 (2.22)	889 (2.38)
Bleeding	1299 (4.62)	1315 (4.44)	1382 (4.46)	1452 (4.40)	1188 (4.29)	1462 (4.57)	1399 (4.41)	1563 (4.36)	1232 (4.37)	1428 (4.32)	1524 (4.29)	1658 (4.44)

NEW JERSEY

	1984				1985				1986			
	Jan-Mar	Apr-Jun	July-Sept	Oct-Dec	Jan-Mar	Apr-Jun	July-Sept	Oct-Dec	Jan-Mar	Apr-Jun	July-Sept	Oct-Dec
Injury												
A+K	606 (1.11)	825 (1.21)	836 (1.27)	886 (1.21)	689 (1.16)	889 (1.17)	871 (1.24)	947 (1.15)	748 (1.15)	820 (1.02)	954 (1.16)	1031 (1.19)
Bleeding	2166 (3.97)	2722 (3.99)	2653 (4.01)	2908 (3.98)	2147 (3.63)	2516 (3.64)	2576 (3.66)	2789 (3.37)	2295 (3.51)	2687 (3.32)	2893 (3.54)	2916 (3.36)

Table A.22. Number and percent of uninjured covered occupants in single and multi-vehicle accidents across time periods (data for Figure 2.21).

PENNSYLVANIA

	1984				1985				1986			
	Jan-Mar	Apr-Jun	July-Sept	Oct-Dec	Jan-Mar	Apr-Jun	July-Sept	Oct-Dec	Jan-Mar	Apr-Jun	July-Sept	Oct-Dec
Crash Type												
Multi-Vehicle Uninjured	23774 (84.59)	24953 (84.31)	26350 (85.02)	27779 (84.16)	23356 (84.39)	26925 (84.25)	26796 (84.54)	30378 (84.79)	23674 (84.03)	27764 (83.93)	29855 (84.13)	31154 (83.42)
Single Vehicle Uninjured	8455 (76.86)	6438 (74.43)	6473 (72.97)	7905 (75.22)	6948 (76.83)	6497 (73.37)	6483 (73.60)	8458 (76.58)	7634 (76.49)	6854 (73.60)	7348 (72.67)	8724 (76.01)

NEW JERSEY

	1984				1985				1986			
	Jan-Mar	Apr-Jun	July-Sept	Oct-Dec	Jan-Mar	Apr-Jun	July-Sept	Oct-Dec	Jan-Mar	Apr-Jun	July-Sept	Oct-Dec
Crash Type												
Multi-Vehicle Uninjured	40908 (75.03)	50221 (73.70)	48276 (72.96)	53017 (72.53)	43828 (74.07)	50390 (72.86)	51615 (73.28)	60648 (73.26)	48283 (73.77)	59367 (73.27)	59985 (73.44)	64154 (73.88)
Single Vehicle Uninjured	6681 (63.21)	6431 (65.50)	6662 (66.56)	7442 (66.64)	7067 (63.85)	6734 (66.46)	7259 (67.74)	8491 (69.27)	7592 (67.52)	7516 (69.23)	7953 (67.59)	9279 (70.60)

Table A.23. Number and percent of covered occupants in single vehicle accidents with certain injury locations across time periods - Pennsylvania data (data for Figures 2.22a and 2.23a).

PENNSYLVANIA

	1984				1985				1986			
	Jan-Mar	Apr-Jun	July-Sept	Oct-Dec	Jan-Mar	Apr-Jun	July-Sept	Oct-Dec	Jan-Mar	Apr-Jun	July-Sept	Oct-Dec
Injury Location												
Face	695 (6.32)	577 (6.67)	626 (7.06)	696 (6.62)	549 (6.07)	561 (6.34)	532 (6.04)	680 (6.16)	584 (5.85)	607 (6.52)	655 (6.48)	728 (6.34)
Head	755 (6.86)	647 (7.48)	670 (7.55)	765 (7.28)	642 (7.10)	689 (7.78)	660 (7.49)	761 (6.89)	698 (6.99)	715 (7.68)	736 (7.28)	752 (6.55)
Neck	158 (1.44)	115 (1.33)	150 (1.69)	147 (1.40)	138 (1.53)	126 (1.42)	141 (1.60)	152 (1.38)	156 (1.56)	141 (1.51)	171 (1.69)	189 (1.65)
Back	116 (1.05)	96 (1.11)	137 (1.54)	114 (1.08)	93 (1.03)	133 (1.50)	125 (1.42)	117 (1.06)	110 (1.10)	118 (1.27)	134 (1.33)	133 (1.16)
Chest/ Stomach	202 (1.84)	140 (1.62)	149 (1.68)	185 (1.76)	148 (1.64)	155 (1.75)	150 (1.70)	157 (1.42)	159 (1.59)	163 (1.75)	193 (1.91)	200 (1.74)

Table A.24. Number and percent of covered occupants in single vehicle accidents with certain injury locations across time periods - New Jersey data (data for Figures 2.22b and 2.23b).

NEW JERSEY

	1984				1985				1986			
	Jan-Mar	Apr-Jun	July-Sept	Oct-Dec	Jan-Mar	Apr-Jun	July-Sept	Oct-Dec	Jan-Mar	Apr-Jun	July-Sept	Oct-Dec
Injury Location												
Head	1503 (14.22)	1164 (11.86)	1180 (11.79)	1438 (12.38)	1475 (13.33)	1152 (11.37)	1177 (10.98)	1347 (10.99)	1313 (11.68)	1124 (10.35)	1239 (10.53)	1315 (10.01)
Face	856 (8.10)	805 (8.20)	719 (7.18)	933 (8.03)	893 (8.07)	691 (6.82)	726 (6.77)	830 (6.77)	752 (6.69)	698 (6.43)	722 (6.14)	847 (6.44)
Neck	207 (1.96)	188 (1.91)	193 (1.93)	215 (1.85)	268 (2.42)	244 (2.41)	241 (2.25)	266 (2.17)	293 (2.61)	273 (2.51)	306 (2.60)	334 (2.54)
Back	192 (1.82)	132 (1.34)	112 (1.12)	160 (1.38)	173 (1.56)	140 (1.38)	146 (1.36)	197 (1.61)	163 (1.45)	166 (1.53)	182 (1.55)	187 (1.42)
Chest/Abd. Pelvis	183 (1.73)	181 (1.85)	184 (1.84)	212 (1.83)	209 (1.89)	222 (2.19)	229 (2.14)	226 (1.85)	238 (2.11)	203 (1.87)	240 (2.04)	242 (1.84)

Table A.25. Number and percent of covered occupants in multi-vehicle accidents with certain injury locations across time periods - Pennsylvania data (data for Figures 2.24a and 2.25a).

PENNSYLVANIA

	1984				1985				1986			
	Jan-Mar	Apr-Jun	July-Sept	Oct-Dec	Jan-Mar	Apr-Jun	July-Sept	Oct-Dec	Jan-Mar	Apr-Jun	July-Sept	Oct-Dec
Injury Location												
Face	731 (2.60)	730 (2.47)	710 (2.29)	828 (2.51)	715 (2.58)	780 (2.44)	685 (2.16)	865 (2.41)	682 (2.42)	766 (2.32)	807 (2.27)	918 (2.46)
Head	1212 (4.31)	1322 (4.47)	1305 (4.21)	1544 (4.68)	1250 (4.52)	1385 (4.33)	1341 (4.23)	1498 (4.18)	1258 (4.47))	1390 (4.20)	1453 (4.09)	1803 (4.83)
Neck	563 (2.00)	670 (2.26)	670 (2.16)	739 (2.24)	600 (2.17)	756 (2.37)	752 (2.37)	808 (2.26)	664 (2.36)	912 (2.76)	913 (2.57)	970 (2.60)
Back	318 (1.13)	349 (1.18)	334 (1.08)	384 (1.16)	316 (1.14)	377 (1.18)	400 (1.26)	384 (1.07)	367 (1.30)	409 (1.24)	446 (1.26)	473 (1.27)
Chest/ Stomach	325 (1.16)	328 (1.11)	338 (1.09)	380 (1.15)	315 (1.14)	348 (1.09)	319 (1.01)	430 (1.20)	320 (1.14)	353 (1.07)	407 (1.15)	458 (1.23)

Table A.26. Number and percent of covered occupants in multi-vehicle accidents with certain injury locations across time periods - New Jersey data (data for Figures 2.24b and 2.25b).

NEW JERSEY

	1984				1985				1986			
	Jan-Mar	Apr-Jun	July-Sept	Oct-Dec	Jan-Mar	Apr-Jun	July-Sept	Oct-Dec	Jan-Mar	Apr-Jun	July-Sept	Oct-Dec
Injury Location												
Head	4854 (8.90)	5746 (8.43)	5585 (8.44)	6665 (9.12)	4821 (8.15)	5151 (7.45)	5069 (7.20)	6615 (7.99)	5443 (8.32)	6172 (7.62)	6158 (7.54)	6879 (7.92)
Face	1368 (2.51)	1516 (2.29)	1480 (2.24)	1863 (2.55)	1373 (2.32)	1402 (2.03)	1370 (1.95)	1717 (2.07)	1371 (2.09)	1523 (1.88)	1498 (1.83)	1786 (2.06)
Neck	2407 (4.41)	3810 (5.59)	4001 (6.05)	4156 (5.69)	3203 (5.41)	4576 (6.62)	4703 (6.68)	5011 (6.05)	3748 (5.73)	5237 (6.46)	5389 (6.60)	5331 (6.14)
Back	1295 (2.38)	1592 (2.34)	1690 (2.55)	1883 (2.58)	1566 (2.65)	1907 (2.76)	1959 (2.78)	2363 (2.85)	1762 (2.69)	2251 (2.78)	2334 (2.86)	2241 (2.58)
Chest/Abd. Pelvis	684 (1.25)	845 (1.24)	816 (1.23)	1020 (1.40)	906 (1.53)	1124 (1.62)	1104 (1.57)	1331 (1.60)	997 (1.52)	1202 (1.49)	1295 (1.58)	1414 (1.63)

Table A.27. Number and percent of non-belted (NB) and belted (SB) occupants in all 1984 accidents for New Jersey and Pennsylvania by injury severity, injury type, and injury location.

1984

Overall

	NJ		PA	
	n (%)	n (%)	n (%)	n (%)
Injury Severity	NB	SB	NB	SB
Uninjured	193,115 (71.79)	46,645 (76.66)	77,936 (81.68)	22,878 (89.87)
Killed	352 (0.13)	23 (0.04)	716 (0.75)	48 (0.19)
Major Injury/Incap.	4,074 (1.51)	492 (0.81)	2,467 (2.59)	307 (1.21)
Moderate Injury	20,732 (7.71)	2,843 (4.67)	14,027 (14.70)	2,141 (8.41)
Complaint of Pain	50,728 (18.86)	10,841 (17.82)	--	--
Unknown Injury	--	--	266 (0.28)	84 (0.33)

Table A.27 (Con't)

1984

Overall

	NJ		PA	
	n (%)	n (%)	n (%)	n (%)
Injury Type	NB	SB	NB	SB
Uninjured	193,115 (71.79)	46,645 (76.66)	77,936 (81.68)	22,878 (89.87)
Amputation	4 (0.00)	1 (0.00)	13 (0.01)	2 (0.01)
Concussion	729 (0.27)	83 (0.14)	790 (0.83)	80 (0.31)
Internal	744 (0.28)	97 (0.16)	--	--
Bleeding	14,780 (5.49)	1,718 (2.82)	6,270 (6.57)	660 (2.59)
Contusions/Bruises/ Abrasions	8,595 (3.20)	1,371 (2.25)	2,084 (2.18)	308 (1.21)
Burns	44 (0.02)	5 (0.01)	43 (0.05)	5 (0.02)
Fracture/Dislocation	1,386 (0.52)	165 (0.27)	2,324 (2.44)	287 (1.13)
Complaint of Pain	44,266 (16.46)	9,631 (15.83)	4,953 (5.19)	1,069 (4.20)
None Visible	5,338 (1.98)	1,128 (1.85)	849 (0.89)	134 (0.53)

Table A.27 (Con't)

	1984			
	Overall			
	NJ		PA	
	n (%)	n (%)	n (%)	n (%)
Injury Location	NB	SB	NB	SB
Uninjured	193,115 (71.79)	46,645 (76.66)	77,936 (81.68)	22,878 (89.87)
Head	25,873 (9.62)	3,771 (6.20)	5,209 (5.46)	595 (2.34)
Face	9,045 (3.36)	1,107 (1.82)	3,617 (3.79)	351 (1.38)
Neck	12,646 (4.70)	3,473 (5.71)	1,642 (1.72)	355 (1.39)
Chest/Stomach/ (Abdomen/Pelvis/ Internal	3,547 (1.31)	894 (1.47)	1,635 (1.72)	320 (1.26)
Back	6,343 (2.36)	1,501 (2.47)	1,067 (1.12)	242 (0.95)
Arm	6,944 (2.58)	2,476 (2.43)	1,128 (1.18)	182 (0.71)
Entire Body	2,323 (0.86)	334 (0.55)	1,090 (1.14)	169 (0.66)
Leg	9,165 (3.41)	1,643 (2.70)	1,637 (1.72)	254 (1.00)
Unknown	--	--	151 (0.16)	35 (0.14)
Other	--	--	300 (0.31)	77 (0.30)

Table A.28. Number and percent of non-belted (NB) and belted (SB) occupants in 1984 rollover accidents for New Jersey and Pennsylvania by injury severity, injury type, and injury location.

	1984							
	Rollovers				Others			
	NJ		PA		NJ		PA	
	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)
Injury Severity	NB	SB	NB	SB	NB	SB	NB	SB
Uninjured	607 (46.95)	128 (55.41)	2,847 (60.32)	869 (76.90)	192,740 (71.93)	46,581 (76.76)	49,211 (81.08)	14,005 (90.96)
Killed	6 (0.46)	1 (0.43)	162 (3.43)	10 (0.88)	346 (0.13)	22 (0.04)	414 (0.68)	20 (0.13)
Major Injury/Incap.	76 (5.88)	10 (4.33)	322 (6.82)	38 (3.36)	3,999 (1.49)	482 (0.79)	2,633 (2.69)	165 (1.07)
Moderate Injury	255 (19.72)	30 (12.99)	1,380 (29.24)	206 (18.23)	20,483 (7.64)	2,816 (4.64)	9,289 (15.30)	1,173 (7.62)
Complaint of Pain	349 (26.99)	62 (26.84)	--	--	50,404 (18.81)	10,784 (17.77)	--	--
Unknown Injury	--	--	9 (0.19)	7 (0.62)	--	--	150 (0.25)	34 (0.22)

Table A.28 (Con't)

1984

Injury Type	Rollovers NJ n (%) NB	Rollovers NJ n (%) SB	Rollovers PA n (%) NB	Rollovers PA n (%) SB	Others NJ n (%) NB	Others NJ n (%) SB	Others PA n (%) NB	Others PA n (%) SB
Uninjured	607 (46.95)	128 (55.41)	2,847 (60.32)	869 (76.90)	192,740 (71.93)	46,581 (76.76)	49,211 (81.08)	14,005 (90.96)
Amputation	0 (0.00)	0 (0.00)	8 (0.17)	0 (0.00)	4 (0.00)	1 (0.00)	4 (0.01)	1 (0.01)
Concussion	8 (0.62)	1 (0.43)	87 (1.84)	12 (1.06)	721 (0.27)	82 (0.14)	529 (0.87)	42 (0.27)
Internal	18 (1.39)	1 (0.43)	--	--	726 (0.27)	96 (0.16)	--	--
Bleeding	186 (14.39)	20 (8.66)	647 (13.71)	76 (6.73)	14,598 (5.45)	1,702 (2.80)	4,495 (7.41)	416 (2.70)
Contusions/Bruises/ Abrasions	123 (9.51)	18 (7.79)	259 (5.49)	39 (3.45)	8,476 (3.16)	1,353 (2.23)	1,408 (2.32)	172 (1.12)
Burns	2 (0.15)	0 (0.00)	12 (0.25)	0 (0.00)	42 (0.02)	5 (0.01)	22 (0.04)	2 (0.01)
Fracture/Dislocation	25 (1.93)	5 (2.16)	329 (6.97)	34 (3.01)	1,362 (0.51)	160 (0.26)	1,540 (2.54)	163 (1.06)
Complaint of Pain	301 (23.28)	52 (22.51)	425 (9.00)	85 (7.52)	43,983 (16.41)	9,583 (15.79)	2,852 (4.70)	509 (3.31)
None Visible	23 (1.78)	6 (2.60)	95 (2.01)	12 (1.06)	5,320 (1.99)	1,122 (1.85)	552 (0.91)	65 (0.42)

Table A.28 (Con't)

1984

Injury Location	Rollovers NJ NB n (%)	Rollovers NJ SB n (%)	Rollovers PA NB n (%)	Rollovers PA SB n (%)	Others NJ NB n (%)	Others NJ SB n (%)	Others PA NB n (%)	Others PA SB n (%)
Uninjured	607 (46.95)	128 (55.41)	2,847 (60.32)	869 (76.90)	192,740 (71.93)	46,581 (76.76)	49,211 (81.08)	14,005 (90.96)
Head	185 (14.31)	22 (9.52)	529 (11.21)	75 (6.64)	25,702 (9.59)	3,752 (6.18)	3,511 (5.78)	325 (2.11)
Face	54 (4.18)	3 (1.30)	257 (5.44)	25 (2.21)	8,995 (3.36)	1,105 (1.82)	2,785 (4.59)	231 (1.50)
Neck	51 (3.94)	9 (3.90)	132 (2.80)	24 (2.12)	12,601 (4.70)	3,467 (5.71)	832 (1.37)	148 (0.96)
Chest/Stomach/ Abdomen/Pelvis/ Internal	32 (2.48)	8 (3.47)	179 (3.80)	17 (1.50)	3,516 (1.31)	886 (1.46)	1,112 (1.83)	193 (1.25)
Back	62 (4.80)	7 (3.03)	171 (3.62)	31 (2.74)	6,282 (2.34)	1,494 (2.46)	559 (0.92)	106 (0.69)
Arm	173 (13.38)	28 (12.12)	207 (4.39)	33 (2.92)	6,773 (2.53)	1,449 (2.39)	651 (1.07)	92 (0.60)
Entire Body	59 (4.56)	8 (3.46)	183 (3.88)	27 (2.39)	2,264 (0.84)	326 (0.54)	678 (1.12)	88 (0.57)
Leg	70 (5.41)	18 (7.79)	165 (3.50)	19 (1.68)	9,099 (3.40)	1,625 (2.68)	1,076 (1.77)	146 (0.95)
Unknown	--	--	11 (0.23)	3 (0.27)	--	--	82 (0.14)	23 (0.15)
Other	--	--	39 (0.83)	7 (0.62)	--	--	200 (0.33)	40 (0.26)

Table A.29. Number and percent of non-belted (NB) and belted (SB) occupants in 1984 head-on accidents for New Jersey and Pennsylvania by injury severity, injury type, and injury location.

1984

	Head-Ons				Others			
	NJ		PA		NJ		PA	
	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)
Injury Severity	NB	SB	NB	SB	NB	SB	NB	SB
Uninjured	9,081 (63.26)	2,068 (68.86)	6,433 (73.13)	1,789 (83.60)	156,294 (73.59)	38,090 (77.14)	68,719 (82.03)	20,145 (90.08)
Killed	81 (0.56)	7 (0.23)	140 (1.59)	10 (0.47)	109 (0.05)	11 (0.02)	574 (0.69)	38 (0.17)
Major Injury/Incap.	570 (3.97)	80 (2.66)	434 (4.93)	73 (3.41)	2,051 (0.97)	291 (0.59)	2,026 (2.42)	234 (1.05)
Moderate Injury	1,793 (12.49)	280 (9.32)	1,774 (20.17)	259 (12.10)	12,612 (5.94)	1,864 (3.77)	12,206 (14.57)	1,873 (8.38)
Complaint of Pain	2,831 (19.72)	568 (18.91)	--	--	41,329 (19.46)	9,123 (18.48)	--	--
Unknown Injury	--	--	16 (0.18)	9 (0.42)	--	--	245 (0.29)	74 (0.33)

Table A.29 (Con't)

1984

	Head-Ons				Others			
	NJ		PA		NJ		PA	
	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)
Injury Type	NB	SB	NB	SB	NB	SB	NB	SB
Uninjured	9,081 (63.26)	2,068 (68.86)	6,433 (73.13)	1,789 (83.60)	156,294 (73.59)	38,090 (77.14)	68,719 (82.03)	20,145 (90.08)
Amputation	0 (0.00)	0 (0.00)	1 (0.01)	0 (0.00)	2 (0.00)	0 (0.00)	12 (0.01)	2 (0.01)
Concussion	64 (0.45)	10 (0.33)	102 (1.16)	11 (0.51)	446 (0.21)	52 (0.11)	685 (0.82)	69 (0.31)
Internal	122 (0.85)	17 (0.57)	--	--	335 (0.16)	60 (0.12)	--	--
Bleeding	1,411 (9.83)	180 (5.99)	977 (11.11)	115 (5.37)	8,150 (8.84)	1,019 (2.06)	5,270 (6.29)	540 (2.41)
Contusions/Bruises/ Abrasions	685 (4.77)	111 (3.70)	282 (3.21)	37 (1.73)	5,579 (2.63)	936 (1.90)	1,796 (2.14)	271 (1.21)
Burns	3 (0.02)	0 (0.00)	7 (0.08)	1 (0.05)	25 (0.01)	4 (0.01)	36 (0.04)	4 (0.02)
Broken Bones	183 (1.27)	34 (1.13)	374 (4.25)	60 (2.80)	642 (0.30)	84 (0.17)	1,941 (2.32)	225 (1.01)
Complaint of Pain	2,499 (17.41)	535 (17.82)	500 (5.68)	105 (4.91)	36,491 (17.18)	8,159 (16.52)	4,437 (5.30)	963 (4.31)
None Visible	308 (2.15)	48 (1.60)	109 (1.24)	17 (0.79)	4,431 (2.09)	975 (1.97)	736 (0.88)	115 (0.51)

Table A.29 (Con't)

1984

	Head-Ons				Others			
	NJ		PA		NJ		PA	
	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)
Injury Location	NB	SB	NB	SB	NB	SB	NB	SB
Uninjured	9,081 (63.26)	2,068 (68.86)	6,433 (73.13)	1,789 (83.60)	156,294 (73.59)	38,090 (77.14)	68,719 (82.03)	20,145 (90.08)
Head	1,934 (13.47)	260 (8.66)	729 (8.29)	77 (3.60)	18,682 (8.80)	2,881 (5.83)	4,464 (5.33)	517 (2.31)
Face	754 (5.25)	103 (3.43)	540 (6.14)	63 (2.94)	5,070 (2.39)	692 (1.40)	3,063 (3.66)	284 (1.27)
Neck	491 (3.42)	125 (4.16)	138 (1.57)	25 (1.17)	11,316 (5.33)	3,168 (6.42)	1,499 (1.79)	329 (1.47)
Chest/Stomach/ (Abdomen/Pelvis/ Internal	341 (2.37)	95 (3.16)	219 (2.49)	57 (2.66)	2,478 (1.17)	654 (1.32)	1,411 (1.68)	263 (1.18)
Back	320 (2.23)	65 (2.16)	80 (0.91)	19 (0.89)	5,358 (2.52)	1,315 (2.66)	985 (1.18)	223 (1.00)
Arm	454 (3.16)	114 (3.80)	136 (1.55)	23 (1.07)	4,936 (2.32)	1,089 (2.21)	987 (1.18)	155 (0.69)
Leg	742 (5.17)	135 (4.50)	286 (3.25)	48 (2.24)	6,746 (3.18)	1,241 (2.51)	1,344 (1.60)	206 (0.92)
Entire Body	239 (1.66)	38 (1.27)	181 (2.06)	24 (1.12)	1,515 (0.71)	249 (0.50)	905 (1.08)	145 (0.65)
Other	--	--	36 (0.41)	10 (0.47)	--	--	261 (0.31)	67 (0.30)
Unknown	--	--	19 (0.22)	5 (0.23)	--	--	132 (0.16)	30 (0.13)

Table A.30. Number and percent of non-belted (NB) and belted (SB) occupants in 1984 single and multi-vehicle accidents for New Jersey and Pennsylvania by injury severity, injury type, and injury location.

1984

	Single				Multi-Vehicle			
	NJ		PA		NJ		PA	
	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)
Injury Severity	NB	SB	NB	SB	NB	SB	NB	SB
Uninjured	24,538 (63.90)	5,780 (45.66)	18,430 (71.54)	5,657 (88.32)	168,809 (73.12)	40,929 (76.82)	59,518 (85.54)	17,222 (90.39)
Killed	153 (0.40)	5 (0.07)	334 (1.30)	17 (0.27)	199 (0.09)	18 (0.03)	382 (0.55)	31 (0.16)
Major Injury/Incap.	2,402 (3.65)	116 (1.52)	1,166 (4.53)	94 (1.47)	2,673 (1.16)	376 (0.71)	1,301 (1.87)	213 (1.12)
Moderate Injury	6,154 (16.03)	674 (8.82)	5,760 (22.36)	620 (9.68)	14,584 (6.32)	2,172 (4.08)	8,269 (11.87)	1,521 (7.98)
Complaint of Pain	6,152 (16.02)	1,064 (13.93)	--	--	44,601 (19.32)	9,782 (18.36)	--	--
Unknown Injury	--	--	71 (0.28)	17 (0.27)	--	--	195 (0.28)	67 (0.35)

Table A.30 (Con't)

1984

	Single				Multi-Vehicle			
	NJ		PA		NJ		PA	
	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)
Injury Type	NB	SB	NB	SB	NB	SB	NB	SB
Uninjured	24,538 (63.90)	5,780 (75.66)	18,430 (71.54)	5,657 (88.32)	168,809 (73.12)	40,929 (76.82)	59,518 (85.43)	17,222 (90.34)
Amputation	2 (0.01)	1 (0.01)	9 (0.03)	1 (0.02)	2 (0.00)	0 (0.00)	4 (0.01)	1 (0.01)
Concussion	216 (0.56)	20 (0.26)	349 (1.35)	33 (0.52)	513 (0.22)	63 (0.12)	441 (0.63)	47 (0.25)
Internal	283 (0.74)	20 (0.26)	--	--	461 (0.20)	77 (0.14)	--	--
Bleeding	5,086 (13.25)	507 (6.64)	3,012 (11.69)	246 (3.84)	9,698 (4.20)	1,215 (2.28)	3,259 (4.68)	414 (2.17)
Contusions/Bruises/ Abrasions	2,250 (5.86)	307 (4.02)	931 (3.61)	104 (1.62)	6,349 (2.75)	1,064 (2.00)	1,153 (1.66)	204 (1.07)
Burns	15 (0.04)	1 (0.01)	21 (0.08)	1 (0.02)	29 (9.01)	4 (0.01)	22 (0.03)	4 (0.02)
Fracture/Dislocation	541 (1.41)	45 (0.59)	1,131 (4.39)	94 (1.47)	864 (0.37)	120 (0.23)	1,193 (1.71)	193 (1.01)
Complaint of Pain	4,904 (12.77)	868 (11.36)	1,503 (5.83)	234 (3.65)	39,380 (17.06)	8,767 (16.46)	3,451 (4.95)	835 (4.38)
None Visible	564 (1.47)	90 (1.18)	323 (1.25)	25 (0.39)	4,779 (2.07)	1,038 (1.95)	526 (0.76)	109 (0.57)

Table A.30 (Con't)

1984

	Single				Multi-Vehicle			
	NJ		PA		NJ		PA	
	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)
Injury Location	NB	SB	NB	SB	NB	SB	NB	SB
Uninjured	24,538 (63.90)	5,780 (75.66)	18,430 (71.54)	5,657 (88.32)	168,809 (73.12)	40,929 (76.82)	59,518 (85.43)	17,222 (90.39)
Head	5,050 (13.15)	596 (7.80)	2,146 (8.33)	201 (3.14)	20,837 (9.03)	3,178 (5.97)	3,063 (4.40)	394 (2.07)
Face	3,140 (8.18)	300 (3.93)	130 (2.03)	130 (2.03)	5,909 (2.56)	808 (1.52)	1,791 (2.57)	221 (1.16)
Neck	273 (1.93)	160 (2.09)	442 (1.72)	66 (1.03)	11,909 (5.16)	3,316 (6.22)	1,200 (1.72)	289 (1.52)
Chest/Stomach/ (Abdomen/Pelvis/ Internal	699 (1.82)	135 (1.77)	699 (2.71)	63 (0.91)	2,849 (1.24)	759 (1.42)	937 (1.35)	257 (1.35)
Back	606 (1.58)	107 (1.40)	413 (1.60)	68 (1.06)	5,738 (2.49)	1,394 (2.62)	654 (0.94)	174 (0.91)
Arm	1,497 (3.90)	259 (3.39)	510 (1.98)	67 (1.05)	5,449 (2.36)	1,218 (2.29)	618 (0.89)	115 (0.60)
Entire Body	539 (1.40)	45 (0.59)	454 (1.76)	58) (0.91)	1,784 (0.77)	289 (0.54)	636 (0.91)	111 (0.58)
Leg	1,587 (4.13)	257 (3.36)	671 (2.60)	67 (1.05)	7,582 (3.28)	1,386 (2.60)	966 (1.39)	187 (0.98)
Unknown	--	--	48 (0.19)	10 (0.16)	--	--	103 (0.15)	25 (0.13)
Other	--	--	121 (0.47)	18 (0.28)	--	--	179 (0.26)	59 (0.31)

Table A.31. Number and percent of non-belted (NB) and belted (SB) occupants in 1984 accidents for New Jersey and Pennsylvania by ejection, injury severity, injury type, and injury location.

	1984							
	Not Ejected				Ejected			
	NJ		PA		NJ		PA	
	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)
Injury Severity	NB	SB	NB	SB	NB	SB	NB	SB
Uninjured	192,377 (71.99)	46,438 (76.70)	77,906 (82.66)	22,872 (90.05)	333 (27.07)	56 (44.80)	25 (2.71)	0 (0.00)
Killed	258 (0.10)	20 (0.03)	528 (0.56)	47 (0.19)	93 (7.56)	3 (2.40)	184 (19.91)	1 (3.33)
Major Injury/Incap.	3,827 (1.43)	483 (0.80)	2,127 (2.26)	299 (1.18)	237 (19.27)	7 (5.60)	298 (32.25)	8 (26.67)
Moderate Injury	20,402 (7.63)	2,824 (4.66)	13,426 (14.25)	2,101 (8.27)	294 (23.90)	17 (13.60)	415 (44.91)	21 (70.00)
Complaint of Pain	50,380 (18.85)	10,780 (17.80)	--	--	273 (22.20)	42 (33.60)	--	--
Unknown Injury	--	--	257 (0.27)	79 (0.31)	--	--	2 (0.22)	0 (0.00)

Table A.31 (Con't)

	1984							
	Not Ejected				Ejected			
	NJ		PA		NJ		PA	
	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)
Injury Type	NB	SB	NB	SB	NB	SB	NB	SB
Uninjured	102,377 (71.99)	46,438 (76.70)	77,906 (82.66)	22,872 (90.05)	333 (27.07)	56 (44.80)	25 (2.71)	0 (0.00)
Amputation	4 (0.00)	1 (0.00	10 (0.01)	2 (0.01)	0 (0.00)	0 (0.00)	3 (0.32)	0 (0.00)
Concussion	699 (0.26)	83 (0.14)	704 (0.75)	79 (0.31)	28 (2.28)	0 (0.00)	77 (8.33)	1 (3.33)
Internal	651 (0.24)	93 (0.15)	--	--	92 (7.48)	4 (3.20)	--	--
Bleeding	14,459 (5.41)	1,705 (2.82)	5,868 (6.23)	646 (2.54)	288 (23.41)	15 (12.00)	299 (32.36)	7 (23.33)
Contusions/Bruises/ Abrasions	8,450 (3.16)	1,362 (2.25)	1,969 (2.09)	302 (1.19)	131 (10.65)	8 (6.40)	80 (8.66)	3 (10.00)
Burns	44 (0.02)	5 (0.01)	37 (0.04)	5 (0.02)	0 (0.00)	0 (0.00)	5 (0.54)	0 (0.00)
Broken Bones	1,315 (0.49)	162 (0.27)	2,088 (2.22)	278 (1.09)	72 (5.85)	3 (2.40)	214 (23.16)	8 (26.67)
Complaint of Pain	43,935 (16.44)	9,576 (15.82)	4,778 (5.07)	1,054 (4.15)	266 (21.63)	35 (28.00)	121 (13.10)	8 (26.67)
None Visible	5,310 (1.99)	1,120 (1.85)	884 (0.94)	160 (0.63)	20 (1.63)	4 (3.20)	100 (10.82)	3 (10.00)

Table A.31 (Con't)

1984

	Not Ejected				Ejected			
	NJ		PA		NJ		PA	
	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)
Injury Location	NB	SB	NB	SB	NB	SB	NB	SB
Uninjured	192,377 (72.99)	46,438 (76.70)	77,906 (82.66)	22,872 (90.05)	333 (27.07)	56 (44.80)	25 (2.71)	0 (0.00)
Head	25,508 (9.54)	3,740 (6.18)	4,827 (5.12)	588 (2.32)	318 (25.85)	27 (21.60)	311 (33.66)	4 (13.33)
Face	8,956 (3.35)	1,104 (1.82)	3,459 (3.67)	342 (1.35)	70 (5.69)	3 (2.40)	96 (10.39)	4 (13.33)
Neck	12,562 (4.70)	3,456 (5.71)	1,578 (1.12)	352 (1.39)	60 (4.88)	14 (11.20)	51 (5.52)	1 (3.33)
Chest/Stomach/ Abdomen/Pelvis/ Internal	3,485 (1.31)	889 (1.47)	1,517 (1.61)	316 (1.23)	58 (4.71)	3 (2.40)	101 (10.93)	1 (3.33)
Back	6,266 (2.34)	1,492 (2.46)	995 (1.06)	240 (0.94)	69 (5.61)	6 (4.80	62 (6.71)	2 (6.67)
Arm	6,858 (2.57)	1,468 (2.42)	1,058 (1.12)	178 (0.70)	79 (6.42)	4 (3.20)	50 (5.41)	2 (6.67)
Leg	9,048 (3.39)	1,634 (2.70)	1,540 (1.63)	248 (0.97)	107 (8.70)	4 (3.20)	84 (9.09)	6 (20.00)
Entire Body	2,184 (0.82)	324 (0.54)	940 (1.00)	157 (0.62)	136 (11.06)	8 (6.40)	131 (14.18)	10 (33.33)
Other	--	--	284 (0.30)	76 (0.30)	--	--	9 (0.97)	0 (0.00)
Unknown	--	--	140 (0.15)	31 (0.12)	--	--	4 (0.43)	0 (0.00)

Table A.32. Number and percent of non-belted (NB) and belted (SB) occupants in 1984 accidents by occupant gender, injury severity, injury type, and injury location.

1984

	Male				Female			
	NJ		PA		NJ		PA	
	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)
Injury Severity	NB	SB	NB	SB	NB	SB	NB	SB
Uninjured	120,947 (76.68)	27,404 (80.81)	51,013 (84.17)	14,466 (91.79)	72,168 (64.86)	19,151 (71.40)	26,923 (77.35)	8,142 (86.74)
Killed	221 (0.14)	12 (0.04)	473 (0.78)	28 (0.18)	131 (0.12)	11 (0.04)	243 (0.70)	20 (0.21)
Major Injury/Incap.	2,189 (1.39)	249 (0.73)	1,476 (2.44)	161 (1.02)	1,885 (1.69)	243 (0.91)	991 (2.85)	146 (1.51)
Moderate Injury	11,251 (7.13)	1,435 (4.22)	7,499 (12.37)	1,060 (6.73)	9,481 (8.52)	1,408 (5.25)	6,528 (18.76)	1,081 (11.15)
Complaint of Pain	23,124 (14.66)	4,833 (14.21)	--	--	27,604 (24.81)	6,008 (22.40)	--	--
Unknown Injury	--	--	145 (0.24)	45 (0.29)	--	--	121 (0.35)	39 (0.40)

Table A.32 (Con't)

1984

	Male				Female			
	NJ		PA		NJ		PA	
	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)
Injury Type	NB	SB	NB	SB	NB	SB	NB	SB
Uninjured	120,947 (76.68)	27,494 (80.81)	51,013 (84.17)	14,466 (91.79)	72,168 (64.86)	19,151 (71.40)	26,923 (77.35)	8,412 (86.74)
Amputation	1 (0.00)	1 (0.00)	9 (0.01)	2 (0.01)	3 (0.00)	0 (0.00)	4 (0.01)	0 (0.00)
Concussion	372 (0.24)	41 (0.12)	404 (0.67)	39 (0.25)	357 (0.32)	42 (0.16)	386 (1.11)	41 (0.42)
Internal	444 (0.28)	51 (0.15)	--	--	300 (0.27)	46 (0.17)	--	--
Bleeding	8,902 (5.64)	1,004 (2.95)	3,935 (6.49)	404 (2.56)	5,878 (2.28)	714 (2.66)	2,335 (6.71)	256 (2.64)
Contusions/Bruises/ Abrasions	4,261 (2.70)	665 (1.95)	1,064 (1.76)	150 (0.95)	4,334 (3.90)	706 (2.63)	1,020 (2.93)	158 (1.63)
Burns	29 (0.02)	2 (0.01)	23 (0.04)	2 (0.01)	15 (0.01)	3 (0.01)	20 (0.06)	3 (0.03)
Broken Bones	717 (0.45)	71 (0.21)	1,261 (2.08)	146 (0.93)	669 (0.60)	94 (0.35)	1,063 (3.05)	141 (1.45)
Complaint of Pain	19,610 (12.43)	4,209 (12.37)	2,322 (3.83)	464 (2.94)	24,656 (22.16)	5,422 (20.22)	2,631 (7.56)	605 (6.24)
None Visible	2,449 (1.55)	485 (1.43)	491 (0.81)	66 (0.42)	2,889 (2.60)	643 (2.40)	68 (0.70)	2,889 (2.60)

Table A.32 (Con't)

1984

	Male				Female			
	NJ		PA		NJ		PA	
	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)
Injury Location	NB	SB	NB	SB	NB	SB	NB	SB
Uninjured	120,947 (76.68)	27,494 (80.81)	51,013 (84.17)	14,466 (91.79)	72,168 (64.86)	19,151 (71.40)	26,923 (77.35)	8,412 (86.74)
Head	12,518 (7.94)	1,700 (5.00)	2,935 (4.84)	328 (2.08)	13,355 (12.00)	2,071 (7.72)	2,274 (6.53)	267 (2.75)
Face	4,755 (3.01)	529 (1.55)	2,131 (3.52)	201 (1.28)	4,290 (3.86)	578 (2.16)	1,486 (4.27)	150 (1.55)
Neck	5,524 (3.50)	1,502 (4.41)	715 (1.18)	133 (0.84)	7,122 (6.40)	1,971 (7.35)	927 (2.66)	222 (2.29)
Chest/Stomach/ Abdomen/Pelvis/ Internal	1,786 (1.14)	375 (1.10)	1,014 (1.67)	165 (0.99)	1,761 (1.58)	519 (1.93)	621 (1.78)	165 (1.70)
Back	3,315 (2.10)	762 (2.24)	555 (0.92)	112 (0.71)	3,028 (2.72)	739 (2.76)	512 (1.47)	130 (1.34)
Arm	3,645 (2.31)	775 (2.28)	636 (1.05)	95 (0.60)	3,299 (2.96)	701 (2.61)	492 (1.41)	87 (0.90)
Leg	4,085 (2.59)	746 (2.19)	760 (1.25)	132 (0.84)	5,080 (4.57)	897 (3.34)	877 (2.52)	122 (1.26)
Entire Body	1,157 (0.73)	140 (0.41)	600 (0.99)	79 (0.50)	1,166 (1.05)	194 (0.72)	490 (1.41)	90 (0.93)
Other	--	--	162 (0.27)	41 (0.26)	--	--	138 (0.40)	36 (0.37)
Unknown	--	--	85 (0.14)	18 (0.11)	--	--	66 (0.19)	17 (0.18)

APPENDIX B

Data for Indiana

Table B.1. Number and percent of drivers in all accidents who were killed, injured or not injured across time periods (data for Figure 2.26).

INDIANA

Injury Severity	1985 Jan-Mar	1985 Apr-Jun	1985 July-Sept	1985 Oct-Dec	1986 Jan-Mar	1986 Apr-Jun	1986 July-Sept	1986 Oct-Dec	1987 Jan-Mar	1987 Apr-Jun	1987 July-Sept	1987 Oct-Dec	1988 Jan-Mar	1988 Apr-Jun	1988 July-Sept
Killed	89 (0.18)	97 (0.20)	86 (0.18)	136 (0.23)	71 (0.13)	99 (0.16)	120 (0.20)	109 (0.16)	84 (0.14)	117 (0.19)	98 (0.16)	111 (0.16)	91 (0.14)	102 (0.17)	116 (0.19)
Injured	6613 (13.28)	7035 (14.76)	7322 (15.34)	8676 (14.42)	6709 (12.25)	7808 (12.92)	8183 (13.46)	8994 (13.13)	7283 (12.50)	8250 (13.52)	7769 (12.89)	8662 (12.20)	7816 (12.24)	7821 (12.82)	8059 (13.27)
Not Injured	43113 (86.55)	40529 (85.04)	40315 (84.48)	51372 (85.36)	48006 (87.62)	52506 (86.91)	52514 (86.35)	59416 (86.71)	50877 (87.35)	52650 (86.29)	52417 (86.95)	62210 (87.64)	55940 (87.62)	53090 (87.01)	52578 (86.54)

Table B.2. Number and percent of drivers in all accidents with certain injury types across time periods (data for Figures 2.27 and 2.28).

INDIANA

Injury Type	1985 Jan-Mar	1985 Apr-Jun	1985 July-Sept	1985 Oct-Dec	1986 Jan-Mar	1986 Apr-Jun	1986 July-Sept	1986 Oct-Dec	1987 Jan-Mar	1987 Apr-Jun	1987 July-Sept	1987 Oct-Dec	1988 Jan-Mar	1988 Apr-Jun	1988 July-Sept
Bleeding	1735 (3.48)	1892 (3.97)	1932 (4.05)	2251 (3.74)	1764 (3.22)	2044 (3.38)	2115 (3.48)	2303 (3.36)	1876 (3.22)	1978 (3.24)	1877 (3.11)	2050 (2.89)	1857 (2.91)	1782 (2.92)	1950 (3.21)
Fracture/ Dislocation	318 (0.64)	330 (0.69)	414 (0.87)	415 (0.69)	307 (0.56)	345 (0.57)	391 (0.64)	411 (0.60)	313 (0.54)	384 (0.63)	376 (0.62)	393 (0.55)	355 (0.56)	379 (0.62)	326 (0.54)
Complaint of Pain	3183 (6.39)	3296 (6.92)	3377 (7.08)	4382 (7.28)	3324 (6.07)	3843 (6.36)	4051 (6.66)	4679 (6.83)	3740 (6.42)	4359 (7.14)	4146 (6.88)	4815 (6.78)	4311 (6.75)	4200 (6.88)	4314 (7.10)
Internal	169 (0.34)	191 (0.40)	222 (0.40)	210 (0.35)	168 (0.31)	186 (0.31)	224 (0.37)	209 (0.31)	188 (0.32)	203 (0.33)	217 (0.36)	211 (0.30)	184 (0.29)	188 (0.31)	234 (0.39)
Abrasion	516 (1.04)	621 (1.30)	681 (1.43)	598 (0.99)	421 (0.77)	641 (1.06)	677 (1.11)	562 (0.82)	472 (0.81)	614 (1.01)	563 (0.93)	498 (0.70)	441 (0.69)	590 (0.97)	588 (0.97)
Contusion/ Bruise	736 (1.48)	743 (1.56)	753 (1.58)	895 (1.49)	748 (1.37)	782 (1.29)	788 (1.30)	874 (1.28)	724 (1.24)	786 (1.29)	630 (1.05)	747 (1.05)	715 (1.12)	736 (1.21)	707 (1.16)

Table B.3. Number and percent of drivers in all accidents with certain injury locations across time periods (data for Figures 2.29 and 2.30).

INDIANA

Injury Location	1985 Jan-Mar	1985 Apr-Jun	1985 July-Sept	1985 Oct-Dec	1986 Jan-Mar	1986 Apr-Jun	1986 July-Sept	1986 Oct-Dec	1987 Jan-Mar	1987 Apr-Jun	1987 July-Sept	1987 Oct-Dec	1988 Jan-Mar	1988 Apr-Jun	1988 July-Sept
Face	1233 (2.48)	1156 (2.43)	1139 (2.39)	1530 (2.54)	1221 (2.23)	1271 (2.10)	1282 (2.11)	1603 (2.34)	1274 (2.19)	1139 (1.87)	1092 (1.81)	1467 (2.07)	1262 (1.98)	1101 (1.80)	1187 (1.95)
Head	2111 (4.24)	2014 (4.23)	2028 (4.25)	2694 (4.48)	2110 (3.85)	2267 (3.75)	2280 (3.75)	2606 (3.80)	2264 (3.89)	2331 (3.82)	1930 (3.20)	2345 (3.30)	2299 (3.60)	2057 (3.37)	2011 (3.31)
Neck	916 (1.84)	1036 (2.17)	1122 (2.35)	1310 (2.18)	1003 (1.83)	1318 (2.18)	1404 (2.31)	1494 (2.18)	1088 (1.87)	1495 (2.45)	1521 (2.52)	1607 (2.26)	1280 (2.00)	1435 (2.35)	1577 (2.60)
Back	423 (0.85)	446 (0.94)	523 (1.10)	587 (0.98)	430 (0.78)	501 (0.83)	546 (0.90)	628 (0.92)	475 (0.82)	586 (0.96)	547 (0.91)	587 (0.83)	514 (0.81)	529 (0.87)	578 (0.95)
Chest/Abd. Pelvis	473 (0.95)	498 (1.04)	567 (1.19)	651 (1.08)	496 (0.91)	562 (0.93)	640 (1.05)	717 (1.05)	593 (1.02)	634 (1.04)	721 (1.20)	759 (1.07)	710 (1.11)	725 (1.19)	764 (1.26)
Shoulder/ Upper Arm	223 (0.45)	356 (0.75)	352 (0.74)	322 (0.54)	250 (0.46)	390 (0.65)	388 (0.64)	343 (0.50)	266 (0.46)	399 (0.65)	425 (0.70)	341 (0.48)	318 (0.50)	401 (0.66)	445 (0.73)
Elbow/ Lower Arm/ Hand	415 (0.83)	577 (1.21)	628 (1.32)	517 (0.86)	399 (0.73)	544 (0.90)	636 (1.05)	557 (0.81)	428 (0.73)	578 (0.95)	588 (0.98)	512 (0.72)	456 (0.71)	562 (0.92)	553 (0.91)
Knee/ Lower Leg/ Foot	588 (1.18)	669 (1.40)	728 (1.53)	775 (1.29)	586 (1.07)	686 (1.14)	741 (1.22)	766 (1.12)	668 (1.15)	789 (1.29)	655 (1.09)	759 (1.07)	700 (1.10)	734 (1.20)	629 (1.04)

Table B.4. Number and percent of drivers in all accidents with bleeding or serious (A+K) injuries across time periods (data for Figure 2.28).

INDIANA

Injury	1985 Jan-Mar	1985 Apr-Jun	1985 July-Sept	1985 Oct-Dec	1986 Jan-Mar	1986 Apr-Jun	1986 July-Sept	1986 Oct-Dec	1987 Jan-Mar	1987 Apr-Jun	1987 July-Sept	1987 Oct-Dec	1988 Jan-Mar	1988 Apr-Jun	1988 July-Sept
A+K	891 (1.79)	950 (1.99)	1028 (2.15)	1119 (1.86)	891 (1.63)	1026 (1.69)	1099 (1.81)	1147 (1.67)	919 (1.57)	1023 (1.67)	1012 (1.68)	1077 (1.52)	970 (1.52)	964 (1.58)	969 (1.59)
Bleeding	1735 (3.48)	1892 (3.97)	1932 (4.05)	2251 (3.74)	1764 (3.22)	2044 (3.38)	2115 (3.48)	2303 (3.36)	1876 (3.22)	1978 (3.24)	1877 (3.11)	2050 (2.89)	1857 (2.91)	1782 (2.92)	1950 (3.21)

Table B.5. Number and percent of drivers in rollover accidents with bleeding or serious (A+K) injuries across time periods (data for Figure 2.31).

INDIANA

	1985				1986				1987				1988		
Injury	Jan-Mar	Apr-Jun	July-Sept	Oct-Dec	Jan-Mar	Apr-Jun	July-Sept	Oct-Dec	Jan-Mar	Apr-Jun	July-Sept	Oct-Dec	Jan-Mar	Apr-Jun	July-Sept
A+K	43 (6.84)	72 (10.70)	101 (13.65)	60 (8.45)	48 (7.04)	73 (9.57)	80 (10.04)	79 (9.04)	62 (7.71)	86 (10.32)	92 (11.26)	91 (8.96)	69 (8.16)	110 (11.54)	84 (9.89)
Bleeding	69 (10.97)	123 (18.28)	129 (17.43)	82 (11.55)	86 (12.61)	105 (13.76)	115 (14.43)	101 (11.56)	108 (13.42)	126 (15.13)	120 (14.69)	114 (11.23)	87 (10.30)	127 (13.33)	112 (13.18)

Table B.6. Number and percent of drivers in non-rollover accidents with bleeding or serious (A+K) injuries across time periods (data for Figure 2.32).

INDIANA

Injury	1985 Jan-Mar	1985 Apr-Jun	1985 July-Sept	1985 Oct-Dec	1986 Jan-Mar	1986 Apr-Jun	1986 July-Sept	1986 Oct-Dec	1987 Jan-Mar	1987 Apr-Jun	1987 July-Sept	1987 Oct-Dec	1988 Jan-Mar	1988 Apr-Jun	1988 July-Sept
A+K	845 (1.72)	873 (1.87)	923 (1.98)	1047 (1.77)	839 (1.59)	948 (1.63)	1016 (1.73)	1063 (1.61)	855 (1.52)	931 (1.58)	918 (1.58)	984 (1.43)	899 (1.46)	852 (1.45)	822 (1.50)
Bleeding	1661 (3.40)	1757 (3.76)	1794 (3.85)	2152 (3.64)	1675 (3.17)	1932 (3.32)	1993 (3.39)	2191 (3.32)	1762 (3.14)	1846 (3.13)	1754 (3.01)	1932 (2.82)	1766 (2.86)	1650 (2.80)	1834 (3.12)

Table B.7. Number and percent of uninjured drivers in rollover and non-rollover accidents across time periods (data for Figure 2.33).

INDIANA

Uninjured	1985 Jan-Mar	1985 Apr-Jun	1985 July-Sept	1985 Oct-Dec	1986 Jan-Mar	1986 Apr-Jun	1986 July-Sept	1986 Oct-Dec	1987 Jan-Mar	1987 Apr-Jun	1987 July-Sept	1987 Oct-Dec	1988 Jan-Mar	1988 Apr-Jun	1988 July-Sept
Non-Rollover Uninjured	42487 (86.88)	39963 (85.62)	39704 (85.10)	50647 (85.68)	46298 (87.70)	50697 (87.11)	50825 (86.55)	57319 (86.84)	49222 (87.59)	51021 (86.57)	50839 (87.22)	60181 (87.88)	54153 (87.78)	51430 (87.39)	51033 (86.84)
Rollover Uninjured	375 (59.62)	288 (42.79)	321 (43.38)	404 (56.90)	413 (60.56)	387 (50.72)	412 (51.69)	494 (56.52)	433 (53.79)	407 (48.86)	412 (50.43)	566 (55.76)	496 (58.70)	464 (48.69)	423 (49.76)

Table B.8. Number and percent of drivers in rollover accidents with certain injury locations across time periods (data for Figures 2.34 and 2.36).

INDIANA

Injury Location	1985 Jan-Mar	1985 Apr-Jun	1985 July-Sept	1985 Oct-Dec	1986 Jan-Mar	1986 Apr-Jun	1986 July-Sept	1986 Oct-Dec	1987 Jan-Mar	1987 Apr-Jun	1987 July-Sept	1987 Oct-Dec	1988 Jan-Mar	1988 Apr-Jun	1988 July-Sept
Face	28 (4.45)	42 (6.24)	49 (6.62)	37 (5.21)	44 (6.45)	38 (4.98)	28 (3.51)	37 (4.23)	44 (5.47)	42 (5.04)	37 (4.53)	50 (4.93)	39 (4.62)	53 (5.56)	42 (4.94)
Head	82 (13.04)	83 (12.33)	83 (11.22)	82 (11.55)	67 (9.82)	79 (10.35)	106 (13.30)	105 (12.01)	105 (13.04)	110 (13.21)	103 (12.61)	120 (11.82)	100 (11.83)	115 (12.07)	83 (9.76)
Neck	18 (2.86)	29 (4.31)	34 (4.59)	27 (3.80)	26 (3.81)	32 (4.19)	34 (4.28)	30 (3.43)	36 (4.47)	39 (4.68)	41 (5.02)	60 (5.92)	34 (4.02)	45 (4.72)	46 (5.41)
Back	29 (4.61)	39 (5.79)	40 (5.41)	27 (3.80)	17 (2.49)	33 (4.33)	36 (4.52)	39 (4.46)	37 (4.60)	41 (4.92)	26 (3.18)	41 (4.04)	30 (3.55)	55 (5.77)	36 (4.24)
Chest/Abd. Pelvis	15 (2.38)	17 (2.53)	34 (4.59)	16 (2.25)	19 (2.79)	26 (3.41)	31 (3.89)	32 (3.66)	39 (4.84)	29 (3.48)	34 (4.16)	33 (3.25)	25 (2.96)	37 (3.88)	39 (4.59)
Shoulder/ Upper Arm	18 (2.86)	45 (6.69)	41 (5.54)	32 (4.51)	19 (2.79)	39 (5.11)	34 (4.27)	38 (4.35)	26 (3.23)	41 (4.92)	43 (5.26)	34 (3.35)	25 (2.96)	37 (3.88)	50 (5.88)

Table B.9. Number and percent of drivers in non-rollover accidents with certain injury locations across time periods (data for Figures 2.35 and 2.37).

INDIANA

	1985				1986				1987				1988		
Injury Location	Jan-Mar	Apr-Jun	July-Sept	Oct-Dec	Jan-Mar	Apr-Jun	July-Sept	Oct-Dec	Jan-Mar	Apr-Jun	July-Sept	Oct-Dec	Jan-Mar	Apr-Jun	July-Sept
Face	1197 (2.45)	1101 (2.36)	1082 (2.32)	1481 (2.51)	1171 (2.22)	1225 (2.10)	1248 (2.13)	1559 (2.36)	1226 (2.18)	1092 (1.85)	1052 (1.80)	1413 (2.06)	1221 (1.98)	1046 (1.78)	1144 (1.95)
Head	2021 (4.13)	1928 (4.13)	1936 (4.15)	2598 (4.40)	2040 (3.86)	2182 (3.75)	2171 (3.70)	2493 (3.78)	2154 (3.83)	2213 (3.76)	1823 (3.13)	2220 (3.24)	2195 (3.56)	1939 (3.29)	1922 (3.27)
Neck	896 (1.83)	1003 (2.15)	1086 (2.33)	1276 (2.16)	977 (1.85)	1284 (2.21)	1369 (2.33)	1462 (2.21)	1051 (1.87)	1454 (2.47)	1477 (2.53)	1544 (2.25)	1246 (2.02)	1389 (2.36)	1529 (2.60)
Back	392 (0.80)	403 (0.86)	480 (1.03)	557 (0.94)	412 (0.78)	468 (0.80)	508 (0.87)	588 (0.89)	437 (0.78)	542 (0.92)	520 (0.89)	544 (0.79)	483 (0.78)	470 (0.80)	542 (0.92)
Chest/Abd. Pelvis	457 (0.93)	480 (1.03)	529 (1.13)	633 (1.07)	473 (0.90)	533 (0.92)	607 (1.03)	681 (1.03)	552 (0.98)	602 (1.02)	687 (1.18)	722 (1.05)	679 (1.10)	688 (1.17)	723 (1.23)
Shoulder/ Upper Arm	205 (0.42)	310 (0.66)	310 (0.66)	290 (0.49)	231 (0.44)	349 (0.60)	354 (0.60)	303 (0.46)	240 (0.43)	356 (0.60)	381 (0.65)	306 (0.45)	291 (0.47)	363 (0.62)	395 (0.67)
Elbow/ Lower Arm/ Hand	381 (0.78)	504 (1.08)	547 (1.17)	481 (0.81)	361 (0.68)	477 (0.82)	575 (0.98)	516 (0.78)	383 (0.68)	512 (0.87)	522 (0.90)	459 (0.67)	411 (0.67)	488 (0.83)	490 (0.83)
Knee/ Lower Leg/ Foot	564 (1.15)	641 (1.37)	689 (1.48)	744 (1.26)	560 (1.06)	648 (1.11)	704 (1.20)	728 (1.10)	638 (1.14)	753 (1.28)	626 (1.07)	732 (1.07)	672 (1.09)	689 (1.17)	590 (1.00)

Table B.10. Number and percent of drivers in head-on accidents with bleeding or serious (A+K) injuries across time periods (data for Figure 2.38).

INDIANA

Injury	1985 Jan-Mar	1985 Apr-Jun	1985 July-Sept	1985 Oct-Dec	1986 Jan-Mar	1986 Apr-Jun	1986 July-Sept	1986 Oct-Dec	1987 Jan-Mar	1987 Apr-Jun	1987 July-Sept	1987 Oct-Dec	1988 Jan-Mar	1988 Apr-Jun	1988 July-Sept
A+K	207 (5.13)	199 (6.50)	208 (7.26)	243 (5.31)	171 (4.63)	203 (6.14)	204 (6.07)	232 (5.34)	205 (5.39)	176 (5.50)	179 (5.54)	209 (4.49)	247 (6.09)	193 (6.07)	204 (6.25)
Bleeding	380 (9.41)	365 (11.92)	343 (11.98)	476 (10.39)	318 (8.61)	339 (10.25)	366 (10.90)	407 (9.37)	376 (9.88)	303 (9.48)	300 (9.29)	361 (7.75)	356 (8.76)	288 (9.05)	342 (10.47)

Table B.11. Number and percent of drivers in non-head-on accidents with bleeding or serious (A+K) injuries across time periods (data for Figure 2.39).

INDIANA

Injury	1985 Jan-Mar	1985 Apr-Jun	1985 July-Sept	1985 Oct-Dec	1986 Jan-Mar	1986 Apr-Jun	1986 July-Sept	1986 Oct-Dec	1987 Jan-Mar	1987 Apr-Jun	1987 July-Sept	1987 Oct-Dec	1988 Jan-Mar	1988 Apr-Jun	1988 July-Sept
A+K	670 (1.50)	725 (1.67)	787 (1.80)	846 (1.56)	706 (1.48)	788 (1.46)	871 (1.61)	891 (1.48)	683 (1.33)	819 (1.50)	811 (1.50)	847 (1.35)	709 (1.26)	743 (1.36)	736 (1.35)
Bleeding	1330 (2.97)	1484 (3.40)	1539 (3.52)	1734 (3.20)	1418 (2.96)	1658 (3.09)	1697 (3.13)	1852 (3.08)	1456 (2.85)	1637 (3.00)	1539 (2.86)	1649 (2.63)	1469 (2.60)	1441 (2.64)	1572 (2.89)

Table B.12. Number and percent of uninjured drivers in head-on and non-head-on accidents across time periods (data for Figure 2.40).

INDIANA

Uninjured	1985 Jan-Mar	Apr-Jun	July-Sept	Oct-Dec	1986 Jan-Mar	Apr-Jun	July-Sept	Oct-Dec	1987 Jan-Mar	Apr-Jun	July-Sept	Oct-Dec	1988 Jan-Mar	Apr-Jun	July-Sept
Non-Head-On Uninjured	39252 (87.63)	37509 (86.06)	37401 (85.45)	46791 (86.30)	42058 (87.93)	46814 (87.23)	46954 (86.74)	52412 (87.05)	44944 (87.89)	47177 (86.48)	47042 (87.27)	54961 (87.82)	49784 (88.10)	47725 (87.32)	47384 (87.01)
Head-On Uninjured	2978 (73.75)	2164 (70.67)	1986 (69.39)	3380 (73.78)	2795 (75.68)	2414 (73.02)	2388 (71.13)	3218 (74.08)	2779 (73.02)	2351 (73.56)	2371 (73.38)	3655 (78.48)	2982 (73.41)	2349 (73.80)	2308 (70.65)

Table B.13. Number and percent of drivers in head-on accidents with certain injury locations across time periods (data for Figures 2.41 and 2.43).

INDIANA

Injury Location	1985 Jan-Mar	1985 Apr-Jun	1985 July-Sept	1985 Oct-Dec	1986 Jan-Mar	1986 Apr-Jun	1986 July-Sept	1986 Oct-Dec	1987 Jan-Mar	1987 Apr-Jun	1987 July-Sept	1987 Oct-Dec	1988 Jan-Mar	1988 Apr-Jun	1988 July-Sept
Face	308 (7.63)	249 (8.13)	209 (7.30)	362 (7.90)	265 (7.18)	261 (7.89)	272 (8.10)	335 (7.71)	302 (7.93)	214 (6.70)	208 (6.44)	277 (5.95)	267 (6.57)	212 (6.66)	236 (7.22)
Head	339 (8.40)	259 (8.46)	282 (9.85)	357 (7.79)	254 (6.88)	260 (7.86)	300 (8.94)	297 (6.84)	301 (7.91)	256 (8.01)	235 (7.27)	289 (6.21)	302 (7.43)	238 (7.48)	247 (7.56)
Neck	79 (1.96)	45 (1.47)	64 (2.24)	80 (1.75)	71 (1.92)	57 (1.72)	63 (1.88)	90 (2.07)	69 (1.81)	69 (2.16)	61 (1.89)	91 (1.95)	95 (2.34)	65 (2.04)	83 (2.54)
Back	31 (0.77)	26 (0.85)	32 (1.12)	39 (0.85)	38 (1.03)	28 (0.85)	26 (0.77)	41 (0.94)	38 (1.00)	18 (0.56)	31 (0.96)	30 (0.64)	30 (0.74)	26 (0.82)	33 (1.01)
Chest/Abd. Pelvis	76 (1.88)	91 (2.97)	71 (2.48)	111 (2.42)	75 (2.03)	77 (2.33)	98 (2.92)	116 (2.67)	101 (2.65)	68 (2.13)	114 (3.53)	113 (2.43)	134 (3.30)	96 (3.02)	134 (4.10)
Shoulder/ Upper Arm	19 (0.47)	33 (1.08)	31 (1.08)	15 (0.33)	25 (0.68)	35 (1.06)	27 (0.80)	29 (0.67)	27 (0.71)	36 (1.13)	33 (1.02)	22 (0.47)	32 (0.79)	29 (0.91)	42 (1.27)
Elbow/ Lower Arm/ Hand	60 (1.49)	68 (2.22)	61 (2.13)	70 (1.53)	43 (1.16)	51 (1.54)	61 (1.82)	66 (1.52)	49 (1.29)	49 (1.53)	56 (1.73)	57 (1.22)	58 (1.43)	40 (1.26)	68 (2.08)
Knee/ Lower Leg/ Foot	103 (2.55)	80 (2.61)	94 (3.28)	116 (2.53)	100 (2.71)	83 (2.51)	82 (2.44)	107 (2.46)	99 (2.60)	81 (2.53)	73 (2.26)	80 (1.72)	112 (2.76)	80 (2.51)	64 (1.96)

Table B.14. Number and percent of drivers in non-head-on accidents with certain injury locations across time periods (data for Figures 2.42 and 2.44).

INDIANA

Injury Location	1985 Jan-Mar	1985 Apr-Jun	1985 July-Sept	1985 Oct-Dec	1986 Jan-Mar	1986 Apr-Jun	1986 July-Sept	1986 Oct-Dec	1987 Jan-Mar	1987 Apr-Jun	1987 July-Sept	1987 Oct-Dec	1988 Jan-Mar	1988 Apr-Jun	1988 July-Sept
Face	909 (2.03)	883 (2.03)	903 (2.06)	1141 (2.10)	936 (1.96)	988 (1.84)	983 (1.82)	1241 (2.06)	936 (1.83)	906 (1.66)	861 (1.60)	1171 (1.87)	977 (1.73)	872 (1.60)	930 (1.71)
Head	1742 (3.89)	1718 (3.94)	1714 (3.92)	2294 (4.23)	1828 (3.82)	1957 (3.65)	1940 (3.58)	2262 (3.76)	1929 (3.77)	2042 (3.74)	1660 (3.08)	2005 (3.20)	1968 (3.48)	1774 (3.25)	1728 (3.17)
Neck	825 (1.84)	972 (2.23)	1043 (2.38)	1207 (2.23)	914 (1.91)	1242 (2.31)	1328 (2.45)	1384 (2.30)	1007 (1.97)	1404 (2.57)	1438 (2.67)	1496 (2.39)	1171 (2.07)	1354 (2.48)	1481 (2.72)
Back	383 (0.86)	409 (0.94)	477 (1.09)	526 (0.97)	384 (0.80)	464 (0.86)	510 (0.94)	576 (0.96)	428 (0.84)	559 (1.02)	506 (0.94)	544 (0.87)	479 (0.85)	485 (0.89)	533 (0.98)
Chest/Abd. Pelvis	387 (0.86)	397 (0.91)	481 (1.10)	527 (0.97)	412 (0.86)	479 (0.89)	533 (0.98)	591 (0.98)	480 (0.94)	553 (1.01)	598 (1.11)	636 (1.02)	570 (1.01)	623 (1.14)	616 (1.13)
Shoulder/ Upper Arm	200 (0.45)	309 (0.71)	309 (0.71)	297 (0.55)	218 (0.46)	343 (0.64)	349 (0.64)	306 (0.51)	230 (0.45)	351 (0.64)	378 (0.70)	315 (0.50)	282 (0.50)	358 (0.65)	394 (0.72)
Elbow/ Lower Arm/ Hand	349 (0.78)	483 (1.11)	544 (1.24)	424 (0.78)	348 (0.73)	472 (0.88)	550 (1.02)	474 (0.79)	365 (0.71)	512 (0.94)	512 (0.95)	441 (0.70)	385 (0.68)	499 (0.91)	475 (0.87)
Knee/ Lower Leg/ Foot	477 (1.06)	576 (1.32)	618 (1.41)	648 (1.20)	477 (1.00)	583 (1.09)	648 (1.20)	633 (1.05)	553 (1.08)	694 (1.27)	573 (1.06)	670 (1.07)	580 (1.03)	642 (1.17)	551 (1.01)

Table B.15. Number and percent of drivers in single vehicle accidents with bleeding and serious (A+K) injuries across time periods (data for Figure 2.45).

INDIANA

	1985				1986				1987				1988		
Injury	Jan-Mar	Apr-Jun	July-Sept	Oct-Dec	Jan-Mar	Apr-Jun	July-Sept	Oct-Dec	Jan-Mar	Apr-Jun	July-Sept	Oct-Dec	Jan-Mar	Apr-Jun	July-Sept
A+K	316 (4.05)	401 (5.63)	416 (5.92)	440 (4.21)	377 (4.03)	429 (5.03)	439 (5.24)	455 (3.90)	337 (3.66)	417 (4.80)	412 (4.99)	456 (3.69)	399 (3.70)	391 (4.56)	415 (5.09)
Bleeding	641 (8.21)	695 (9.75)	706 (10.05)	823 (7.86)	655 (7.01)	753 (8.83)	776 (9.28)	837 (7.17)	699 (7.59)	696 (8.00)	663 (8.03)	817 (6.62)	721 (6.69)	668 (7.80)	725 (8.89)

Table B.16. Number and percent of drivers in multi-vehicle accidents with bleeding or serious (A+K) injuries across time periods (data for Figure 2.46).

INDIANA

	1985				1986				1987				1988		
Injury	Jan-Mar	Apr-Jun	July-Sept	Oct-Dec	Jan-Mar	Apr-Jun	July-Sept	Oct-Dec	Jan-Mar	Apr-Jun	July-Sept	Oct-Dec	Jan-Mar	Apr-Jun	July-Sept
A+K	575 (1.37)	549 (1.35)	612 (1.51)	679 (1.36)	514 (1.13)	597 (1.15)	660 (1.26)	692 (1.22)	582 (1.19)	606 (1.16)	600 (1.15)	621 (1.06)	571 (1.08)	573 (1.09)	554 (1.05)
Bleeding	1094 (2.60)	1197 (2.95)	1226 (3.01)	1428 (2.87)	1109 (2.44)	1291 (2.49)	1339 (2.55)	1466 (2.58)	1177 (2.40)	1282 (2.45)	1214 (2.33)	1233 (2.10)	1136 (2.14)	1114 (2.12)	1225 (2.33)

Table B.17. Number and percent of uninjured drivers in single and multi-vehicle accidents across time periods (data for Figure 2.47).

INDIANA

	1985				1986				1987				1988		
Crash Type	Jan-Mar	Apr-Jun	July-Sept	Oct-Dec	Jan-Mar	Apr-Jun	July-Sept	Oct-Dec	Jan-Mar	Apr-Jun	July-Sept	Oct-Dec	Jan-Mar	Apr-Jun	July-Sept
Multi-Vehicle Uninjured	37097 (88.32)	35290 (87.06)	35247 (86.61)	43255 (87.02)	40606 (89.35)	46006 (88.67)	46192 (88.06)	50143 (88.21)	43625 (88.97)	45966 (87.85)	46086 (88.58)	52254 (89.11)	47378 (89.27)	46443 (88.55)	46479 (88.37)
Single Vehicle Uninjured	6016 (77.02)	5239 (73.52)	5068 (72.12)	8117 (77.48)	7400 (79.22)	6500 (76.21)	6322 (75.59)	9273 (79.43)	7252 (78.74)	6684 (76.87)	6331 (76.70)	9956 (80.66)	8562 (79.45)	6647 (77.62)	6099 (74.78)

Table B.18. Number and percent of drivers in single vehicle accidents with certain injury locations across time periods (data for Figures 2.48 and 2.50).

INDIANA

Injury Location	1985				1986				1987				1988		
	Jan-Mar	Apr-Jun	July-Sept	Oct-Dec	Jan-Mar	Apr-Jun	July-Sept	Oct-Dec	Jan-Mar	Apr-Jun	July-Sept	Oct-Dec	Jan-Mar	Apr-Jun	July-Sept
Face	471 (6.03)	474 (6.65)	451 (6.42)	624 (5.96)	499 (5.34)	526 (6.17)	493 (5.89)	673 (5.76)	526 (5.71)	446 (5.13)	437 (5.29)	615 (4.98)	543 (5.04)	457 (5.34)	478 (5.86)
Head	596 (7.63)	513 (7.20)	538 (7.66)	749 (7.15)	615 (6.58)	582 (6.82)	588 (7.03)	643 (5.51)	598 (6.49)	589 (6.77)	522 (6.32)	667 (5.40)	665 (6.17)	503 (5.87)	513 (6.29)
Neck	120 (1.54)	124 (1.74)	113 (1.61)	165 (1.58)	135 (1.45)	127 (1.49)	128 (1.53)	197 (1.69)	133 (1.44)	157 (1.81)	153 (1.85)	197 (1.60)	194 (1.80)	142 (1.66)	180 (2.21)
Back	85 (1.09)	95 (1.33)	104 (1.48)	120 (1.15)	103 (1.10)	86 (1.01)	105 (1.26)	134 (1.15)	112 (1.22)	111 (1.28)	98 (1.19)	136 (1.10)	122 (1.13)	106 (1.24)	111 (1.36)
Chest/Abd. Pelvis	130 (1.66)	140 (1.96)	168 (2.39)	163 (1.56)	133 (1.42)	137 (1.61)	154 (1.84)	205 (1.76)	156 (1.69)	155 (1.78)	164 (1.99)	185 (1.50)	175 (1.62)	148 (1.73)	181 (2.22)
Shoulder/ Upper Arm	62 (0.79)	108 (1.52)	112 (1.59)	82 (0.78)	84 (0.90)	127 (1.49)	97 (1.16)	98 (0.84)	76 (0.83)	100 (1.15)	110 (1.33)	107 (0.87)	95 (0.88)	107 (1.25)	138 (1.69)

Table B.19. Number and percent of drivers in multi-vehicle accidents with certain injury locations across time periods (data for Figures 2.49 and 2.51).

INDIANA

Injury Location	1985 Jan-Mar	1985 Apr-Jun	1985 July-Sept	1985 Oct-Dec	1986 Jan-Mar	1986 Apr-Jun	1986 July-Sept	1986 Oct-Dec	1987 Jan-Mar	1987 Apr-Jun	1987 July-Sept	1987 Oct-Dec	1988 Jan-Mar	1988 Apr-Jun	1988 July-Sept
Face	762 (1.81)	682 (1.68)	688 (1.69)	906 (1.82)	722 (1.59)	745 (1.44)	789 (1.50)	930 (1.64)	748 (1.53)	693 (1.32)	655 (1.26)	852 (1.45)	719 (1.35)	644 (1.23)	709 (1.35)
Head	1515 (3.61)	1501 (3.70)	1490 (3.66)	1945 (3.91)	1495 (3.29)	1685 (3.25)	1692 (3.23)	1963 (3.45)	1666 (3.40)	1742 (3.33)	1408 (2.71)	1678 (2.86)	1634 (3.08)	1554 (2.96)	1498 (2.85)
Neck	796 (1.90)	912 (2.25)	1009 (2.48)	1145 (2.30)	868 (1.91)	1191 (2.30)	1276 (2.43)	1297 (2.28)	955 (1.95)	1338 (2.56)	1368 (2.63)	1410 (2.40)	1086 (2.05)	1293 (2.47)	1397 (2.66)
Back	338 (0.80)	351 (0.87)	419 (1.03)	467 (0.94)	327 (0.72)	415 (0.80)	441 (0.84)	494 (0.87)	363 (0.74)	475 (0.91)	449 (0.86)	451 (0.77)	392 (0.74)	423 (0.81)	467 (0.89)
Chest/Abd. Pelvis	343 (0.82)	358 (0.88)	399 (0.98)	488 (0.98)	363 (0.80)	425 (0.82)	486 (0.93)	512 (0.90)	437 (0.89)	479 (0.92)	557 (1.07)	574 (0.98)	535 (1.01)	577 (1.10)	583 (1.11)
Shoulder/ Upper Arm	161 (0.38)	248 (0.61)	240 (0.59)	240 (0.48)	166 (0.37)	263 (0.51)	291 (0.55)	245 (0.43)	190 (0.39)	299 (0.57)	315 (0.61)	234 (0.40)	223 (0.42)	294 (0.56)	307 (0.58)
Elbow/ Lower Arm/ Hand	286 (0.68)	389 (0.96)	412 (1.01)	335 (0.67)	259 (0.57)	368 (0.71)	416 (0.79)	391 (0.69)	303 (0.62)	403 (0.77)	403 (0.77)	316 (0.54)	308 (0.58)	372 (0.71)	370 (0.70)
Knee/ Lower Leg/ Foot	462 (1.10)	525 (1.30)	563 (1.38)	597 (1.20)	453 (1.00)	523 (1.01)	577 (1.10)	589 (1.04)	520 (1.06)	629 (1.20)	505 (0.97)	602 (1.03)	525 (0.99)	556 (1.06)	486 (0.92)