UM-HSRI-81-55

OCCUPANT SURVIVABILITY IN HEAVY-TRUCK CRASHES

Brian Wolf
Kenneth L. Campbell
James O'Day

NOVEMBER 1981

THE UNIVERSITY OF MICHIGAN
HIGHWAY SAFETY RESEARCH INSTITUTE

UM-HSRI-81-55

MVMA-1164

OCCUPANT SURVIVABILITY IN HEAVY-TRUCK CRASHES

Brian Wolf
Kenneth L. Campbell
James O'Day

The University of Michigan
HIGHWAY SAFETY RESEARCH INSTITUTE
Ann Arbor, Michigan 48109

November 1981

The research reported herein was conducted under general research funds provided by the Motor Vehicle Manufacturers Association, the Western Highway Institute, and the American Trucking Associations. The opinions, findings, and conclusions expressed in this publication are not necessarily those of the MVMA, WHI, or ATA.

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
UM-HSRI-81-55		

4. Title and Subtitle	5. Report Date
Occupant Survivability in Large-Truck Crashes	November 1981
	6. Performing Organization Code
7. Author(s) Brian Wolf, Kenneth L. Campbell, and James O'Day	8. Performing Organization Report No. UM-HSRI-81-55
9. Performing Organization Name and Address Highway Safety Research Institute The University of Michigan Ann Arbor, Michigan 48109	10. Work Unit No. (TRAIS) 11. Contract or Grant No.
12. Sponsoring Agency Name and Address Motor Vehicle Manufacturers Association 320 New Center Building Detroit, Michigan 48202	13. Type of Report and Period Covered Special 14. Sponsoring Agency Code #1164

15. Supplementary Notes

16. Abstract

Rollover and ejection are associated with heavy-truck occupant fatalities about twice as frequently as for passenger-car occupant fatalities. A panel reviewed 41 in-depth cases to assess the possible effectiveness of restraint use and the contribution of rollover and ejection to the fatal injuries. The panel's responses indicated that belt use was expected to be particularly effective in preventing fatalities resulting from occupant ejection.

The effectiveness of FMVSS 206, which required stronger door latches, seems to be reflected in lower ejection rates for 1972 and newer model year heavy trucks.

17. Key Words	18. Distribution Statement

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
		34	

ACKNOWLEDGEMENTS

This study used data collected as part of the Multi-Disciplinary Accident Investigation (MDAI) program that was funded by the National Highway Traffic Safety Administration (NHTSA), the Motor Vehicle Manufacturers Association, (MVMA), and the Canadian Department of Transportation. The authors wish to acknowledge the sponsors of this program, as well as the various teams throughout the United States and Canada that carried out these detailed investigations.

The authors of this report would also like to thank each of the review panel members for their contribution to this project. The panel members were:

Peter Cooley
Donald F. Huelke
Wendell E. Young
Brian Wolf
Kenneth L. Campbell
James O'Day

Acknowledgement is also due John Pachuta, of the Pennsylvania Department of Transportation, who provided the Institute with computerized accident data.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

SUMMARY

The results of this preliminary review indicate that the proportion of heavy-truck occupant fatalities associated with rollover and/or ejection is about double that for fatally injured occupants of passenger cars. For those cases involving ejection, the review panel felt that restraint use would be effective in improving the chances of survival. For example, 53 percent of the review panel responses indicated a 60 percent or greater chance of survival for lap belt use in cases involving ejection and 63 percent of the responses indicated a 60 percent or greater chance of survival for lap and shoulder belt use. However, the estimated effectiveness of restraints was much lower for fatalities not involving ejection. Only 10 percent of the responses indicated a 60 percent or greater chance of survival with lap belt use and 17 percent of the responses indicated a 60 percent or greater chance of survival for lap and shoulder belt use. In general, the fatalities not involving ejection frequently involved substantial damage to the passenger compartment.

A review of the proportion of ejections by model year indicated that 1972 model year and newer heavy trucks have about 20 percent fewer ejections. Ejection through the doors was reduced by 80 percent. This difference seems to reflect the effectiveness of FMVSS 206, which required stronger door latches.

1. INTRODUCTION

This report reviews the potential for survival among occupants of heavy trucks (combination vehicles and single-unit trucks having a Gross Vehicle Weight greater than 26,000 pounds) in highway crashes. In 1979, the National Highway Traffic Safety Administration (NHTSA) Fatal Accident Reporting System (FARS) recorded approximately 1100 heavy-truck occupant fatalities. More than two-thirds of these fatalities were associated with rollover and/or ejection. By comparison, rollover and/or ejection were associated with only about one-third of all passenger-car occupant fatalities. Tables 1 and 2 show the one-year totals of occupant fatalities involving rollover and ejection for passenger cars and heavy trucks, respectively, as derived from the 1979 NHTSA FARS file.

TABLE 1

Passenger-Car Occupant Fatalities Involving Rollover or Ejection

1979 FARS

Ejection	Rollover				Total	
	Yes		No		N	%
	N	%	N	%		
Yes	3333	12.2	2617	9.6	5950	21.7
No	2972	10.9	18236	66.7	21208	77.5
Unknown	43	0.2	157	0.6	200	0.7
Total	6348	23.2	21010	76.8	27358	100.0

TABLE 2

Heavy-Truck Occupant Fatalities Involving
Rollover or Ejection

1979 FARS

Ejection	Rollover				Total	
	Yes		No		N	%
	N	%	N	%		
Yes	225	20.7	158	14.5	383	35.2
No	374	34.3	322	29.6	696	63.9
Unknown	3	0.3	7	0.6	10	0.90
Total	602	55.3	487	44.7	1089	100.0

Other differences are also indicated in these tables. For passenger cars involving an occupant fatality, ejection was strongly associated with rollover. Over half of the fatally injured occupants of passenger cars that rolled over were ejected, while only 12.5 percent of the fatally injured occupants of passenger cars that did not roll over were ejected. For heavy trucks, however, occupant ejection occurred at about the same proportion whether or not the truck rolled over. Overall, about 22 percent of the fatally injured passenger car occupants were ejected, while about 35 percent of the fatally injured truck occupants were ejected. The primary difference here was in the accidents that did not involve rollover. Fatally injured truck occupants were ejected from vehicles that did not roll over about 2.5 times as frequently as fatally injured occupants of passenger cars that did not roll over.

Data files with information on all police-reported accidents in a given state provide a basis to estimate the overall influence of ejection on the probability of death or injury. Statistics derived from the 1978 Pennsylvania accident file show that the chances of death or

injury are much higher for ejected occupants of combination vehicles as compared to those that are not ejected. The Pennsylvania file includes all police-reported towaway accidents involving a combination vehicle. Overall, only 1.5 percent of the occupants of combination vehicles involved in accidents in Pennsylvania were ejected. Both total and partial ejection are included in this figure. The probability of fatality was 58 times higher for the ejected occupants (0.175 for ejected occupants and 0.003 for occupants not ejected). Ejection was associated with 48% of the combination-vehicle occupant fatalities in Pennsylvania. The probability of injury (not including fatal injuries) was 3.65 times higher for ejected occupants: 0.80 as compared to 0.22.

The primary objective of this study was to gain an understanding of the mechanisms of rollover and ejection in heavy-truck occupant fatalities in order to assess the effectiveness of possible countermeasures. A panel of specialists trained in accident investigation reviewed hard-copy reports on 41 heavy-truck occupant fatalities. The reports reviewed were originally produced by the Multi-Disciplinary Accident Investigation (MDAI) program. Each panel member assessed the contribution of rollover or ejection to the fatal injuries as well as the potential effectiveness of restraint use. The cases selected and review method are described in the next section.

2. METHOD

Detailed information on the circumstances and consequences of heavy-truck accidents is contained in the Collision Performance and Injury Report (CPIR) files. The CPIR data were collected from the late 1960's to the late 1970's by several accident investigation teams located in the United States and Canada. These investigations were originally conducted through the Multi-Disciplinary Accident Investigation (MDAI) program funded by the National Highway Traffic Safety Administration (NHTSA), the Motor Vehicle Manufacturers Association (MVMA), and the Canadian Department of Transportation. The MDAI teams were staffed by a variety of professionals, including, but not limited to, engineers, physicians, physicists, psychiatrists, and medical examiners. These teams generally collected quite detailed and voluminous information. Cases were selected for investigation by the teams based on their varied interests and objectives. Consequently, the cases in the CPIR-B file are not expected to provide a representative distribution of all heavy-truck accidents. Depending on the date of investigation, the data were either directly recorded on the CPIR-B accident reporting form developed for heavy trucks, or were subsequently transcribed to this format from the original report. The extensive descriptive detail, especially regarding occupant injury, permits assessment of the contribution of rollover and ejection to the fatal injuries, and an estimate of the possible effectiveness of restraint use.

For this study, the CPIR-B truck file was subset to accidents involving heavy-truck occupant fatalities. Table 3 shows the number of truck occupant fatalities in this subset associated with rollover and ejection. These distributions are similar to those observed in the FARS heavy-truck occupant fatalities, except that the incidence of ejection is higher in the CPIR cases. For the panel review, the original CPIR-B "hard copy" forms and color photographs of the vehicles and accident site were assembled. Most of the slides used in this study were supplied from files maintained in the Detroit offices of the Motor Vehicle Manufacturers Association.

TABLE 3

Heavy-Truck Occupant Fatalities Involving
Rollover or Ejection

CPIR-B

Ejection	Rollover						Total	
	Yes		No		Unknown		N	%
	N	%	N	%	N	%		
Yes	14	34.1	9	22.0	1	2.4	24	58.5
No	10	24.4	7	17.1	0	0.0	17	41.5
Total	24	58.5	16	39.0	1	2.4	41	100.0

University staff members experienced in accident investigation and accident analysis reviewed the information available on the 41 heavy truck occupant fatality cases in the CPIR-B file. Each case was reviewed by six persons, for a total of 246 review responses. The reviewers studied all of the available material for each accident--hard copy of the original data forms and photographs of the vehicle and accident site--and assessed the contribution of rollover and/or ejection in the fatal injuries. The possible effectiveness of various restraint systems was also estimated. Each reviewer recorded an estimated probability that the fatality would have been prevented had a restraint been used, as well as an estimate of the expected reduction in injury severity (using the Abbreviated Injury Scale). The review data form is reproduced below as Figure 1. The resulting information was then entered into a computer file for subsequent tabulation. The relevant findings are presented in the remainder of this report.

Case Number_____Team_____Date_____ Reviewer_____

Case Vehicle_____Fatal Occupant_____

Item	Probability of NO Fatality with Item	Estimated Maximum AIS with Item	Comments, qualifications, etc.
Lap Belt	0 10 20 30 40 50 60 70 80 90 100	0 1 2 3 4 5 6	
Lap+Shoulder Belt	0 10 20 30 40 50 60 70 80 90 100	0 1 2 3 4 5 6	
Air Bag	0 10 20 30 40 50 60 70 80 90 100	0 1 2 3 4 5 6	
Lap Belt+Air Bag	0 10 20 30 40 50 60 70 80 90 100	0 1 2 3 4 5 6	
Did Ejection Contribute to Fatal Injury?	Yes No NA Can't Tell		
Did Vehicle Rollover Contribute to Fatal Injury? . .	Yes No NA Can't Tell		
If Vehicle is Cabover, would Conventional reduce injury? .	Yes No NA Can't Tell		
Other Factors Contributing to Fatal Injury, such as Cargo Shift Interior Hardware Fire			

General Comments:

Figure 1
Review Panel Data Form

3. RESULTS

This section of the report presents a basic statistical description of the review panel responses. Each of the 41 actual fatalities was reviewed by each of the six panel members, for a total of 246 responses. Tabulations in this section are based on the number of responses. Each panelist estimated the likelihood that restraint usage would have prevented the fatality under review. These probabilities were recorded in increments of 10 percent, as shown on the data form. The following tabulations present the number of responses which equaled or exceeded a given estimated chance of survival. The two levels selected for presentation are (1) responses which estimated a 60 percent or greater chance of survival and (2) responses which estimated a 90 percent or greater chance of survival. The panelists' responses were compared with one another, and generally good agreement was found. The initial tabulations show overall estimates of the effectiveness of restraints in the selected CPIR heavy-truck occupant fatalities. Subsequent tabulations focus on cases involving ejection and rollover separately.

Of the 246 review responses, 35 percent indicated a 60 percent or greater chance of survival for the occupant had lap belts been used, while 15 percent of the responses indicated a 90 percent or greater chance of survival for the occupant had lap belts been used. The distribution of responses is illustrated in Figure 2. Missing data (M.D.) are panelists that chose not to estimate the chance of survival for particular cases. The percentages shown in the figure reflect the number of responses equal to or greater than a given estimated chance of survival. Panelists not making an estimate (M.D.) are included in the denominator. The magnitude of this group is reflected by the difference in height of the first two columns on the left.

A somewhat greater effect was estimated by the panel for use of a lap and shoulder belt. Of the 246 review response cases, 44 percent were estimated to have had a 60 percent or greater chance of survival had lap and shoulder belts been used, while 30 percent were estimated to have had a 90 percent or greater chance of survival had lap and shoulder belts been used, as shown in Figure 3.

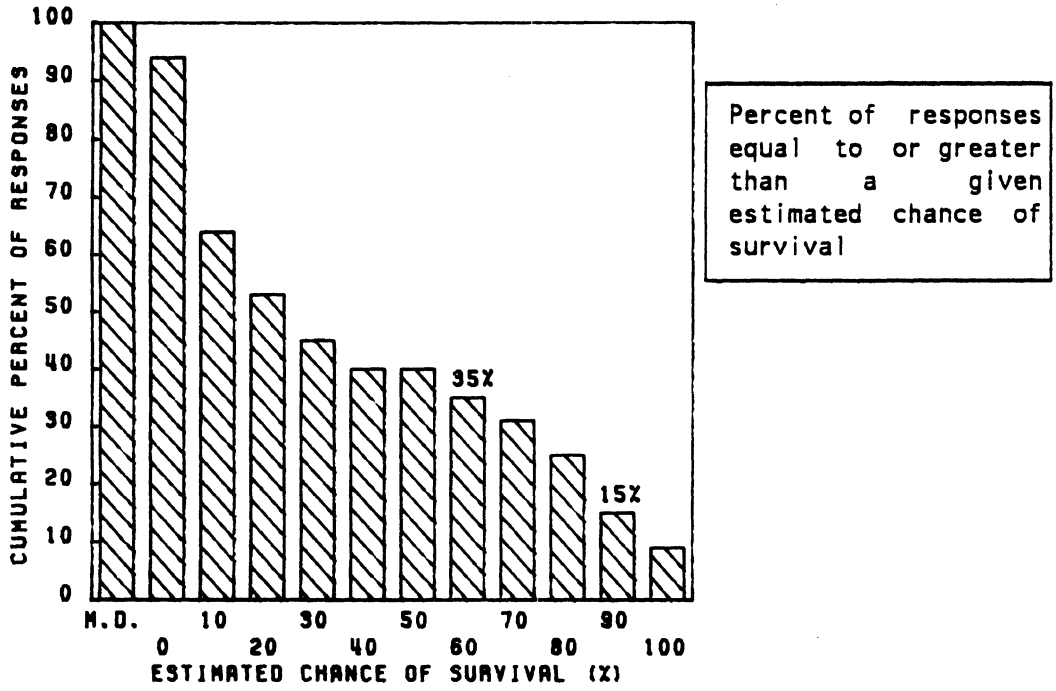

Figure 2. Overall Estimated Survival with Lap Belts

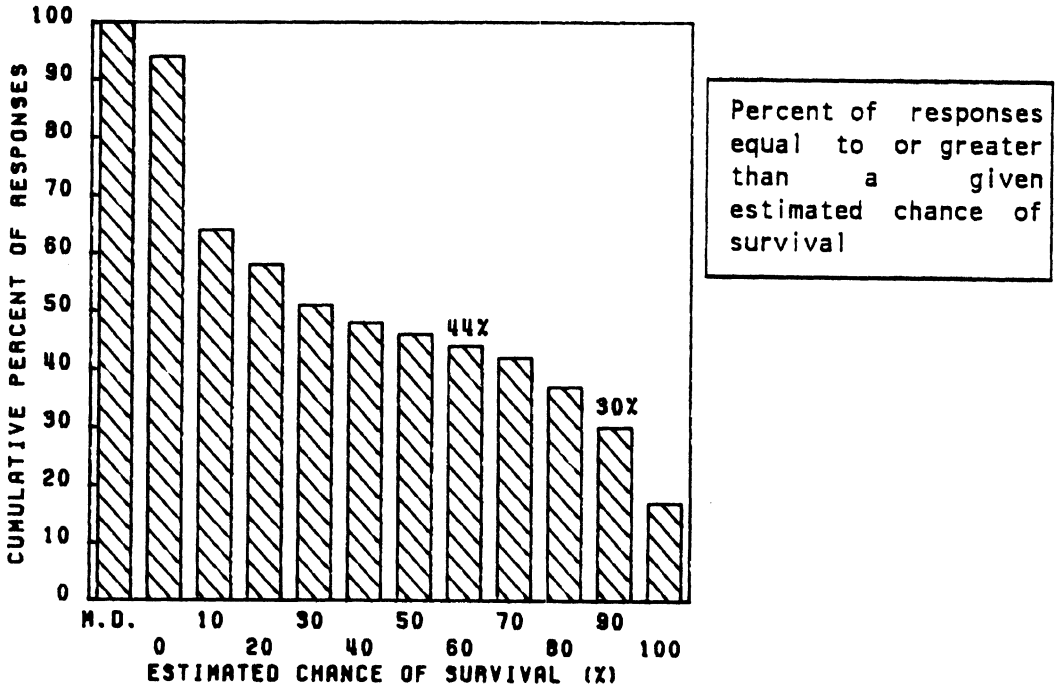

Figure 3. Overall Estimated Survival with Lap and Shoulder Belts

In general, the responses of the review panel reflect the opinion that belt use would have substantially improved the chances of survival in the cases reviewed. The remaining tabulations address the

relationship of rollover and ejection to the estimated effectiveness of restraint use.

Ejection. Ejection occurred in 58 percent of the heavy-truck occupant fatalities in the CPIR-B file and 36 percent of the heavy-truck occupant fatalities in the 1979 FARS file. These proportions are illustrated in Figure 4.

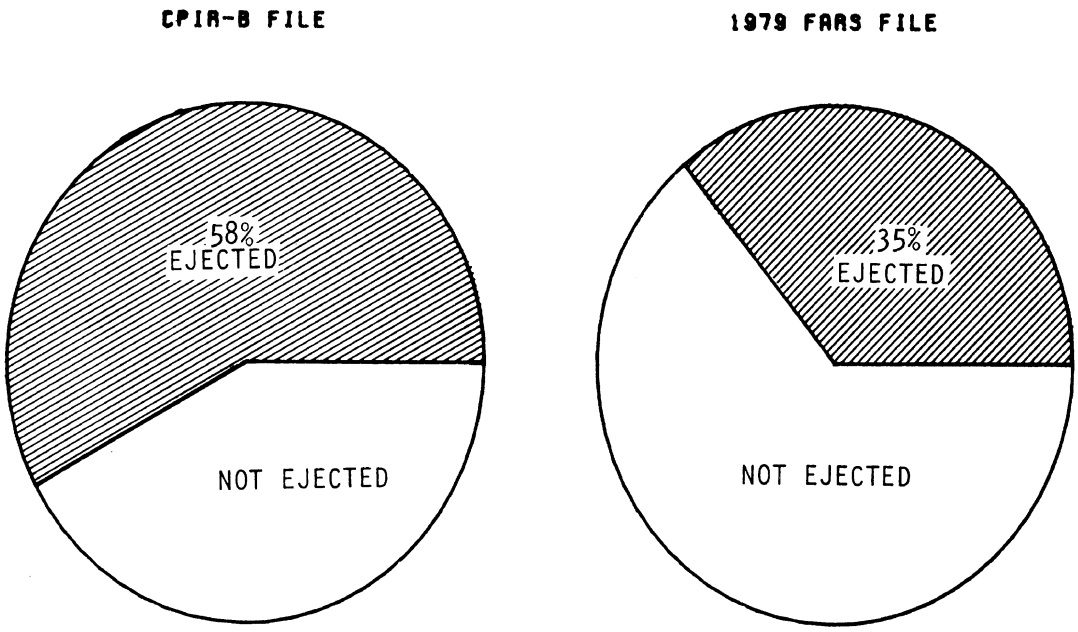

Figure 4. Proportion of Heavy-Truck Occupant Fatalities Involving Ejection

Looking at the the 144 review response cases involving occupant ejection, 76 (53 percent) were estimated to have had a 60 percent or greater chance of survival had lap belts been worn, while 35 (24 percent) were estimated to have had a 90 percent or greater chance of survival had lap belts been worn. This result is illustrated in Figure 5. The panel's estimates of the chances of survival with belt use are substantially higher for ejected occupants than for all occupants, as can be seen by comparing Figure 5 and Figure 2.

With respect to the possible benefits of lap and shoulder belt use for ejected occupants: 91 (63 percent) were estimated to have had a 60 percent or greater chance of survival had lap and shoulder belts been worn, with 67 (47 percent) being in the 90 percent or greater estimated

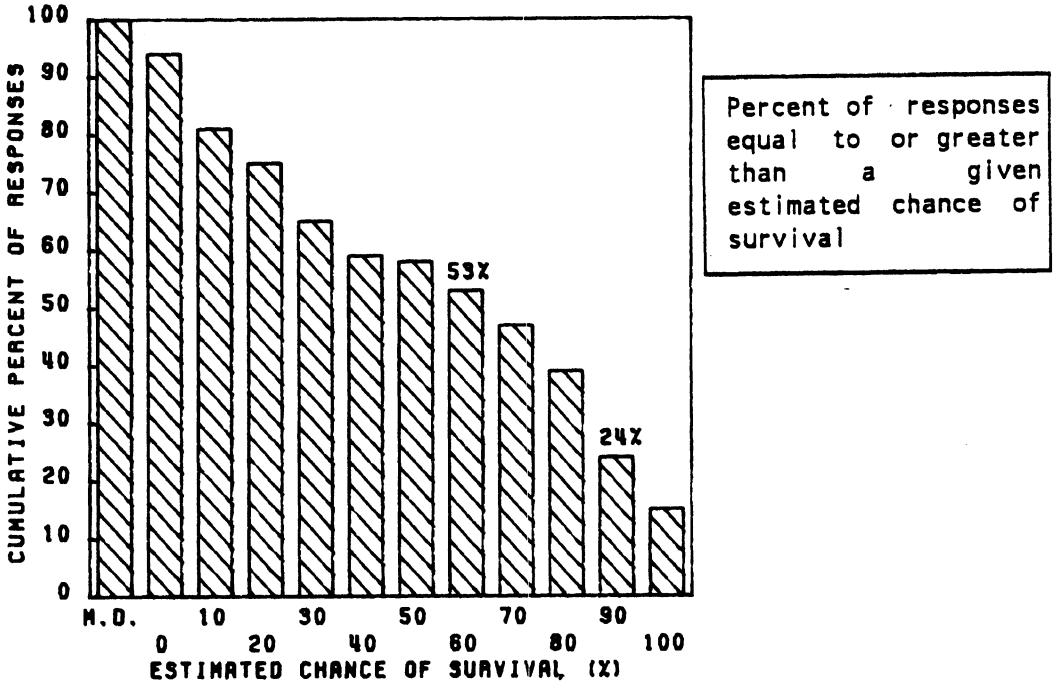

Figure 5. Estimated Survival with Lap Belts when Ejection is Involved

survival range. That is, nearly half of the fatalities involving occupant ejection were thought to be preventable with the use of lap and shoulder restraints, as shown in Figure 6.

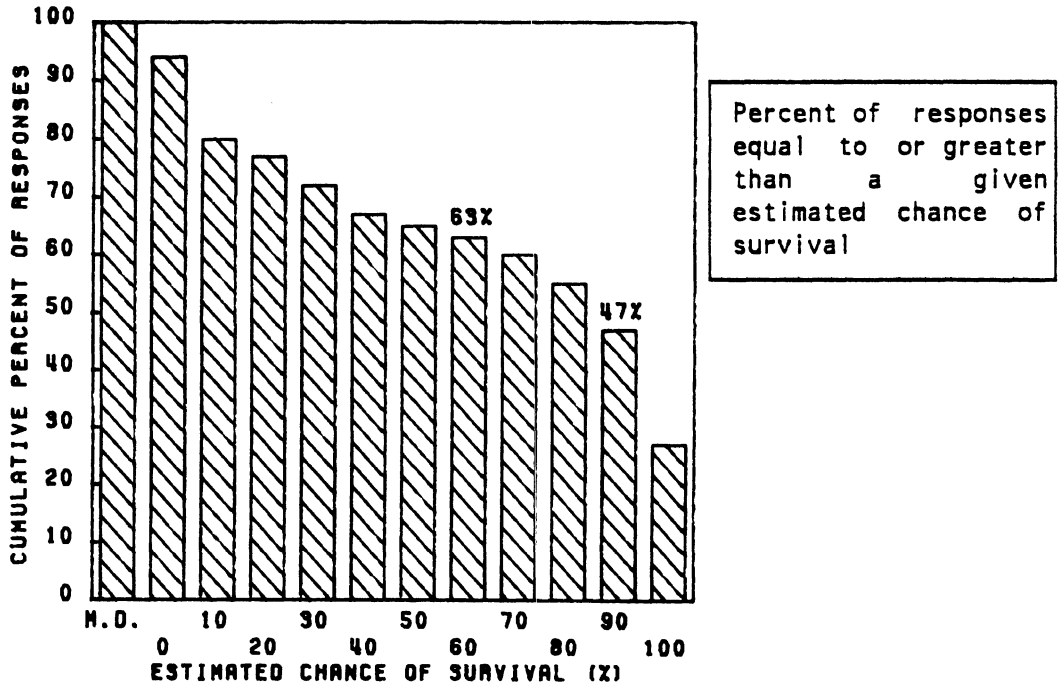

Figure 6. Estimated Survival with Lap and Shoulder Belts when Ejection is Involved

The survival estimates for those cases not involving ejection are not as optimistic as are those for ejection cases. For lap belt use, only 10 percent of the responses indicated a 60 percent or greater chance of survival for cases not involving ejection, and only 17 percent of the responses for lap and shoulder belt use indicated a 60 percent or greater chance of survival. The results described in the preceding paragraphs are summarized in Table 4.

TABLE 4

Estimated Chance of Survival with Occupant Restraints versus Ejection

Ejection	Review Responses	≥60% Chance of Survival		≥90% Chance of Survival	
		Lap Belt	Lap + Shoulder Belt	Lap Belt	Lap + Shoulder Belt
Ejection	144	76 (53%)	91 (63%)	35 (24%)	67 (47%)
No Ejection	102	10 (10%)	17 (17%)	2 (2%)	7 (7%)
Total	246	86 (35%)	108 (44%)	37 (15%)	74 (30%)

The review panel considered restraints to be more effective in reducing the probability of a fatality for those cases involving an ejection than for those not involving an ejection. The most apparent reason for the panel's high estimated effectiveness of belt restraints with regard to ejection is that the fatal injury is often a direct result of the ejection. Belt restraints have proven to be excellent deterrents to occupant ejection. Fatalities not attributable to ejection usually are associated with accidents involving extreme cab deformation.

The review panel also assessed the contribution of ejection to the fatal injuries, and determined that in the majority of those cases involving occupant ejection, the ejection did, in fact, contribute to

the fatal injury. Of the 144 review response cases involving occupant ejection, the review panel estimated that in 87 (60 percent) of the cases the ejection contributed directly to the fatal injury.

Of these 87 cases in which ejection was thought to have contributed to the fatal injury, 65 (75 percent) were estimated by the review panel to have had a 60 percent or greater chance of survival had lap belts been worn, with 30 (34 percent) being in the estimated 90 percent or greater survival range.

The estimated survival rates with the use of lap and shoulder belts are even higher. The review panel estimated that nearly two-thirds of those fatalities attributable to ejection could probably (≥90 percent chance of survival) have been prevented had lap and shoulder belts been used. The estimates of the possible benefits of belt use are much lower when the ejection did not appear to have contributed to the fatal injuries. Results summarizing the contribution of ejection to the fatal injuries are presented in Table 5.

TABLE 5

Ejection Resulting in Fatal Injury:
Survival Estimates with Occupant Restraint

Contribution of Ejection	Review Responses	≥60% Chance of Survival		≥90% Chance of Survival	
		Lap Belt	Lap + Shoulder Belt	Lap Belt	Lap + Shoulder Belt
Ejection Contributed	87	65 (75%)	74 (85%)	30 (34%)	58 (66%)
Ejection Did Not Contribute	57	11 (19%)	17 (30%)	5 (9%)	9 (16%)
Total Ejection	144	76 (53%)	91 (63%)	35 (24%)	67 (46%)

When ejection is judged to contribute to the fatal injuries, the review panel responses reflect the opinion that restraint use is likely to substantially improve the chances of survival for the occupant. In many of these cases deformation to the occupant compartment is slight, so that simply keeping the occupant in the vehicle is sufficient to prevent the fatal injuries. However, cases in which there is a fatality without ejection usually involve substantial damage. Consequently, estimates of the effectiveness of restraints are appreciably lower for these cases.

Written comments of the panel also reflected another important function of restraints in a few cases: that of keeping the driver in his seat and behind the wheel. Occasionally, a severe accident developed from a relatively minor incident because the driver was thrown from his seat, and was unable to regain control of the vehicle before a serious impact occurred. In these instances, restraint use might have prevented the major impact altogether.

Rollover. The other important aspect of heavy-truck occupant fatalities mentioned in the Introduction besides ejection was rollover. Rollover occurred in 54 percent of the 1979 FARS heavy-truck occupant fatalities and in 58 percent of the CPIR-B cases. The relationship of ejection and rollover in the review response cases from the CPIR-B file is shown in Table 6. This table is the same as Table 3 in the Introduction, except that the counts are multiplied by the six responses of the panel. Describing the panel's estimates of the possible benefits of restraint use in cases involving rollover is complicated by the overlap of rollover and ejection, as can be seen in Table 6. Both rollover and ejection are associated with 34.1 percent of the heavy-truck occupant fatalities in the CPIR-B file (84 response cases, 14 actual cases).

In assessing the contribution of rollover and ejection to the fatal injuries for these 14 cases, 63 percent of the panel's responses (53 out of 84) indicated that both rollover and ejection contributed. In these cases, the rollover was responsible for the ejection, and the panel's responses indicated that restraint use would be expected to substantially improve heavy-truck occupants' chances of survival. These

TABLE 6

Review Response Cases by Ejection and Rollover

CPIR-B File

Ejection	Rollover						Total	
	Yes		No		Unknown		N	%
	N	%	N	%	N	%		
Yes	84	34.1	54	22.0	6	2.4	144	58.5
No	60	24.4	42	17.1	0	--	102	41.5
Total	144	58.5	96	39.0	6	2.4	246	100.0

cases were included in the results (already presented) addressing ejection and the possible effectiveness of restraint use.

Looking only at the cases in which rollover was recorded as contributing to the fatal injuries and ejection was not, the panel's responses reflect a relatively low assessment of the possible benefits of restraint use. For lap belt use, only 13 percent of the responses indicated a 60 percent or greater chance of survival and only 7 percent indicated a 90 percent or greater chance of survival. For lap and shoulder belt use, 19 percent of the responses estimated a 60 percent or greater chance of survival, and 13 percent indicated a 90 percent or greater chance of survival.

Injury. The review panel also estimated the maximum overall injury severity for the respective fatality had belt restraints been used. The review panel utilized the Abbreviated Injury Scale (AIS) in making the injury severity estimates:

Referring to Table 7, the review panel estimated that of the 246 review responses, had lap belts been worn, 88 (36 percent) would have received injuries of an AIS level 3 or below, while 110 (45 percent) would have received injuries of an AIS level 4 or below. Had lap and

Abbreviated Injury Scale (AIS)

0 No Injury
1 Minor
2 Moderate
3 Severe (not life-threatening)
4 Serious (life-threatening, survival probable)
5 Critical (survival uncertain)
6 Fatal (within 24 hours)

TABLE 7

Estimated AIS Level with Occupant Restraints

Restraint Type Associated With Estimated AIS	Estimated AIS Level	
	AIS $\leq$ 3	AIS $\leq$ 4
Lap Belts	88 (36%)	110 (45%)
Lap & Shoulder Belts	105 (43%)	116 (47%)

shoulder belts been worn, it was estimated that of the 246 review responses, 105 (43 percent) would have received injuries of an AIS level 3 or below, while 116 (47 percent) would have received injuries of an AIS level 4 or below. AIS 3 and 4 generally distinguish serious (life-threatening) from non-serious injuries.

When the estimated AIS levels for restraint use are broken down by ejection, the results are similar to the estimated chances of survival, as would be expected. For fatalities involving ejection, restraint use is expected to produce AIS levels of three or less in over 50 percent of the responses. For those fatalities not involving ejection, restraint use is only expected to produce AIS levels of three or less in 10 percent to 18 percent of the responses. These results are summarized in Table 8.

Door Latches. Since many of the accident reports in the CPIR-B file involve older trucks, it is of interest to determine whether occupant ejection is less likely for more recently produced trucks.

TABLE 8

Estimated AIS Level with Occupant Restraints versus Ejection

Ejection	Number of Cases	Estimated Number of Cases With an AIS Level ≤ 3 With Use of:		Estimated Number of Cases With an AIS Level ≤ 4 With Use of:	
		Lap Belt	Lap & Shoulder Belt	Lap Belt	Lap & Shoulder Belt
Yes	144	78 (54%)	87 (60%)	91 (63%)	92 (64%)
No	102	10 (10%)	18 (18%)	19 (19%)	24 (24%)
Total	246	88 (36%)	105 (43%)	110 (45%)	116 (47%)

Federal Motor Vehicle Safety Standard No. 206 required that trucks, as of January 1, 1972, meet certain safety standards regarding door locks and door retention components. Two-thirds of the vehicles in the CPIR-B subset reviewed were 1971 model year or older. Table 9 shows the proportion of heavy-truck occupants who were ejected, as well as the fatal ejections, by model year from the 1979 FARS file.

All occupants of heavy trucks which were involved in fatal accidents are included in Table 9. In multiple-vehicle fatal accidents involving heavy trucks, the fatality is usually in the other vehicle. The column labeled "Ejections" includes non-fatal ejections. Overall, only 8.9 percent of all occupants of heavy trucks involved in fatal accidents are ejected.

The proportion of heavy-truck occupant ejections declines for 1972 model year and newer vehicles, as summarized in Table 10. Total ejections in fatal accidents for post-FMVSS 206 heavy trucks are reduced 20 percent and fatal ejections are reduced 17 percent. Viewing the 1979 calendar year's data as a sample of a longer time period, the difference in the percentage of ejections for pre- and post-standard heavy trucks shown in Table 10 is statistically significant at the 95 percent

TABLE 9

Ejection by Model Year:
All Occupants of Heavy Trucks in Fatal Accidents
1979 FARS

Model Year	N	Ejections	%	Ejection Fatals	%
1962	18	2	11.1	2	11.1
1963	21	6	28.6	4	19.0
1964	37	3	8.1	3	8.1
1965	38	4	10.5	2	5.3
1966	60	4	6.7	2	3.3
1967	100	14	14.0	12	12.0
1968	141	11	7.8	9	6.4
1969	157	19	12.1	15	9.6
1970	218	22	10.1	15	6.9
1971	236	24	10.2	18	7.6
1972	347	30	8.6	17	4.9
1973	513	32	6.3	28	5.5
1974	537	43	8.0	30	5.6
1975	436	28	8.9	24	5.5
1976	388	31	10.1	26	6.7
1977	705	63	8.9	48	6.8
1978	877	89	10.1	75	8.6
1979	573	56	9.8	43	7.5
Total	5402	481	8.9	373	6.9

NOTE: Missing data on ejection and model year excluded.

confidence level, but the difference in the proportion of fatalities which involved ejection is not.

The areas of ejection and release of the door latches are recorded in the CPIR-B file. Table 11 shows door and windshield ejections separately for pre- and post-FMVSS 206 vehicles by cab style. Only tractors were included in this tabulation, but all occupants were included (non-fatal as well as fatal) to increase the sample size. Overall, cabover tractors have a higher proportion of ejections than do conventional cab tractors. The proportion of ejections through doors for post-FMVSS 206 tractors is only one-fifth that of pre-standard tractors. However, the proportion of windshield ejections for the post-

TABLE 10

Summary:
Occupant Ejection for Heavy Trucks Manufactured
Before and After FMVSS 206

1979 FARS

	N	Ejections	%	Fatal Ejections	%
Pre-FMVSS No.206 (1971 & older)	1026	109	10.6	82	8.09
Post-FMVSS No.206 (1972 & newer)	4376	372	8.5	291	6.6

standard tractors is more than double that of the pre-standard tractors. The overall proportion of ejections is reduced by 25 percent. The reduction in door ejections is present in both the conventional and cabover style tractors.

The sample sizes in this table are rather small. However, the differences in the percentage of door latches released for pre- and post-standard tractors shown in Table 11 is statistically significant at the 95 percent confidence level if a simple random sample is assumed. The difference in the percentage of door latches released for conventional cab-style tractors as compared to cabover tractors is also statistically significant at the 95 percent level. The decrease in all ejections and the increase in window ejections for post-standard tractors are not statistically significant at the 95 percent level.

The incidence of door latch release from the CPIR-B vehicle file is shown in Table 12 for pre- and post-standard tractors by cab style. In this table, the overall sample size is the number of doors examined, roughly twice the number of tractors. Overall, the proportion of released door latches is reduced about 50 percent for the post-FMVSS 206 tractors. This difference is statistically significant at the 95 percent level. The proportion of door latch release is about 25 percent

TABLE 11

Area of Ejection by Cab Style
Before and After FMVSS 206
Tractor Occupants CPIR-B File

Model Year	Cab Style				Total	
	Conventional		Cabover		N	%
	N	%	N	%		
Pre-FMVSS 206 (1971 & Older)						
Ejection						
Door	3	5.1	12	12.1	15	9.5
Windshield	1	1.7	4	4.0	5	3.2
All	4	6.8	20	20.2	24	15.2
No Ejection	55	93.2	79	79.8	134	84.8
Total	59	100.0	99	100.0	158	100.0
Post-FMVSS 206 (1972 & Newer)						
Ejection						
Door	0	0.0	2	2.7	2	1.8
Windshield	2	4.9	7	9.6	9	7.9
All	4	9.8	9	12.3	13	11.4
No Ejection	37	90.2	64	87.7	101	88.6
Total	41	100.0	73	100.0	114	100.0
Total						
Ejection						
Door	3	3.0	14	8.1	17	6.3
Windshield	3	3.0	11	6.4	14	5.1
All	8	8.0	29	16.9	37	13.6
No Ejection	92	92.0	143	83.1	235	86.4
Total	100	100.0	172	100.0	272	100.0

higher for cabover tractors as compared to conventional cab tractors. This difference is not statistically significant.

The observed differences in the proportion of occupants ejected by model year and cab style are likely to be associated with other factors not included in this preliminary study. For example, ejection is likely

TABLE 12

Proportion of Door Latch Release by Cab Style
Before and After FMVSS 206
Tractors, CPIR-B File

Model Year	Cab Style		Total
	Conventional	Cabover	
Pre-FMVSS 206 (1971 & older)			
N (Doors)*	102	161	263
Released	18	44	62
Percent	17.6	27.3	23.6
Post-FMVSS 206 (1972 & newer)			
N (Doors)*	72	124	196
Released	7	16	23
Percent	9.7	12.9	11.7
Total			
N (Doors)*	174	285	459
Released	25	60	85
Percent	14.4	21.1	18.5

*N is the number of doors examined.

to be associated with high-speed rural accidents. The CPIR file is a collection of accidents that were investigated because they suited the particular interests of the investigating team. Consequently, they are not a representative selection of all heavy-truck accidents. In addition, differences in the use of tractors by cab style or age may also influence the likelihood of these vehicles being involved in the type(s) of accidents which tend to result in ejection. As commercial trucks become older, they are often shifted into local pick-up and delivery service, reducing their mileage on rural roads substantially. New vehicles are typically in long-haul service. Similarly, cabover tractors are more likely to be used in long-haul service, as compared to conventional cab tractors. Differences related to the age of the vehicle are further complicated in the CPIR file, since these investigations were conducted over a ten-year period. At the time of the accidents, some of these vehicles were quite new, and some were not.

The more frequent use of older trucks in local service would suggest that these vehicles might be less likely to be associated with occupant ejection. The observation, both in the 1979 FARS and the CPIR-B files, that the proportion ejected is reduced for 1972 and newer heavy trucks seems to reflect the effectiveness of the design changes implemented in response to FMVSS 206.

Cab style (cabover vs. conventional) could not be identified in FARS, but was available in the CPIR-B file. In the CPIR-B file, cabover tractors have a higher proportion of ejections than conventional cab tractors. However, it is not clear whether this difference is related to the design of the vehicle or to differences in the use of cabover tractors.