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EJECTION AND THE EFFECT OF AUSTRALIAN DESIGN RULE 2
FOR DOOR LATCHES AND HINGES

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Abstract

Australian Design Rule No. 2 (ADR 2) specifies requirements for side door latches and hinges, with the intention of minimising the likelihood of occupant ejection in crashes. It came into effect for new passenger cars and derivatives on 1 January 1971 and for other types of vehicles at later dates. Australian manufacturers began fitting so-called "anti-burst" door latches to some cars in the early 1960's.

Information from the Royal Australasian College of Surgeons Pattern of Injury Survey of crashes and injuries in Victoria was analysed to measure the effect of the anti-burst door latches and ADR 2. Initially it was established that ejection doubles the risk of severe-to-fatal injury compared with being contained in the car in the same crash circumstances. Ejection, door opening, and the proportion of ejectees who were ejected from vehicles with closed doors were then used as criteria for the effect of ADR 2.

The study concluded that ADR 2 (and the anti-burst door latches fitted prior to formal requirements) is effective in reducing the risk of ejection, via a reduction in the probability of door opening, for the occupants of cars and car derivatives involved in

Abstract (continued)

non-rollover crashes. ADR 2 transfers the route of ejection of the remaining ejectees away from the door opening and towards non-door portals. Regarding the effectiveness of ADR 2 in rollover crashes, the study was inconclusive due to the relatively small number of occupant casualties involved in crashes of this type and also due to the possibility that the later model cars may have been involved in more severe rollover crashes than the older cars. Anti-burst door latches may be in need of improved design to take account of whatever mechanism opens doors in rollovers.

ADR 2 still has a meaningful role in modern vehicles with high rates of seat belt use. The Design Rule is effective, at least in non-rollover crashes, in reducing the risk of ejection of seat belt wearers as well as non-wearers.

C/Boughton

Report to
Office of Road Safety
Commonwealth Department of Transport

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September, 1980

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INTRODUCTION

AUSTRALIAN DESIGN RULE 2

Australian Design Rule for Motor Vehicle Safety No. 2 (ADR 2) for door latches and hinges came into effect for passenger cars and derivatives manufactured on or after 1 January 1971. It specifies requirements for side door locks and side door retention components including latches, hinges, and other supporting means, with the intention of minimising the likelihood of occupants being ejected from a vehicle as a result of impact. The Design Rule later became effective for multi-purpose passenger cars (1 January 1973), small trucks (1 July 1974), and large trucks (1 July 1975).

ADR 2 seeks to achieve its intention by requiring the door latches and hinges to withstand a longitudinal, tensile load (representing the load induced by body shell distortion) and a transverse load acting outwards (representing the load induced by occupant contact). The Design Rule is based on U.S. Federal Motor Vehicle Safety Standard No. 206 (FMVSS 206).

FMVSS 206 came into effect for passenger cars sold in the U.S. since 1 January 1968. However, most U.S. manufacturers included improved door retention components (so-called "anti-burst" door latches) as early as the 1956 model year (Garrett 1969; Comptroller General of the United States 1976). These anti-burst door latches were initially aimed at restraining the door longitudinally and their design was gradually improved in stages during the next decade (Garrett 1969). It is understood that Australian manufacturers began fitting anti-burst door latches in the early 1960's (in response to the availability of American technology) and that the advent of ADR 2 caused a design change in only a minority of passenger cars and derivatives produced in 1971.

LITERATURE ON EJECTION AND INJURY

A number of researchers have identified an association between ejection and death or serious injury, with the risk of severe-to-fatal injury to ejectees ranging from 3 to 16 times higher than that for non-ejectees from crashes in general (Tourin 1958; Kihlberg 1965; Adams 1967; Tarrière 1973; Anderson 1974; Hobbs 1978) and from 5 to 40 times higher in rollover crashes (Hight et al 1972; Anderson 1974; Huelke et al 1977a, b). Ejection is typically associated with increased risk of serious injury to the head, neck and spine, in particular (Huelke et al 1977a; Walz 1979).

Most of these researchers have not taken into account the possibility that the ejectees may have been involved in more severe crashes and that their increased injury risk may have been due, at least in part, to this difference before ejection (though, to be fair, Adams 1967 commented on this possibility). Tonge et al (1972) found that 81 per cent of ejected fatalities received their major fatal injury inside the vehicle before ejection. Tourin (1958) found that ejectees were indeed involved in more severe crashes and additionally tended to have occupied seating positions with a higher fatality risk than non-ejectees. When he controlled for these differences in crash severity and seating position, he found that the fatality risk of ejectees was only 2.3 times the expected risk had they remained inside the car, compared with the crude ratio of 4.8 when the fatality risks of ejectees and non-ejectees were directly compared.

Thus it would appear that ejection per se directly causes an increase in the risk of severe-to-fatal injury, though perhaps not as great an increase as is commonly thought. Huelke and Gikas (1966) identified ejection as the leading cause of occupant death in their data (27 per cent of the fatalities considered), after discounting about one-third of their ejected fatalities who received fatal injuries inside the car.

Some researchers have identified the wearing of seat belts (lap or three-point) as having a large effect on occupant ejection (Huelke and Gikas 1966; Adams 1967; Tonge et al 1972; Hight et al 1972; Huelke et al 1977a, b; Cameron and Nelson 1977). Tourin (1958) discussed the dual role of a seat belt (specifically, of the lap type) of, first, preventing ejection and, second, reducing the risk of injury of contained occupants. However, Walz et al (1979) were still able to find instances of seat belt wearers who were ejected, with a disproportionate frequency of cervical and thoracic spine fractures. They also found a high proportion of ejectees who were wearing two-point shoulder belts rather than three-point belts. However, Huelke et al (1977b) found no evidence of a difference in ejection rate when wearers of lap belts were compared with wearers of lap and shoulder belts.

Ejection was found to be related to crash severity (Tourin 1958; Adams 1967; Anderson 1974) and to the crash type, with rollovers being the most frequent source of ejection (Tonge et al 1972; Anderson 1974). Anderson also found ejection rates to be higher in side impacts compared with other non-rollover impacts, as well as for occupants of the front seats (confirming the finding of Tourin 1958). Hight et al (1972) found ejection to be related to roof crush in rollovers, and Quayle (1968) found a relationship between the loss of survival space and door opening in rollovers. However, Huelke et al (1977a) were unable to confirm Hight et al's finding.

A number of researchers have investigated the route of ejection. In crashes in general, Huelke and Gikas (1966) found that in 1961-65 most fatal ejectees were ejected through opened doors. Hight et al (1972) had similar findings in rollovers. However, when studying newer American cars (1968 models onwards) in rollovers, Huelke et al (1972, 1977a found that the most common ejection route had changed to the side windows or windscreen, followed by ejection through opened doors. Anderson (1974) confirmed this finding, but he found that through opened doors remained the most common ejection route for the newer cars involved in non-rollover crashes. Anderson also quoted Garrett (1973) who demonstrated an increase in the proportion of ejectees who were ejected through the windscreen, side windows and rear windows associated with the newer car models.

LITERATURE ON ANTI-BURST DOOR LATCH EFFECTIVENESS

Almost without exception, the incidence of door opening in crashes has been used as the evaluation criterion in studies of the effectiveness of anti-burst door latches. In none of the literature sighted has the incidence of ejection per se been used. The direct criterion (ejection) may have been more appropriate than an indirect measure (door opening), particularly as it appears that an effect of improved door latches and hinges in American cars may have been to transfer the predominant ejection route from the door opening to the glass areas in some types of crashes, if ejection took place.

Garrett (1961, 1964, 1969) conducted a series of studies of door opening of American cars involved in rural, injury-producing crashes. In the 1961 study, he compared pre-1956 cars with 1956-59 models and found that the door opening rate changed from 45 per cent to 28 per cent. At the same time the incidence of ejection through an open door fell by 40 per cent. The next major door latch design change in American cars occurred with the 1963 models and Garrett's 1964 study found a further fall in the door opening rate to 23 per cent. Further improvements in door latch design were made during the 1960's, especially in the 1967-68 models. Garrett's 1969 study was more refined in that it standardized the year model comparisons for differences in impact speed and accident type, and found the following door opening rates by year of manufacture:

- pre-1956 : 42.5%
- 1956-62 : 28.4%
- 1962-63 : 22.6%
- 1964 : 17.3%
- 1965-66 : 17.5%
- 1967-68 : 12.4%

Anderson (1972) moved away from door opening as the evaluation criterion, and used door-related ejection instead. He found that the incidence rate fell from 5.0 per cent in 1960-65 model American cars to 3.1 per cent in 1968-72 models. Garrett (1973) used the same criterion in a comparison of 1960-67 and 1968-70 model Volkwagens. He found a 55 per cent reduction in the door-related occupant ejection rate, attributable to recently introduced door latch design modifications (presumably in response to the impending FMVSS 206).

Anti-burst door latches were introduced in Europe in the late 1960's (Mackay et al 1975). Kolbuszewski et al (1972) considered the performance of door locks with and without longitudinal restraint in British cars involved in a representative sample of crashes. They found the door opening rate to be 4.8 per cent with longitudinal restraint, compared to 12.0 per cent without. Gloyns et al (1975, unpublished) (quoted by Mackay et al 1975) made a more definitive study of three particular British car models, before and after they were fitted with anti-burst door latches. In severe crashes, with a slight bias towards high energy frontal impacts, they found a door opening rate of 33 per cent for the older cars, compared with 16 per cent for the anti-burst latches.

Read et al (1979) compared the opening rates of different types of anti-burst latches fitted to British cars. They found significant differences in performance, with least satisfactory performance from the rotary latch previously fitted to some Chrysler models. They also observed that intrusion was the most serious consequence of door opening in non-rollover crashes, and confirmed that ejection was the most common outcome of door opening in rollovers.

DATA FOR THIS STUDY

The data on which this study was based were collected during the Royal Australasian College of Surgeons (RACS) Pattern of Injury Survey of Victorian road casualties (Nelson 1974). From 1 June 1971, legislation was in force in Victoria requiring hospitals to supply, on a Road Trauma Report (RTR) form, details of injuries for all road accident victims treated. In the RACS Survey these data were supplemented by RTRs filled out using post-mortem reports on fatally-injured road users. In addition, Road Crash Report (RCR) forms describing the crash circumstances of occupant casualties were completed by ambulance officers. As there was no legal compulsion associated with this source, RCR forms were returned for only about one-third of crashes attended by ambulances, with a bias toward rural crashes. Examples of the two data collection forms are shown in Appendix A.

A matched file of trauma and crash reports for the first two years was originally created for analysis by Nelson (1974). This file was later supplemented by data for the third year (Cameron 1977). At the same time the injuries recorded on the RTR were translated to the Abbreviated Injury Scale (AIS) (Joint Committee on Injury Scaling 1976). The full matched file covers 8537 occupants of passenger cars and car derivatives. Further details of the return rates, matching rates, bias and accuracy of the data are given in Nelson (1974), Cameron and Wessels (1975), and Cameron (1977).

The RACS matched file was chosen for this study because of the presence of information on ejection of occupant casualties. It also contains information on seat belt wearing and door opening, though in the latter case this variable pertains to the opening of any door of the occupied vehicle, not to the door adjacent to the occupant's seating position or to the door space through which the occupant may have been ejected. No alternative candidate mass data files contained these three critical variables.

However, the choice of the RACS matched file, which covers occupants of passenger cars and car derivatives only, precluded an evaluation of the effect of ADR 2 for small or large trucks. There were too few occupants of multi-purpose passenger cars in the data file to consider them separately.

PRELIMINARY ANALYSIS

The preliminary analysis first sought to establish the relationship between ejection and severe injury, under Australian conditions. Ejection then became the criterion variable and its relationship with seat belt wearing, crash location, crash configuration, occupant seating position, and door opening were investigated. These relationships were then used in the main analysis where the association between ejection and year of manufacture was considered.

EJECTION AND INJURY SEVERITY

Table I shows the association between ejection and maximum AIS of occupant casualties. Maximum AIS is now the preferred whole-body injury severity measure recommended by the American Medical Association's joint Committee on Injury Scaling, replacing the Overall AIS which is considered too judgemental for research purposes (Petrucelli *et al* 1980). About 12 per cent of the casualties included in Table I had a maximum AIS of zero. This does not imply that they were uninjured, only that their injuries were too minor to be recorded on the AIS scale, such as some of the injuries listed in the General section of the RTR form (see Appendix A).

The association between ejection and injury severity in each of six body regions (defined by Huelke *et al* 1977b) was also considered (Appendix B). Because Huelke *et al* (1977a) had identified a particularly high injury risk to the spine, the AIS score in this body region (thoracic and lumbar spine) was considered explicitly, in addition. Injuries to the thoracic and lumbar spine are also included in the thorax and lower torso body regions in the tables in Appendix B.

In each body region, as for the whole body, there was a statistically significant association between ejection and injury severity, with ejectees being associated with increased injury severity in every case. How much of this association was due to ejection *per se* or due to more severe crash circumstances (which, in turn, were associated with ejection) was not known at this stage (see page 10).

SEAT BELT WEARING

The strong relationship between seat belt wearing and ejection is shown in Tabel II. Also shown is the relationship between ejection and seat belt type. While this latter association between variables was not statistically significant, the data add support to a suggestion by Walz _et al_ (1979) that two-point belts (lap or diagonal type) are associated with higher ejection risk than seat belts of more complex structure (lap/sash, harness, and child type).

CRASH LOCATION

The ejection rate was more than double for occupant casualties in crashes on the open road compared with those in crashes in built-up areas (Table III), presumably because of the difference in travelling speed and hence in crash severity in these two environments. It was not considered to be due to difference in seat belt wearing rates.

CRASH CONFIGURATION

At least part of the difference in ejection rate between the two crash locations is explained by a higher proportion of rollovers in open road crashes and the much higher ejection rate associated with this event compared to non-rollovers (Table III).

Among occupant casualties in non-rollover crashes, there was not a great deal of difference in ejection rate between the two crash environments (8.2 per cent versus 5.4 per cent), but there was evidence of substantial differences as a function of the side of impact on the vehicle (Table IV). Impacts to the sides of the vehicle were associated with higher ejection rates than those to the front, which in turn had a higher ejection rate than impacts to the rear.

SEATING POSITION

Because of the known relationships between seating position and seat belt fitting and wearing (Boughton _et al_, in press; Cameron and Nelson 1977), the association between seating position and ejection could not be considered meaningfully without the simultaneous consideration of seat belt wearing (Table V). Among occupant casualties who were not wearing seat belts, there was a statistically significant ($p < 0.005$) association between seating position and ejection, with higher ejection rates for drivers and front left passengers than other seats. Among seat belt wearers there was also a statistically significant ($p < 0.005$) association, with a tendency for higher ejection rates in the rear seats.

There was also some evidence of an interaction between seating position and side of impact in terms of their relationship with ejection in non-rollover crashes. Table VI shows that unbelted drivers and front left passengers had higher ejection rates when their vehicle was impacted on the side on which they were sitting compared with like occupants sitting opposite the side of impact. There were too few rear outboard occupants to make meaningful comparisons of this type.

DOOR OPENING

The strong relationship between door opening (any door of the occupied vehicle) and ejection is shown in Table VII, for both unbelted and belted occupant casualties. These data indicate that door opening is a good surrogate for occupant ejection, but of course the incidence of door opening cannot, in the RACS data file, be linked to the ejection route of ejected occupants. In addition, door opening occurred with reasonable frequency (5.4 per cent) to the vehicles of seat belted occupants, in contrast with their ejection frequency (2.1 per cent). This means that in circumstances where door opening is used as an alternative criterion for evaluating the effect of ADR 2, data pertaining to seat belted occupants can play a meaningful role.

However, it should be noted that door opening is neither a necessary nor sufficient condition for occupant ejection. There were numerous occupant casualties ejected from vehicles whose doors did not open, and numerous occupants not ejected even though at least one door of their vehicle opened.

EFFECT OF EJECTION PER SE ON INJURY SEVERITY

An attempt was made to estimate the effect on injury severity of ejection *per se*, i.e. the effect of ejection over and above the injuries which would have been sustained had the occupant been contained in the vehicle, after making due allowance for the more severe crash circumstances normally associated with ejection.

In the preceding analyses, it was found that the factors seat belt use, crash location, and type of crash (rollover versus non-rollover) each have a large effect on the ejection rate of occupant casualties. Other studies of the same data (Cameron 1979a) and similar data (Huelke et al 1972) have shown that these same three factors have a strong effect on injury severity measured on the AIS scale. Thus the ejected casualties in the data would have been exposed, had they been contained, to crash circumstances likely to lead to more severe injury, compared with non-ejected occupant casualties.

These prior differences between ejected and non-ejected casualties were controlled by comparing their injury severity distributions only in identical crash circumstances in terms of seat belt use, crash location and type of crash, following the method of Tourin (1958). Tourin also found crash severity to be related to both ejection rate and injury severity, but differences in crash severity could not be controlled due to its absence from the data analysed here, except crudely via the relationship between impact speed and crash location (open road versus built-up area).

The observed number of ejected casualties with serious-to-fatal injuries, i.e. AIS at least 4 (life-threatening, survival probable), was compared with the expected number based on the distribution of maximum AIS among non-ejected casualties in identical crash circumstances (Table VIII). When these observed and expected numbers were summed over all the different crash circumstances, the ratio of the sums represents an estimate of the increase in risk of serious-to-fatal injury due to ejection per se (Table X). Thus ejectees are 2.7 times more likely to sustain serious-to-fatal injuries than if they remain in the car. This compares with a ratio of 3.5 times based on a crude comparison of the injury severity distributions of ejected and non-ejected occupant casualties from Table I. This crude ratio is inflated due to the more severe crash circumstances experienced by ejectees compared with non-ejectees in the data.

Since there were relatively few occupant casualties with maximum AIS at least 4, the effect of ejection per se was also estimated in terms of the risk of severe-to-fatal injuries, i.e. AIS at least 3 (not life-threatening) (Tables IX and X). Thus ejectees are twice as likely to sustain severe-to-fatal injuries than if they remain in the car.

Consideration of the risk of injury ranging from a lower level of severity (AIS at least 3, compared with AIS at least 4) resulted in a more stable estimate of the effect of ejection per se. This can be seen by comparing the risk ratio for ejected casualties who were (formerly) using a seat belt with the ratio for unbelted ejectees, since the consequences of ejection would be expected to be the same for these two types of occupant once they were ejected from the car (Table X). Thus the estimate that ejection per se doubles the risk of severe-to-fatal injury appears to be quite precise, whereas the estimated effect on serious-to-fatal injury does not.

TABLE I: Maximum AIS score of occupant casualties, by presence or absence of ejection.

MAXIMUM AIS	EJECTED		NOT EJECTED	
	No.	%	No.	%
0	49	6.5	991	12.7
1	260	34.3	4147	53.3
2	80	10.6	1033	13.3
3	109	14.4	856	11.0
4	58	7.7	254	3.3
5	173	22.9	437	5.6
6	28	3.7	62	0.8
TOTAL	757	100.0	7780	100.0

Chi-square test for difference in injury distributions:
$X_6^2 = 459.6$ ($p < 0.0001$)

TABLE II: Ejection rate by seat belt wearing and type of belt.

Seat Belt Wearing and Type	NOT EJECTED	EJECTED	EJECTION RATE (%)
NOT WORN	4588	673	12.8
WORN	3082	65	2.1
- lap/sash	2659	52	1.9
- lap	301	11	3.5
- diagonal	31	1	3.1
- harness	29	0	0.0
- child	11	0	0.0
- other and NK	51	1	1.9
NOT KNOWN	110	19	14.7
TOTAL	7780	757	8.9

TABLE III: Ejection rate by crash location and configuration.

Crash Location and Configuration	NOT EJECTED	EJECTED	EJECTION RATE (%)
OPEN ROAD			
- Rollover	661	248	27.3
- Non-rollover	1859	167	8.2
- TOTAL	2520	415	14.1
BUILT-UP AREA			
- Rollover	384	59	13.3
- Non-rollover	4737	269	5.4
- TOTAL	5121	328	6.0
ALL VICTORIA*			
- Rollover	1056	314	22.9
- Non-rollover	6724	445	6.2
- TOTAL	7780	759	8.9

*Includes 153 occupants in crashes in unknown locations.

<u>TABLE IV</u>: Ejection rate by crash configuration.

Crash Configuration	NOT EJECTED	EJECTED	EJECTION RATE (%)
ROLLOVER	1056	314	22.9
NON-ROLLOVER			
- Frontal	2043	100	4.7
- Rear	333	6	1.8
- Right centre	506	46	8.3
- Right front	387	31	7.4
- Right rear	50	6	10.7
- Left centre	713	42	5.6
- Left front	438	47	9.7
- Left rear	73	7	8.8
- Other and NK	2181	158	6.8
TOTAL	7780	757	8.9

TABLE V: Ejection rate by seating position and seat belt wearing*.

Seating Position	BELT NOT WORN		BELT WORN	
	Total Occupant Casualties	EJECTION RATE (%)	Total Occupant Casualties	EJECTION RATE (%)
DRIVER	2291	14.0	1986	1.8
FRONT CENTRE	325	9.5	23	0.0
FRONT LEFT	1316	13.1	1040	2.2
REAR RIGHT	450	10.4	39	7.7
REAR CENTRE	223	9.4	14	14.3
REAR LEFT	496	9.1	45	2.2
OTHER AND NK	160	21.9	0	-
TOTAL	5261	12.8	3082	2.1

*Table excludes 129 occupants for whom seat belt use was unknown.

TABLE VI: Ejection rates (%) of unbelted occupant casualties involved in non-rollover crashes, by seating position and side of impact.
(Number of occupant casualties on which ejection rate based shown in brackets.)

Seating Position	Side of Impact Non-rollovers)			
	FRONTAL OR REAR	RIGHT SIDE	LEFT SIDE	OTHER AND NK
DRIVER	6.8 (724)	13.6 (287)	8.7 (263)	11.2 (642)
FRONT CENTRE	4.4 (89)	2.9 (35)	11.2 (54)	5.2 (96)
FRONT LEFT	7.5 (373)	11.4 (141)	12.6 (230)	10.6 (388)
REAR RIGHT	5.9 (119)	12.5 (56)	10.6 (76)	4.1 (122)
REAR CENTRE	2.4 (42)	7.1 (28)	4.4 (45)	3.3 (61)
REAR LEFT	1.8 (112)	16.3 (49)	8.6 (105)	4.6 (151)
OTHER AND NK	15.1 (33)	0.0 (7)	16.6 (12)	17.6 (51)
TOTAL	6.4 (1492)	12.1 (603)	10.1 (785)	9.3 (1511)

TABLE VII: Ejection rate by seat belt wearing and the incidence of door opening.

Seat Belt Wearing and Door Opening	NOT EJECTED	EJECTED	EJECTION RATE (%)
BELT NOT WORN			
- Doors opened	278	280	50.2
- Doors did not open	4310	393	8.4
BELT WORN			
- Doors opened	146	25	14.6
- Doors did not open	2936	40	1.3
ALL OCCUPANTS*			
- Doors opened	425	308	42.0
- Doors did not open	7355	449	5.8

*Includes 129 occupants for whom seat belt use was unknown.

TABLE IX: Observed and expected frequencies of ejected casualties with maximum AIS at least 3, by seat belt use and crash location and type.

Seat Belt Wearing / Crash Location / Crash Type	NOT EJECTED		EJECTED		
	Total Occupant Casualties	Pct. with Maximum AIS ≥ 3	Total Occupant Casualties	No. with Maximum AIS ≥ 3	Expected No.* with Maximum AIS ≥ 3
1. BELT NOT WORN					
(a) OPEN ROAD					
Non-rollover	1052	31.4	142	88	44.6
Rollover	361	27.1	222	126	60.2
(b) BUILT-UP AREA					
Non-rollover	2869	15.7	240	71	37.7
Rollover	217	13.8	56	27	7.7
(c) LOCATION NK					
Non-rollover	81	21.0	7	6	1.5
Rollover	8	12.5	6	2	0.8
Not Worn Subtotal	4588	20.2	673	320	152.4
2. BELT WORN					
(a) OPEN ROAD					
Non-rollover	745	34.0	16	8	5.4
Rollover	291	24.1	24	15	5.8
(b) BUILT-UP AREA					
Non-rollover	1835	12.2	21	5	2.6
Rollover	164	14.0	3	1	0.4
(c) LOCATION NK					
Non-rollover	44	20.5	0	0	0.0
Rollover	3	66.7	1	0	0.7
Worn Subtotal	3082	18.8	65	29	14.9
3. BELT USE NK					
(a) OPEN ROAD					
Non-rollover	62	93.5	9	9	8.4
Rollover	9	77.8	2	2	1.6
(b) BUILT-UP AREA					
Non-rollover	33	97.0	8	8	7.8
Rollover	3	100.0	0	0	0.0
(c) LOCATION NK					
Non-rollover	3	66.7	0	0	0.0
Rollover	0	0.0	0	0	0.0
TOTAL	7780	20.7	757	368	185.0

* The expected number is based on the distribution of maximum AIS among non-ejected casualties.

TABLE X: Observed and expected numbers of ejected casualties with maximum injury severity level at least (a) AIS = 4, and (b) AIS = 3.

	Maximum AIS ≥ 4	Maximum AIS ≥ 3
NOT EJECTED (N=7780)		
(1) Observed Number	755	1610
(2) Percentage of Total	9.7	20.7
EJECTED (N=757)		
(3) Observed Number	259	368
(4) Crude Expected Number : Nx(2)/100	73.3	156.5
(5) Crude Ratio $\frac{\text{Observed}}{\text{Expected}}$: (3)÷(4)	3.53	2.35
(6) Expected Number after controlling for differences in crash circumstances (Tables VIII and IX)	95.2	185.0
(7) Ratio $\frac{\text{Observed}}{\text{Expected}}$: (3)÷(6)	2.72	1.99
(8) Observed Number by seat belt use		
- belt not worn	215	320
- belt worn	25	29
(9) Expected Number after controlling for crash location and type		
- belt not worn	71.2	152.4
- belt worn	7.0	14.9
10) Ratio $\frac{\text{Observed}}{\text{Expected}}$: (8)÷(9)		
- belt not worn	3.02	2.10
- belt worn	3.57	1.95

MAIN ANALYSIS

INTRODUCTION

The main analysis considered the relationship between year of manufacture and (a) occupant ejection and (b) door opening, in turn. At times both of these criteria were considered together, to gain a better understanding of any change in ejection paths during later years of manufacture.

Because of the known association between seat belt fitting (and hence wearing) and year of manufacture (Boughton and Cameron 1976; Carter 1979), seat belt wearers and non-wearers were considered separately, so far as ejection was concerned. This division of the analysis was also designed to produce results more meaningful in terms of modern vehicles, since any effect of ADR 2 should be seen against a background of high rates of seat belt fitting and wearing in these vehicles.

Rollover and non-rollover crashes were also considered separately, because of the large difference in ejection rates found for occupant casualties involved in these two types of crash.

Since anti-burst door latches were introduced gradually in Australian cars manufactured in the period from the early 1960's up to 1970 (after which ADR 2 required them, along with other door component improvements, to be fitted to all new cars), the hypothesis under test was that there was a monotonic decrease in the risks of ejection and door opening with increasing year of manufacture, versus the hypothesis of no change in risk. This hypothesis could have been tested by a simple test for inequality of the ejection rates and door opening rates between years of manufacture (e.g., Fleiss 1973, section 9.1). However, statistically significant differences between the rates could result from uncontrolled differences between vehicles of different years, such as differences of crash severity and other factors affecting ejection and door opening. Accordingly, a more specific test of the hypothesis of monotonic decrease in ejection and door opening risks was sought for use in conjunction with the test for inequality of the risks.

Barlow *et al* 1972 give a statistical test for a monotonic gradient in proportions, which is described in simpler terms by Fleiss (1973, section 9.3). The test requires that the number of occupant casualties (on which the ejection rate or door opening rate is based) in each vehicle year of manufacture group be constant if there are more than four such groups. Hence for unbelted occupant casualties, the year of manufacture groups were chosen to meet this condition approximately, consistent with other objectives of the study (e.g., separate identification of ADR 2 cars). For belted occupant casualties, which appeared more frequently in the newer cars compared with the unbelted, this condition could not be met easily. In this case, four year of manufacture groups were chosen and an exact version of test, which does not require the condition to be satisfied, was used instead (Fleiss 1973).

Since a number of American researchers had identified an increasing tendency for ejection (if it took place) to be through non-door portals with the advent of anti-burst door latches and FMVSS 206, this aspect of ejection was also investigated in this study. Due to limitations of the data collected, the criterion was limited to the proportion of ejectees who were ejected from vehicles recorded as having had closed doors. In this case, a test for a monotonic *increase* in the proportion was made using the same methods of Barlow *et al* (1972) described above.

UNBELTED OCCUPANTS IN ROLLOVER CRASHES

There was statistically significant evidence of inequalities related to the vehicle year of manufacture for the ejection rate, door opening rate, and proportion of ejectees with closed doors in the case of unbelted occupant casualties involved in rollovers (Table XI). However, there was no statistically significant evidence of gradients in these rates or proportion in the hypothesised directions.

For these occupant casualties, the interaction between year of manufacture and crash location was statistically significant, but that between vehicle year and occupant seating position was not (Table XII). Unbelted casualties involved in rollovers in the later model cars were more likely to have crashed on the open road than like occupants of older model cars.

Since occupants casualties involved in rollovers on the open road were more than twice as likely to have been ejected than those in rollovers in built-up areas (Table III), the above interaction may have contributed to the apparent absence of a decreasing gradient in ejection rate with increasing vehicle year (Table XI). However, when casualties involved in crashes on the open road and in built-up areas were considered separately, there was no statistically significant evidence of a decreasing gradient in ejection rate in either case (Table XIII).

UNBELTED OCCUPANTS IN NON-ROLLOVER CRASHES

In the case of unbelted occupant casualties involved in non-rollover crashes, there was statistically significant evidence of decreasing gradients in the ejection rate and door opening rate, and of an increasing gradient in the proportion of ejectees who were ejected from vehicles with closed doors (Table XIV).

For these occupant casualties, the interactions between vehicle year and (a) occupant seating, (b) crash location, and (c) side of impact, were all statistically significant. Unbelted casualties involved in non-rollover crashes in the later model cars were more likely to have crashed on the open road and less likely to have occupied front seats or vehicles impacted in the side than like occupants of older cars (Tables XV and XVI). While occupant casualties involved in non-rollover crashes on the open road had higher ejection rates than occupants in like crashes in built-up areas (Table III), and ejection rates were higher in front seats compared with rear seats for the unbelted (Table V) and higher in side impacts compared with other impacts (Table IV), these differences were marginal. These marginal differences in ejection rate, coupled with the directions of the interactions identified above, were considered to be insufficient to invalidate the decreasing gradient in ejection rate found in Table XIV.

BELTED OCCUPANTS IN ROLLOVER CRASHES

As with unbelted occupant casualties in rollovers, belted casualties in crashes of the same type displayed no statistically significant evidence of decreasing gradients in ejection rate or door opening rate (Table XVII). (The apparent increasing gradient in ejection rate was not tested for statistical significance in the direction of an increase as this would have been inconsistent with the hypothesised effect of anti-burst door latches and ADR 2; the observed increase may have been due to uncontrolled factors in the analysis, such as crash severity). However, there was statistically significant evidence of an increasing gradient in the proportion of ejectees who were ejected from vehicles with closed doors.

Again as with unbelted occupant casualties, the belted casualties displayed a statistically significant interaction between vehicle year and crash location (Table XVIII). Since belted casualties involved in rollovers in the later model cars were more likely to have crashed on the open road than like occupants of older model cars, the higher ejection rate in this crash environment may have contributed to the apparent absence of a decrease and the presence of an increase in the gradient in ejection rate with increasing vehicle year (Table XVII). However, there was no statistically significant evidence of a decreasing gradient in the ejection rate for belted casualties in rollovers either on the open road or in built-up areas (Table XIX).

BELTED OCCUPANTS IN NON-ROLLOVER CRASHES

As with unbelted occupant casualties from crashes of the same type, the belted casualties in non-rollover crashes displayed statistically significant evidence of decreasing gradients in the ejection rate and door opening rate (Table XX). However, the increasing gradient in the proportion of ejectees with closed doors was not statistically significant.

For these occupant casualties, the interactions between vehicle year and (a) occupant seating position, and (b) crash location, were both statistically significant (Table XXI), but the interaction with side of impact was not (Table XXII). Belted casualties involved in non-rollover crashes in the later model cars were more likely to have crashed on the open road and to have occupied rear seats. Elevated ejection rates were known to be associated with non-rollover crashes on the open road compared with in built-up areas (Table III) and, for seat belt wearers, with rear seat occupancy compared with the front seating positions (Table V). However, the directions of the interactions identified above were such that these elevated ejection rates could only tend to negate, and not invalidate, the decreasing gradient in ejection rate found in Table XX.

DOOR OPENING IN ROLLOVER CRASHES

In this and the following section, belted and unbelted occupant casualties were pooled and the relationship between year of manufacture and door opening was considered. The pooled data allowed more sensitive investigations of this relationship compared with the investigations based on unbelted and belted casualties separately. However, the pooled data could not be used to study the relationship between ejection and vehicle year as the association between these two variables in the pooled data would be distorted by the higher seat belt wearing rates in the newer cars and the known dependence of ejection on seat belt use.

For all occupant casualties involved in rollovers, there was no statistically significant evidence of a decreasing gradient in the door opening rate with increasing vehicle year (Table XXIII). It should be recalled at this stage, that due to the manner in which data were recorded on the Road Crash Report (Appendix A), the incidence of door opening (any door of the occupied vehicle) relates to the vehicle occupied and hence is recorded identically for all occupant casualties from the same vehicle. Hence vehicles with more than one occupant casualty are recorded more than once in the first two columns of Table XXIII. The frequency of this multiple recording is not known, as it is not possible to uniquely identify individual vehicles in the RACS matched file, which is occupant-centred.

One solution to this problem is to consider only driver casualties in the data. This avoids multiple counting of vehicles, but efffectively ignores those vehicles whose drivers were not injured and recorded in the matched file. However, consideration of driver casualties alone meant that their door opening rates were closer to being based on independent events (the crashes), and hence more closely satisfying one of the conditions for validity of the statistical tests.

In the event when driver casualties only were considered, there was still no statistically significant evidence of a decreasing gradient in door opening rate (Table XXIII). The pattern of door opening rates based on drivers only was similar to that based on all occupant casualties.

Since a statistically significant interaction between the crash location and year of manufacture of vehicles involved in rollovers was identified for unbelted and belted casualties separately (Tables XII and XVIII), the evidence for a decreasing gradient in door opening rate was examined for each crash location individually (Table XXIV). There was no statistically significant evidence of a decreasing gradient in the door opening rate of vehicles occupied by driver casualties from crashes either on the open road or in built-up areas.

DOOR OPENING IN NON-ROLLOVER CRASHES

In non-rollover crashes, there was statistically significant evidence of a decreasing gradient in the door opening rate when all occupant casualties were considered and when driver casualties alone were considered (Table XXV). These findings confirmed parallel findings when unbelted and belted casualties involved in non-rollover crashes were studied separately (Tables XIV and XX).

As with rollover crashes, statistically significant interactions between the crash location and year of manufacture of vehicles involved in non-rollover crashes had been identified for unbelted and belted casualties separately (Tables XV and XXI). While the common direction of these interactions would have tended to negate the decreasing gradient in door opening rate found in Table XXV, it was considered instructive to examine door opening rates in the two crash locations separately. In the event, there were statistically significant decreasing gradients in the door opening rates of vehicles occupied by driver casualties from crashes in each crash environment (Table XXVI).

The availability of the pooled data on non-rollover crashes meant that a meaningful study could be made of door opening rates and their gradients (if any) as a function of the crash configuration. There were statistically significant decreasing gradients in the door opening rates of vehicles impacted in the ends (front or rear) or the side, but only weakly statistically significant evidence of such a gradient among vehicles impacted in other (i.e. more than one location) and unknown locations (Table XXVII).

TABLE XI: Unbelted occupant casualties in rollovers.
Ejection rate, door opening rate, and proportion of ejectees whose vehicles had closed doors, by year of manufacture.

Year of Manufacture	Total Occupant Casualties	EJECTION RATE (%)	DOOR OPENING RATE (%)	EJECTEES WITH CLOSED DOORS (%)
UP TO 1959	133	32.3	15.0	77
1960-62	137	40.8	32.8	50
1963-64	113	24.8	18.6	54
1965-66	131	27.5	23.7	44
1967-68	111	36.9	33.3	42
1969-70	122	23.0	22.2	50
1971-74	111	44.1	29.7	61
NOT KNOWN	12	25.0	0.0	100
TOTAL	870	32.6	24.6	54

Ejection rates

Test for inequality of rates: $X_6^2 = 21.77$ $(p < 0.002)$

Test for decreasing gradient: $\bar{X}_7^2 = 3.02$ $(p > 0.1)$

Door opening rates

Test for inequality of rates: $X_6^2 = 20.15$ $(p < 0.003)$

Test for decreasing gradient: $\bar{X}_7^2 = 0.0$ $(p > 0.1)$

Proportion of ejectees with closed doors

Test for inequality of proportions: $X_6^2 = 14.44$ $(p < 0.03)$

Test for increasing gradient: $\bar{X}_7^2 = 0.31$ $(p > 0.1)$

TABLE XII: Unbelted occupant casualties in rollovers. Distributions by seating position and crash location, by year of manufacture.

Year of Manufacture	SEATING POSITION*		CRASH LOCATION**	
	FRONT (%)	REAR (%)	OPEN ROAD (%)	BUILT-UP AREA (%)
UP TO 1959	70.0	24.8	63.2	35.3
1960-62	75.2	18.2	65.0	31.4
1963-64	73.5	21.2	78.8	19.5
1965-66	67.9	26.0	51.9	47.3
1967-68	64.0	31.5	66.7	32.4
1969-70	64.8	26.2	73.0	27.0
1971-74	78.4	15.3	77.5	19.8
NOT KNOWN	41.7	25.0	33.3	66.7
TOTAL	70.1	23.3	67.0	31.4

Note: Percentages do not necessarily add to 100 per cent.

* Excludes 57 occupants with unknown seating position.

** Excludes 14 occupants involved in crashes in unknown locations.

Tests for interaction with year of manufacture

(a) Seating Position: $X^2_6 = 11.67$ ($p > 0.05$)

(b) Crash Location: $X^2_6 = 31.50$ ($p < 0.0001$)

TABLE XIII: Unbelted occupant casualties in rollovers. Ejection rate by year of manufacture and crash location*.

Year of Manufacture	OPEN ROAD		BUILT-UP	
	Total Occupant Casualties	EJECTION RATE (%)	Total Occupant Casualties	EJECTION RATE (%)
UP TO 1959	84	39.3	47	21.3
1960-62	89	49.4	43	20.9
1963-64	89	25.8	22	22.7
1965-66	68	41.2	62	12.9
1967-68	74	39.2	36	30.6
1969-70	89	25.8	33	15.2
1971-74	86	48.8	22	22.7
NOT KNOWN	4	0.0	8	37.5
TOTAL	583	38.1	273	20.5

*Table excludes 14 occupants involved in crashes in unknown locations.

Ejection rates in open road crashes

Test for inequality of rates: $X_6^2 = 20.69$ ($p < 0.003$)

Test for decreasing gradient: $\bar{X}_7^2 = 3.97$ ($p > 0.01$)

Ejection rates in crashes in built-up areas

Test for inequality of rates: $X_6^2 = 5.22$ ($p > 0.5$)

Test for decreasing gradient: $\bar{X}_7^2 = 0.28$ ($p > 0.1$)

TABLE XIV: Unbelted occupant casualties in non-rollover crashes. Ejection rate, door opening rate, and proportion of ejectees whose vehicles had closed doors, by year of manufacture.

Year of Manufacture	Total Occupant Casualties	EJECTION RATE (%)	DOOR OPENING RATE (%)	EJECTEES WITH CLOSE DOORS (%)
UP TO 1959	582	12.4	9.1	60
1960-62	558	13.2	12.3	57
1963-64	680	10.7	10.4	47
1965-66	687	6.0	8.2	59
1967-68	682	7.2	4.8	73
1969-70	662	5.8	5.3	71
1971-74	492	7.7	4.9	76
NOT KNOWN	48	8.3	6.3	50
TOTAL	4391	8.9	7.8	61

Ejection rates

Test for inequality of rates: $X_6^2 = 43.47$ ($p < 0.0001$)

Test for decreasing gradient: $\bar{X}_7^2 = 41.24$ ($p < 0.005$)

Door opening rates

Test for inequality of rates: $X_6^2 = 43.96$ ($p < 0.0001$)

Test for decreasing gradient: $\bar{X}_7^2 = 34.55$ ($p < 0.005$)

Proportion of ejectees with closed doors

Test for inequality of proportions: $X_6^2 = 15.67$ ($p < 0.02$)

Test for increasing gradient: $\bar{X}_7^2 = 12.70$ ($p < 0.005$)

TABLE XV: Unbelted occupant casualties in non-rollover crashes. Distributions by seating position and crash location, by year of manufacture.

Year of Manufacture	SEATING POSITION*		CRASH LOCATION**	
	FRONT (%)	REAR (%)	OPEN ROAD (%)	BUILT-UP AREA (%)
UP TO 1959	77.8	18.9	23.0	74.2
1960-62	78.3	20.1	25.8	72.6
1963-64	78.7	19.4	27.2	70.6
1965-66	76.4	20.7	22.7	76.0
1967-68	75.5	22.1	30.2	67.9
1969-70	70.1	28.9	30.7	66.7
1971-74	73.2	23.8	31.7	67.1
NOT KNOWN	68.8	22.9	20.8	75.0
TOTAL	75.7	22.0	27.2	70.8

Note: Percentages do not necessarily add to 100 per cent.

*Excludes 103 occupants with unknown seating position.

**Excludes 88 occupants involved in crashes in unknown locations.

Tests for interaction with year of manufacture

(a) Seating Position: $X^2_6 = 25.39$ ($p < 0.0005$)

(b) Crash Location: $X^2_6 = 25.12$ ($p < 0.0005$)

TABLE XVI: Unbelted occupant casualties in non-rollover crashes. Distribution by side of impact and year of manufacture.

Year of Manufacture	SIDE OF IMPACT		
	FRONTAL OR REAR (%)	LEFT OR RIGHT SIDE (%)	OTHER AND NK (%)
UP TO 1959	29.9	33.8	36.3
1960-62	30.1	35.1	34.8
1963-64	33.1	32.4	34.6
1965-66	36.5	31.7	31.7
1967-68	35.3	31.4	33.3
1969-70	38.4	29.5	32.2
1971-74	34.3	27.6	38.0
NOT KNOWN	20.8	25.0	54.2
TOTAL	34.0	31.6	34.4

Test for interaction between side of impact and year of manufacture: $X^2_{12} \doteq 22.57$ ($p < 0.05$)

TABLE XVIII: Belted occupant casualties in rollovers. Distributions by seating position and crash location, by year of manufacture.

Year of Manufacture	SEATING POSITION		CRASH LOCATION*	
	FRONT (%)	REAR (%)	OPEN ROAD (%)	BUILT-UP AREA (%)
UP TO 1964	94.9	5.1	54.7	44.4
1965-68	96.2	3.8	61.7	37.6
1969-70	95.8	4.2	65.6	32.3
1971-74	92.7	7.3	75.2	24.8
NOT KNOWN	100.0	0.0	100.0	0.0
TOTAL	94.9	5.1	64.8	34.4

Note: Percentages do not necessarily add to 100 per cent.

*Excludes 4 occupants involved in crashes in unknown locations.

Tests for interaction with year of manufacture

(a) Seating Position: $X_3^2 = 2.00$ ($p > 0.5$)

(b) Crash Location: $X_3^2 = 11.84$ ($p < 0.01$)

TABLE XIX: Belted occupant casualties in rollovers. Ejection rate by year of manufacture and crash location*.

Year of Manufacture	OPEN ROAD		BUILT-UP AREA	
	Total Occupant Casualties	EJECTION RATE (%)	Total Occupant Casualties	EJECTION RATE (%)
UP TO 1964	64	4.7	52	0.0
1965-68	82	2.4	50	2.0
1969-70	63	6.3	31	3.2
1971-74	103	14.6	34	2.9
NOT KNOWN	3	0.0	0	n.c.
TOTAL	315	7.6	167	1.8

*Table excludes 4 occupants involved in crashes in unknown locations.

n.c.: Not calculable (no occupant casualties involved)

Ejection rates in open road crashes

Test for inequality of rates: $X_3^2 = 11.01$ ($p < 0.05$)

Test for decreasing gradient: $\bar{X}_4^2 = 0.0$ ($p > 0.1$)

Ejection rates in crashes in built-up areas

Test for inequality of rates: $X_3^2 = 1.57$ ($p > 0.6$)

Test for decreasing gradient: $\bar{X}_4^2 = 0.0$ ($p > 0.1$)

TABLE XX: Belted occupant casualties in non-rollover crashes. Ejection rate, door opening rate, and proportion of ejectees whose vehicles had closed doors, by year of manufacture.

Year of Manufacture	Total Occupant Casualties	EJECTION RATE (%)	DOOR OPENING RATE (%)	EJECTEES WITH CLOSED DOORS (%)
UP TO 1964	524	2.3	5.5	50
1965-68	841	1.2	3.6	70
1969-70	623	1.6	2.9	70
1971-74	657	0.8	2.9	80
NOT KNOWN	16	0.0	12.5	n.c.
TOTAL	2661	1.4	3.7	65

n.c.: Not calculable (no ejectees involved)

Ejection rates

Test for inequality of rates: $X_3^2 = 5.42$ ($p > 0.1$)

Test for decreasing gradient: $\bar{X}_4^2 = 4.97$, $c_1 = 0.40$, $c_2 = 0.54$ ($p < 0.05$)

Door opening rates

Test for inequality of rates: $X_3^2 = 7.44$ ($0.1 > p > 0.05$)

Test for decreasing gradient: $\bar{X}_4^2 = 7.44$, $c_1 = 0.40$, $c_2 = 0.54$ ($p < 0.025$)

Proportion of ejectees with closed doors

Test for inequality of proportions: $X_3^2 = 1.90$ ($p > 0.5$)

Test for increasing gradient: $\bar{X}_4^2 = 1.90$, $c_1 = 0.52$, $c_2 = 0.41$ ($p > 0.1$)

TABLE XXI: Belted occupant casualties in non-rollover crashes. Distributions by seating position and crash location, by year of manufacture.

Year of Manufacture	SEATING POSITION		CRASH LOCATION*	
	FRONT (%)	REAR (%)	OPEN ROAD (%)	BUILT-UP AREA (%)
UP TO 1964	98.7	1.3	25.8	71.4
1965-68	98.3	1.7	23.7	74.4
1969-70	98.1	1.9	28.7	69.7
1971-74	93.9	6.1	37.0	62.6
NOT KNOWN	100.0	0.0	31.3	68.8
TOTAL	97.3	2.7	28.6	69.7

Note: Percentages do not necessarily add up to 100 per cent.

*Excludes 44 occupants involved in crashes in unknown locations.

Tests for interaction with year of manufacture

(a) Seating Position: $X_3^2 = 36.45$ ($p < 0.0001$)

(b) Crash Location: $X_3^2 = 32.15$ ($p < 0.0001$)

TABLE XXII: Belted occupant casualties in non-rollover crashes. Distribution by side of impact, by year of manufacture.

Year of Manufacture	SIDE OF IMPACT		
	FRONTAL OR REAR (%)	LEFT OR RIGHT SIDE (%)	OTHER AND NK (%)
UP TO 1964	32.6	34.7	32.6
1965-68	34.4	34.7	30.9
1969-70	36.3	32.9	30.8
1971-74	39.3	32.9	27.9
NOT KNOWN	18.8	31.3	50.0
TOTAL	35.6	33.8	30.6

Test for interaction between side of impact and year of manufacture: $X_6^2 = 7.22$ $(p > 0.3)$

TABLE XXIII: Door opening rates in rollovers. Belted and unbelted occupant casualties considered together, as well as belted and unbelted driver casualties.

Year of Manufacture	ALL OCCUPANTS		DRIVERS ONLY	
	Total Occupant Casualties	DOOR OPENING RATE (%)	Total Driver Casualties	DOOR OPENING RATE (%)
UP TO 1959	172	14.5	85	16.5
1960-62	170	31.8	82	30.5
1963-64	158	17.1	80	17.5
1965-66	187	20.9	94	19.1
1967-68	193	24.9	88	23.9
1969-70	221	19.9	108	18.5
1971-74	254	19.7	146	19.2
NOT KNOWN	15	0.0	4	0.0
TOTAL	1370	20.9	687	20.4

All occupants

Test for inequality of rates: $X_6^2 = 19.68$ ($p < 0.005$)

Test for decreasing gradient: $\bar{X}_7^2 = 1.31$ ($p > 0.1$)

Drivers only

Test for inequality of rates: $X_6^2 = 7.44$ ($p > 0.2$)

Test for decreasing gradient: $\bar{X}_7^2 = 1.24$ ($p > 0.1$)

TABLE XXIV: Door opening rates of driver casualties in rollovers, by year of manufacture and crash location*.

Year of Manufacture	OPEN ROAD		BUILT-UP AREA	
	Total Driver Casualties	DOOR OPENING RATE (%)	Total Driver Casualties	DOOR OPENING RATE (%)
UP TO 1959	50	16.0	33	15.2
1960-62	49	34.7	31	22.6
1963-64	53	17.0	25	20.0
1965-66	51	27.5	42	9.5
1967-68	60	26.7	27	14.8
1969-70	73	20.5	35	14.3
1971-74	111	18.9	35	20.0
NOT KNOWN	2	0.0	2	0.0
TOTAL	449	22.3	230	16.1

*Table excludes 8 drivers involved in crashes in unknown locations.

Door opening rates in open road crashes

Test for inequality of rates: $X_6^2 = 8.64$ ($p > 0.1$)

Test for decreasing gradient: $\bar{X}_7^2 = 1.56$ ($p > 0.1$)

Door opening rates in crashes in built-up areas

Test for inequality of rates: $X_6^2 = 3.10$ ($p > 0.7$)

Test for decreasing gradient: $\bar{X}_7^2 = 0.89$ ($p > 0.1$)

TABLE XXV: Door opening rates in non-rollover crashes. Belted and unbelted occupant casualties considered together, as well as belted and unbelted driver casualties.

Year of Manufacture	ALL OCCUPANTS		DRIVERS ONLY	
	Total Occupant Casualties	DOOR OPENING RATE (%)	Total Driver Casualties	DOOR OPENING RATE (%)
UP TO 1959	719	8.8	363	8.3
1960-62	734	10.8	359	9.2
1963-64	925	9.1	453	7.7
1965-66	1031	6.6	505	7.1
1967-68	1201	4.2	653	4.3
1969-70	1305	4.1	662	3.9
1971-74	1188	3.6	634	3.3
NOT KNOWN	64	7.8	33	6.1
TOTAL	7167	6.2	3662	5.8

All occupants

Test for inequality of rates: $X_6^2 = 79.52$ ($p < 0.0001$)

Test for decreasing gradient: $\bar{X}_7^2 = 76.93$ ($p < 0.005$)

Drivers only

Test for inequality of rates: $X_6^2 = 30.66$ ($p < 0.0001$)

Test for decreasing gradient: $\bar{X}_7^2 = 30.41$ ($p < 0.005$)

TABLE XXVI: Door opening rates of driver casualties in non-rollover crashes, by year of manufacture and crash location*.

Year of Manufacture	OPEN ROAD		BUILT-UP AREA	
	Total Driver Casualties	DOOR OPENING RATE (%)	Total Driver Casualties	DOOR OPENING RATE (%)
UP TO 1959	82	14.6	272	6.3
1960-62	93	12.9	258	7.8
1963-64	127	14.2	318	5.0
1965-66	110	10.0	385	6.5
1967-68	157	7.0	484	3.5
1969-70	193	6.2	455	3.1
1971-74	218	4.6	409	2.7
NOT KNOWN	10	10.0	22	4.5
TOTAL	990	8.8	2603	4.6

*Table excludes 69 drivers involved in crashes in unknown locations.

Door opening rates in open road crashes

Test for inequality of rates: $X_6^2 = 17.29$ ($p < 0.01$)

Test for decreasing gradient: $\bar{X}_7^2 = 17.17$ ($p < 0.005$)

Door opening rates in crashes in built-up areas

Test for inequality of rates: $X_6^2 = 17.72$ ($p < 0.01$)

Test for decreasing gradient: $\bar{X}_7^2 = 16.19$ ($p < 0.005$)

TABLE XXVII: Door opening rates of driver casualties in non-rollover crashes, by year of manufacture and side of impact.

DOOR OPENING RATES (%)

Year of Manufacture	SIDE OF IMPACT		
	FRONTAL OR REAR	LEFT OR RIGHT SIDE	OTHER AND UNKNOWN
UP TO 1959	5.4	8.8	10.8
1960-62	11.8	8.9	6.7
1963-64	8.2	9.1	6.0
1965-66	4.3	9.4	8.2
1967-68	3.1	2.9	7.5
1969-70	2.7	4.8	4.6
1971-74	2.0	3.2	5.1
NOT KNOWN	0.0	14.3	5.6
TOTAL	4.6	6.2	6.7

Door opening rates in frontal or rear impacts

Test for inequality of rates: $X_6^2 = 27.21$ ($p < 0.0001$)

Test for decreasing gradient: $\bar{X}_7^2 = 21.18$ ($p < 0.05$)

Door opening rates in side impacts

Test for inequality of rates: $X_6^2 = 15.10$ ($p < 0.02$)

Test for decreasing gradient: $\bar{X}_7^2 = 14.43$ ($p < 0.005$)

Door opening rates in other and unknown impacts

Test for inequality of rates: $X_6^2 = 6.35$ ($p > 0.3$)

Test for decreasing gradient: $\bar{X}_7^2 = 5.58$ ($0.1 > p > 0.05$)

SUMMARY AND DISCUSSION

There was strong evidence of a decreasing gradient in ejection risk with increasing vehicle year for occupant casualties involved in non-rollover crashes. This applied to unbelted occupants and also to belted occupants even though the ejection risk of the latter was considerably lower. This decreasing gradient in ejection risk was accompanied by a similar decreasing gradient in the probability of door opening of the vehicles occupied by the same casualties. These changes took place among vehicles manufactured during a period when anti-burst door latches were gradually being introduced into Australian cars. The last few years of the period saw the introduction of ADR 2, which formalised the requirement for anti-burst doors. These three parallel series of events represent strong evidence that ADR 2 (and the anti-burst door latches fitted prior to the formal requirement) is effective in reducing the risk of ejection, via a reduction in the probability of door opening, for occupants involved in non-rollover crashes.

There was no statistically significant evidence of a decreasing gradient in ejection risk for occupant casualties involved in rollover crashes, neither for unbelted nor belted occupants. The occupants of later model cars were more likely to have crashed in a high speed environment (the open road) than occupants of the older cars, but when this difference in crash location was taken into account, there was still no statistically significant evidence of a decreasing gradient in ejection risk. Similar results were found for the probability of door opening of vehicles involved in rollovers. One of three factors may explain the lack of evidence of an effect of anti-burst door latches and ADR 2 on the risk of ejection and door opening in rollover crashes.

First, there were more than five times as many occupant casualties involved in non-rollover crashes than in rollovers. Thus, even though the risks of ejection and door opening were considerably higher in the latter type of crash, there may have been insufficient occupant casualties involved in rollovers in the data file for real decreases in these risks to be apparent.

Second, the occupant casualties from later model cars may have been involved in more severe rollover crashes than the occupants of older cars, thus negating any beneficial effects of anti-burst door latches and ADR 2. This difference in crash severity may have been greater than the effect due to the difference in crash location distribution between older and newer cars; this latter difference was, of course, observed in the data and taken into account in the analysis of rollover crashes. An analysis of frontal impacts in the same data file indicated that there was a tendency for occupants of later model cars to have been involved in crashes of greater severity, over and above that explained by having crashed in a higher speed environment (Cameron 1979b).

Third, there may not, in fact, exist beneficial effects from anti-burst door latches and ADR 2 in rollovers. The more complex nature and increased severity of crashes of this type, compared with non-rollover crashes, may militate against the design of door components intended to prevent door opening. None of the studies on the effectiveness of anti-burst door latches reviewed earlier included a specific evaluation in rollover crashes alone, usually because of the paucity of data from such crashes compared with crashes in general. However, regarding the effectiveness or ineffectiveness of anti-burst door latches and ADR 2 in rollover crashes, this study must be considered inconclusive because of the possibility of one or both of the first two explanations given above.

For occupant casualties in non-rollover crashes, for whom decreasing gradients in the risks of ejection and door opening were identified, there was evidence of an increasing gradient in the proportion of ejectees who were ejected from vehicles with closed doors. This evidence was statistically significant for unbelted ejectees, but not for those ejectees who were initially belted. These results tend to suggest that while anti-burst door latches and ADR 2 are effective (in non-rollover crashes) in reducing the probability of door opening and hence also the risk of ejection, these vehicle design features do not achieve their full potential in terms of ejection risk reduction because the door space is but one of the portals of ejection; in addition, some ejectees may now exit via the door windows whereas previously they would have passed through opened doors.

While on the subject of ejection with closed doors, an increasing gradient in the proportion of previously belted ejectees who were so ejected was the only statistically significant result in an hypothesised direction among those casualties involved in rollovers. However, this was considered to be weak evidence of an effect of anti-burst door latches and ADR 2 in this type of crash because of the absence of parallel evidence of decreasing gradients in the risks of ejection and door opening.

There was strong evidence of an association between ejection and injury severity. However, there was also evidence that the ejected casualties were associated with more severe crash circumstances in terms of seat belt non-use, crash location, and type of crash compared with the non-ejected casualties. When these differences in crash circumstances were taken into account, it was found that the increase in the risk of severe injury due to ejection per se was not as great as that based on a crude comparison of the injury severity distributions of the ejected and non-ejected casualties. Ejected casualties were twice as likely to sustain severe-to-fatal injuries (AIS at least 3) than if they had been contained within the car.

ADR 2 still has a meaningful role to play in modern vehicles, in which ADRs for seat belt fitting, coupled with legislation in all Australian States and Territories requiring use of available belts, have lead to high rates of seat belt use. While seat belt use has a strong effect on the risk of ejection (Table II), there is still a substantial risk of ejection for seat belt wearers (particularly in rollover crashes). In addition, there is still a substantial proportion of occupants who do not wear available belts. This study has shown that ADR 2 is effective, at least in non-rollover crashes, in reducing the risk of ejection of seat belt wearers as well as non-wearers.

CONCLUSIONS

1. Ejection doubles the risk of severe-to-fatal injury (AIS at least 3) compared with being contained in the car in the same crash circumstances.

2. ADR 2 (and the anti-burst door latches fitted to Australian cars prior to the formal requirement) is effective in reducing the risk of ejection, via a reduction in the probability of door opening, for occupants of cars and car derivatives involved in non-rollover crashes.

3. Regarding the effectiveness of ADR 2 in rollover crashes, this study was inconclusive due to the relatively small number of occupant casualties involved in crashes of this type and also due to the possibility that the later model cars may have been involved in more severe rollover crashes than the older cars. Anti-burst door latches may be in need of improved design to take account of whatever mechanism opens doors in rollovers.

4. ADR 2 (and the anti-burst door latches fitted prior to formal requirements) transfers the route of ejection of the remaining ejectees away from the door opening and towards non-door portals.

5. ADR 2 still has a meaningful role in modern vehicles with high rates of seat belt use. The Design Rule is effective, at least in non-rollover crashes, in reducing the risk of ejection of seat belt wearers as well as non-wearers.

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APPENDIX A

DATA COLLECTION FORMS

1. Road Trauma Report
2. Road Crash Report

ROAD TRAUMA REPORT

NAME.. Sex.............................. Age..........................

Vehicle Registration No. [ ] Seat Belt Worn [ ] Yes [ ] No

Date of Accident................../................../.................... Time of Accident ....a.m. ....p.m.

Locality of Accident..

Hospital.. Casualty No. .... UR No. ....

Time of Hospital Examination ....a.m. ....p.m.

SOURCE OF INFORMATION [ ] 1. CASUALTY [ ] WARD [ ] 3. CORONER

[Please place tick in relevant box (✓)]

A. GENERAL

LOSS OF CONSCIOUSNESS YES [ ] NO [ ]
1. Transient [ ]
2. Conscious on Arrival [ ]

Unconscious on Arrival YES [ ] NO [ ]
1. From Time of Accident [ ]
2. Lucid Interval [ ]
3. Recovery Rapid [ ]
4. Delayed [ ]

BLOOD LOSS YES [ ] NO [ ]
1. <500 Ml. [ ]
2. >500 Ml. [ ]

VOMIT YES [ ] NO [ ]
1. Inhaled [ ]
2. Not Inhaled [ ]

SHOCK YES [ ] NO [ ]
1. Moderate [ ]
2. Severe [ ]

CONTINUING HAEMORRHAGE YES [ ] NO [ ]
1. Head and Neck [ ]
2. Trunk [ ]
3. Intraabdominal [ ]
4. Intrathoracic [ ]
5. Limbs [ ]

FACIAL BONE FRACTURE YES [ ] NO [ ]
1. Malar [ ]
2. Middle $\frac{1}{3}$ [ ]
3. Mandible [ ]
4. Nasal [ ]

CERVICAL SPINE FRACTURE YES [ ] NO [ ]
1. Body Stable [ ]
2. Body Unstable [ ]
3. Accessory Process [ ]

NON SPECIFIC (WHIPLASH) YES [ ] NO [ ]

SPINAL CORD DAMAGE YES [ ] NO [ ]
1. Transient [ ]
2. Paraplegia – Arms [ ]
3. Paraplegia – Legs [ ]

EYE DAMAGE YES [ ] NO [ ]
1. Major [ ]
2. Minor [ ]

BRAIN DAMAGE YES [ ] NO [ ]
1. Concussion [ ]
2. Primary Severe Brain Damage [ ]
3. Secondary Intracranial Compression [ ]

TREATMENT YES [ ] NO [ ]
1. Operative – Major [ ]
2. Operative – Minor [ ]
3. Conservative [ ]

B. HEAD AND NECK

YES [ ] NO [ ]
1. Major [ ]
2. Minor [ ]

SOFT TISSUE YES [ ] NO [ ]
1. Laceration [ ]
2. Abrasion [ ]
3. Bruising [ ]
4. Penetrating [ ]
5. Loss of Tissue [ ]

SKULL FRACTURE YES [ ] NO [ ]
1. Vault – closed [ ]
2. Vault – depressed [ ]
3. Vault – compound [ ]
4. Base [ ]

C. CHEST

YES [ ] NO [ ]
1. Major [ ]
2. Minor [ ]

SURFACE TISSUE YES [ ] NO [ ]
1. Laceration [ ]
2. Abrasion [ ]
3. Bruising [ ]
4. Penetrating [ ]
5. Loss of Tissue [ ]

FRACTURE YES [ ] NO [ ]
1. Ribs [ ]
   Minor [ ]
   Flail [ ]
2. Clavicle [ ]
3. Sternum [ ]
4. Scapula [ ]

ROAD TRAUMA REPORT

[Please place tic[illegible] relevant box (✓)]

CHEST (Cont.)

PNEUMOTHORAX YES ☐ NO ☐
1. Right – Open ☐
2. Right – Closed ☐
3. Right – Tension ☐
4. Left – Open ☐
5. Left – Closed ☐
6. Left – Tension ☐

HAEMOTHORAX YES ☐ NO ☐
1. Right ☐
2. Left ☐

LUNG DAMAGE YES ☐ NO ☐
1. Right ☐
2. Left ☐

AORTA DAMAGE YES ☐ NO ☐
1. Major ☐
2. Minor ☐

TRACHEA DAMAGE YES ☐ NO ☐
1. Major ☐
2. Minor ☐

OESOPHAGUS DAMAGE YES ☐ NO ☐
1. Major ☐
2. Minor ☐

HEART DAMAGE YES ☐ NO ☐
1. Major ☐
2. Minor ☐

MAJOR VEIN DAMAGE YES ☐ NO ☐
1. Major ☐
2. Minor ☐

TREATMENT YES ☐ NO ☐
1. Operative – Major ☐
2. Operative – Minor ☐
3. Conservative ☐

D. ABDOMEN AND PELVIS YES ☐ NO ☐
1. Major ☐
2. Minor ☐

SURFACE TISSUES YES ☐ NO ☐
1. Laceration ☐
2. Abrasion ☐
3. Bruising ☐
4. Penetrating ☐
5. Loss of Tissue ☐

DAMAGED INTERNAL ORGANS YES ☐ NO ☐
1. Spleen ☐
2. Liver ☐
3. Bladder – Intraperitoneal ☐
4. Bladder – Extraperitoneal ☐
5. Urethra Membranous ☐
6. Urethra Extramembranous ☐
7. Ureter – Right ☐
8. Ureter – Left ☐
9. Pancreas ☐
10. Kidney – Right ☐

DAMAGED INTERNAL ORGANS (Cont.)
11. Kidney – Left YES ☐ NO ☐
12. Duodenum ☐
13. Diaphragm ☐
14. Bowel – Large ☐
15. Bowel – Small ☐
16. Mesentery ☐
17. Major Vessel ☐
18. Stomach ☐
19. Other ☐

TREATMENT YES ☐ NO ☐
1. Operative – Major ☐
2. Operative – Minor ☐
3. Conservative ☐

E. SPINE AND PELVIC BONES YES ☐ NO ☐
1. Major ☐
2. Minor ☐

FRACTURE SPINE YES ☐ NO ☐

BODY YES ☐ NO ☐
1. Thoracic ☐
2. Lumbar ☐
3. Sacral ☐

Stable YES ☐ NO ☐
1. Thoracic ☐
2. Lumbar ☐
3. Sacral ☐

Unstable YES ☐ NO ☐
1. Thoracic ☐
2. Lumbar ☐
3. Sacral ☐

ACCESSORY PROCESS YES ☐ NO ☐
1. Thoracic ☐
2. Lumbar ☐
3. Sacral ☐

FRACTURE PELVIS YES ☐ NO ☐

	L.	R.
1. Pubic Rami	☐	☐
2. Ischial Rami	☐	☐
3. Sacro Iliac Joint	☐	☐
4. Acetabulum (Central Dislocation)	☐	☐
5. Other	☐	☐

SPINAL CORD DAMAGE YES ☐ NO ☐
1. Transient ☐
2. Paraplegia ☐
3. Cauda Equina ☐

TREATMENT YES ☐ NO ☐
1. Operative – Major ☐
2. Operative – Minor ☐
3. Conservative ☐

(Please place tick in relevant box (✓))

F. EXTREMITIES

UPPER LIMBS YES[ ] NO[ ]

1. Major [ ]
2. Minor [ ]

SURFACE TISSUE YES[ ] NO[ ]

	L.	R.
1. Laceration	[ ]	[ ]
2. Abrasion	[ ]	[ ]
3. Bruising	[ ]	[ ]
4. Penetrating	[ ]	[ ]
5. Loss of Tissue	[ ]	[ ]

FRACTURES YES[ ] NO[ ]

	L.	R.
1. Arm	[ ]	[ ]
2. Forearm	[ ]	[ ]
3. Wrist	[ ]	[ ]
4. Fingers	[ ]	[ ]

DISLOCATION YES[ ] NO[ ]

	L.	R.
1. Acromioclavicular	[ ]	[ ]
2. Shoulder	[ ]	[ ]
3. Elbow	[ ]	[ ]
4. Wrist	[ ]	[ ]
5. Fingers	[ ]	[ ]

NERVE INJURY YES[ ] NO[ ]

L. [ ] R. [ ]

MAJOR VESSEL INJURY YES[ ] NO[ ]

L. [ ] R. [ ]

TREATMENT YES[ ] NO[ ]

	L.	R.
1. Operative – Major	[ ]	[ ]
2. Operative – Minor	[ ]	[ ]
3. Conservative – Plaster	[ ]	[ ]
4. Conservative – Traction	[ ]	[ ]
5. Conservative – Manipulation	[ ]	[ ]
6. Other	[ ]	[ ]

LOWER LIMBS YES[ ] NO[ ]

1. Major [ ]
2. Minor [ ]

SURFACE TISSUE YES[ ] NO[ ]

	L.	R.
1. Laceration	[ ]	[ ]
2. Abrasion	[ ]	[ ]
3. Bruising	[ ]	[ ]
4. Penetrating	[ ]	[ ]
5. Loss of Tissue	[ ]	[ ]

FRACTURES YES[ ] NO[ ]

	L.	R.
1. Thigh	[ ]	[ ]
2. Knee/Patella	[ ]	[ ]
3. Leg	[ ]	[ ]
4. Ankle	[ ]	[ ]
5. Foot	[ ]	[ ]

DISLOCATION YES[ ] NO[ ]

	L.	R.
1. Hip	[ ]	[ ]
2. Knee	[ ]	[ ]
3. Ankle	[ ]	[ ]
4. Toes	[ ]	[ ]

NERVE INJURY YES[ ] NO[ ]

L. [ ] R. [ ]

MAJOR VESSEL INJURY YES[ ] NO[ ]

L. [ ] R. [ ]

TREATMENT YES[ ] NO[ ]

	L.	R.
1. Operative – Major	[ ]	[ ]
2. Operative – Minor	[ ]	[ ]
3. Conservative – Plaster	[ ]	[ ]
4. Conservative – Traction	[ ]	[ ]
5. Conservative – Manipulation	[ ]	[ ]
6. Other	[ ]	[ ]

G. DISPOSAL

TREATED IN CASUALTY YES[ ] NO[ ]

1. Observation [ ]
2. Minor treatment [ ]

WARD ADMISSION YES[ ] NO[ ]

1. Operative treatment in Theatre [ ]
2. Conservative [ ]

TIME IN HOSPITAL (No. of Days) ....DAYS

DIED FROM INJURIES YES[ ] NO[ ]

1. In Hospital [ ]
2. Not Admitted to Hospital [ ]

MAJOR CAUSE OF DEATH (Specify)

1. ....
2. ....
3. ....

SECONDARY OR CONTRIBUTING CAUSE (Specif

1. ....
2. ....
3. ....

DIED FROM UNRELATED CAUSE YES[ ] NO[ ]

ROAD CRASH REPORT

(MOTOR CARS ONLY)

FILE NO.
(Office Use Only)

NAME OF DRIVER OF VEHICLE..

Vehicle Registration No. [ ] Date of Accident..........................

Locality.. Post Code................

METROPOLITAN [ ] COUNTRY [ ] OPEN ROAD [ ] BUILT UP AREA [ ]

A. VEHICLE OCCUPANTS
INDICATE (PLACE ✓ IN SQUARE) POSITION OF ALL OCCUPANTS ..

POSITION OF OCCUPANTS

DRIVER	2 FRONT CENTRE	3 FRONT LEFT	4 REAR RIGHT	5 REAR CENTRE	6 REAR LEFT	OTHER UNKNOWN

B. SEAT BELTS (Place ✓ in square)

1. Were seat belts fitted in any position? ..
2. Were seat belts worn in any position? ..
3. Indicate type of seat belts (a, b, c, etc.) ..
   (a) Lap (d) Harness
   (b) Lap Sash (e) Diagonal
   (c) Child (f) Other

C. HEAD SUPPORTS
Were head supports fitted in any position? (Place ✓ in square) ..

D. INJURIES

1. Names of Occupants killed:–
....
....
....
....
....

POSITION OF OCCUPANTS KILLED

2. Names of Occupants injured and taken to Hospital
....
....
....
....
....

POSITION OF

3. To which Hospital were injured taken?..................................
.... Not Known [ ]

4. If injured, did impact against interior of car contribute to injury? [ ] Yes [ ] No

WHICH OBJECTS (Place ✓ in square)

POSITION OF OCCUPANTS INJURED

Loose Objects ..							
Windscreen ..							
Steering Column/Wheel ..							
Dash Board ..							
Roof ..							
Gear Shift ..							
Rear Vision Mirror ..							
Glass Splinters ..							
Front Seats ..							
Door or Window Pillars ..							
Engine ..							
Door or Window Handles ..							
Transmission Tunnel ..							
Seat Belts ..							
Other (Specify) [ ]							
Which, if any, of the occupants were thrown from the car ..							

E. NATURE OF ACCIDENT

1. Vehicle to Vehicle .. [ ]
2. Struck Pedestrian/Object/Animal .. [ ]
3. Ran Off Road .. [ ]
4. Vehicle Overturned .. [ ]
5. Caught Fire .. [ ]
6. Doors Opened (Specify)........................ [ ]

7. Impact:–
   Head On .. [ ]
   Rear End .. [ ]
   Side *Left* [ ] *Right* [ ] *Front* [ ] *Rear* [ ]
8. Side Swipe Opposite Direction .. [ ]
   Same Direction .. [ ]

F. MOTOR VEHICLE DETAILS Make.............................. Model.......................... Year of Manufacture......................

G. ESTIMATE OF REPAIR COST (Office Use Only)...................................

APPENDIX B

EJECTION AND INJURY SEVERITY BY BODY REGION

TABLE B1: Head-face AIS score of occupant casualties, by presence or absence of ejection.

HEAD-FACE REGION

AIS	EJECTED No.	EJECTED %	NOT EJECTED No.	NOT EJECTED %
0	175	23.1	3034	39.0
1	294	38.8	3263	41.9
2	85	11.2	849	10.9
3	31	4.1	241	3.1
4	10	1.3	27	0.3
5	134	17.7	304	3.9
6	28	3.7	62	0.8
TOTAL	757	100.0	7780	100.0

Chi-square test for difference in injury distributions:
$X_6^2 = 376.15$ ($p < 0.0001$)

TABLE B2: Neck AIS score of occupant casualties, by presence or absence of ejection.

NECK REGION

AIS	EJECTED		NOT EJECTED	
	No.	%	No.	%
0	707	93.4	7461	95.9
1	11	1.5	201	2.6
2	2	0.3	17	0.2
3	17	2.2	34	0.4
4	0	0.0	2	0.0
5	20	2.6	65	0.8
TOTAL	757	100.0	7780	100.0

Chi-square test for difference in injury distributions:
$X_5^2 = 64.65$ ($p < 0.0001$)

TABLE B3: Thorax AIS score of occupant casualties, by presence or absence of ejection.

THORAX REGION

AIS	EJECTED		NOT EJECTED	
	No.	%	No.	%
0	456	60.2	5872	75.5
1	112	14.8	1074	13.8
2	25	3.3	308	4.0
3	73	9.6	218	2.8
4				
5				
TOTAL				

Chi-square test for difference in injury distributions:
$X^2_5 = 214.53$ ($p < 0.0001$)

TABLE B4: Lower torso AIS score of occupant casualties, by presence or absence of ejection.

LOWER TORSO REGION

AIS	EJECTED		NOT EJECTED	
	No.	%	No.	%
0	545	72.0	6792	87.3
1	72	9.5	472	6.1
2	2	0.3	20	0.3
3	25	3.3	159	2.0
4	105	13.9	309	4.0
5	8	1.1	28	0.4
TOTAL	757	100.0	7780	100.0

Chi-square test for difference in injury distributions:
$X_5^2 = 184.06$ ($p < 0.0001$)

TABLE B5: Upper extremities AIS score of occupant casualties, by presence or absence of ejection.

UPPER EXTREMITIES REGION

AIS	EJECTED		NOT EJECTED	
	No.	%	No.	%
0	435	57.5	5632	72.4
1	203	26.8	1562	20.1
2				
3				
TOTAL				

Chi-square test for difference in injury distributions:
$X_3^2 = 94.19$ ($p < 0.0001$)

TABLE B6: Lower extremities AIS score of occupant casualties, by presence or absence of ejection.

LOWER EXTREMITIES REGION

AIS	EJECTED		NOT EJECTED	
	No.	%	No.	%
0	430	56.8	5132	66.0
1	215	28.4	2047	26.3
2	7	0.9	72	0.9
3	105	13.9	529	6.8
TOTAL	757	100.0	7780	100.0

Chi-square test for difference in injury distributions:
$X^2_3 = 56.47$ ($p < 0.0001$)

TABLE B7: Spine AIS score of occupant casualties, by presence or absence of ejection.

SPINE REGION

AIS	EJECTED		NOT EJECTED	
	No.	%	No.	%
0	739	97.6	7721	99.2
1	0	-	0	-
2	0	-	0	-
3	12	1.6	45	0.6
4	6	0.8	14	0.2
TOTAL	757	100.0	7780	100.0

Chi-square test for difference in injury distributions:
$X^2_2 = 21.71$ ($p < 0.0001$)