ADELAIDE IN-DEPTH ACCIDENT STUDY

1975-1979

PART 6: CAR ACCIDENTS

by

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ABSTRACT : This report contains descriptions of the causes and consequences of the accidents involving cars in a representative sample of road traffic accidents to which an ambulance was called in metropolitan Adelaide. The characteristics of the drivers are reviewed in relation to the causation of these accidents and to accident prevention measures in general and the role of vehicle factors in accident and injury causation is discussed with emphasis on the Australian Design Rules for Motor Vehicle Safety. Two hundred and sixty-two, or 86 per cent of the accidents in the survey involved one or more cars. Alcohol intoxication and inexperience in driving in traffic were the two characteristics of drivers that were most often obviously related to accident involvement. Vehicle defects played only a minor role. Seat belts were found to reduce the frequency and severity of injury; this was particularly so for the later inertia-reel belts which were also more likely to be worn. Seventy-nine per cent of drivers and 65 per cent of left front passengers wore a seat belt where one was available. Door latches and hinges, seat anchorages, and the steering wheel and instrument panel were either deficient in the crash or otherwise were frequently found to be objects causing injury to the occupants of the car.

*Non IRRD Keywords

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FOREWORD

This study was conducted by the Road Accident Research Unit of the University of Adelaide and was jointly sponsored by the Office of Road Safety, Commonwealth Department of Transport and the Australian Road Research Board.

The general aims were to evaluate the effectiveness of many existing safety measures and to identify other factors related to accident or injury causation in road accidents in metropolitan Adelaide. The areas studied included characteristics of road users, the vehicles and the road and traffic environment.

To achieve these aims a representative sample of all road accidents to which an ambulance was called in the Adelaide metropolitan area was studied in the 12 months from March 1976. Two teams, each comprising a medical officer, an engineer and a psychologist attended 304 randomly selected accidents and collected medical, engineering and sociological data.

The findings are presented in a series of reports, each covering a specific topic. Part 1 provides an overview, and is followed by reports dealing with pedestrians, pedal cyclists, motorcyclists, commercial vehicles, passenger cars and road and traffic factors. The final report in the series provides a summary of the findings and recommendations.

Basic data from the study are held on computer by both the Road Accident Research Unit, University of Adelaide and the Australian Road Research Board. Access to these data can be arranged for bona fide research workers on application to the Australian Road Research Board. Further copies of this report and copies of other reports in the series are available from the Office of Road Safety, Commonwealth Department of Transport.

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The collection of data at the scene of the accident and in the follow-up investigations was performed by:

H.S. Aust and C.T. Hall
(Engineers)

N.D. Brewer and B.L. Sandow
(Psychologists)

J.R. Lipert and P.J. Tamblyn
(Medical Officers)

The completion of this study was due mainly to the willingness of these team members to work exceptionally long hours under difficult and often hazardous conditions.

Much of the road and traffic data was collected by W.J. Offler, who also atttended the scenes of the accidents during the final three months.

The recorded information was processed by the above personnel, assisted by J.K. Darwin, G.M. Haymes, O.T. Holubowycz and C.A. Latta.

Mr. R.W. Scriven of the Highways Department of South Australia reviewed much of the material in this report and assisted with many constructive suggestions.

The Steering Committee for the study provided valuable assistance and advice. Its members were: Professor R.E. Luxton (Chairman), Professors: I.D. John, R.B. Potts, J.S. Robertson, A.T. Welford, Drs.: B.L. Cornish (representing the Director-General of Medical Services), I.R. Johnston (D.O.T.), J.B. Metcalf (A.R.R.B.), G. Sved, A.P. Vulcan (D.O.T.), and Messrs.: J.F.M. Bryant (A.R.R.B.), R. Culver, H.E. Roeger (later R.W. Scriven and then M. Knight) (representing the Commissioner for Highways), R. Ungers (D.O.T.) and F.E. Yeend (D.O.T.). The first Chairman was the late Professor N.T. Flentje.

The St. John Ambulance Transport Division played an essential role in the conduct of this study by notifying the Road Accident Research Unit when an ambulance was called to attend a road accident. The South Australian Highways Department, the Road Traffic Board, and the Police Department cooperated in many ways in the execution of this study, as did the Hospitals Department. The proprietors and operators of towing services and crash repair shops facilitated inspections of the damaged vehicles.

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1. INTRODUCTION

A sample of accidents to which an ambulance was called in the Adelaide metropolitan area was investigated at the scene by multi-disciplinary teams from the Road Accident Research Unit of the University of Adelaide. This survey, which ran for twelve months from 23 March, 1976, was sponsored by the Commonwealth Departnent of Transport and the Australian Road Research Board. Each accident was studied by an engineer, a psychologist and a medical officer. Their observations at the scene started an average of ten minutes after the ambulance was called and were supplemented by further investigations including interviews with the drivers and other active participants (pedestrians and cyclists), detailed examination of the accident site and observation of traffic behaviour at the same time of day as the accident. The injured persons were examined and interviewed in hospital and the vehicles were inspected in towing service depots and elsewhere.

An eight per cent sample, totalling 304 accidents, was obtained of all road accidents as defined above. The sample was representative of this accident population by time of day and day of week. The purpose of this survey, the sampling technique and the method of investigation are described in detail in another report in this series (McLean and Robinson, 1979) together with a review of the types of accidents investigated and an outline of the general conclusions.

Two hundred and sixty-two accidents involving passenger cars or passenger car derivatives are reviewed in this report. The term 'passenger car derivative' means

> *a motor vehicle of the kind known as a coupe, utility, or panel van of the same make as a factory produced passenger car, and in which the forward part of the body form and the greater part of the mechanical equipment are the same as those in the said passenger car.*
> (Australian Transport Advisory Council (ATAC), 1979.)

Passenger cars and passenger car derivatives (referred to from here on simply as 'cars') are required to comply with certain specifications set down in the Australian Design Rules (ADRs) for Motor Vehicle Safety by the Australian Transport Advisory Council (1979).

The characteristics of the drivers are presented in Chapter 3 and discussed in relation to their role in the causation of the accidents. The types of cars involved are described in Chapter 4, together with vehicle factors in accident and injury causation and the performance of the relevant Australian Design Rules for Motor Vehicle Safety (ATAC, 1979). The consequences of the accidents are reviewed in Chapter 5 in terms of the nature, severity and causes of the injuries sustained by the occupants of the cars. The final Chapter of the report lists the main conclusions and recommendations.

2. THE ACCIDENTS

2.1 TIME OF DAY, DAY OF WEEK, AND ALCOHOL USAGE

The distribution of the 262 accidents involving one or more cars is shown in Figure 2.1 by time of day for weekday accidents and in Figure 2.2 for those which occurred on a Saturday or a Sunday. Those accidents in which a blood alcohol (BAC reading of 0.05 or above was obtained from a driver are also noted. It can be seen from these Figures that the peak accident periods on week-days were 4 p.m. to 6 p.m. and 7 p.m. to 8 p.m., and that 79 per cent of the accidents involving alcohol occurred after 7 p.m. At week-ends these two peaks were accompanied by one in the hour after midnight. The role of alcohol is discussed in detail in Section 3.2.1.

2.2 TYPES OF ACCIDENTS

Table 2.1 lists the frequency of these accidents for each category of road layout and type of traffic control. Nearly 40 per cent of the accidents involving a car occurred at uncontrolled midblock locations and these include 75 per cent of the single car accidents.

The type of accident, classified in terms of the initial event, is listed for active drivers of cars (as defined in the Introduction) in Table 2.2. A collision with another moving vehicle was by far the most frequent type, occurring in 70 per cent of these accidents.

A summary table of the vehicle movements, type of location and type of traffic control for the 216 car accidents not involving a collision with a pedestrian or a pedal cyclist is presented in Appendix 1. No attempt has been made to distinguish between cars and other motor vehicles. That information is presented in the report on motorcycle accidents (McLean, Brewer, Hall, Sandow and Tamblyn, 1979) and in the report on commercial vehicle accidents (McLean, Aust and Sandow, 1979). The most common vehicle movements were right-angle collisions (57 accidents) and turn right across oncoming traffic (30 accidents) at four-way intersections, veering off the road to the left (19) and turning right from the stem of a T-junction across the path of traffic approaching from the right (18 accidents).

TABLE 2.1: ACCIDENTS INVOLVING CARS : LOCATION AND TYPE OF TRAFFIC CONTROL

Type of Traffic Control	Location					Total
	Cross Roads	T-junction	Y-junction	Multi-leg	Midblock	
Signals, operating	37 (2)[1]	2	1	2	1	43 (2)
Signals, not operating normally	-	-	-	1	-	1
Signs	14 (1)	21	1	1	-	37 (1)
Other[2]	2 (1)	8	1 (1)	-	-	11 (2)
Uncontrolled	48 (1)	18 (7)	2	-	102 (38)	170 (46)
Total	101 (5)	49 (7)	5 (1)	4	103 (38)	262 (51)

Notes: [1] Number in parentheses refers to single vehicle accidents.

[2] Involves accidents where one vehicle was turning from a priority road.

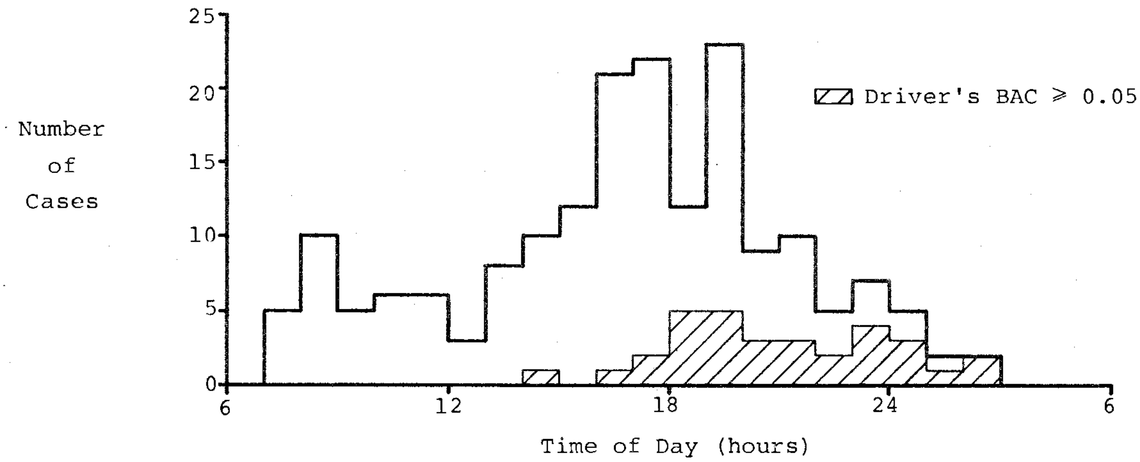


FIGURE 2.1: TIME OF DAY AND ALCOHOL INVOLVEMENT: CAR ACCIDENTS OCCURRING ON A WEEKDAY.

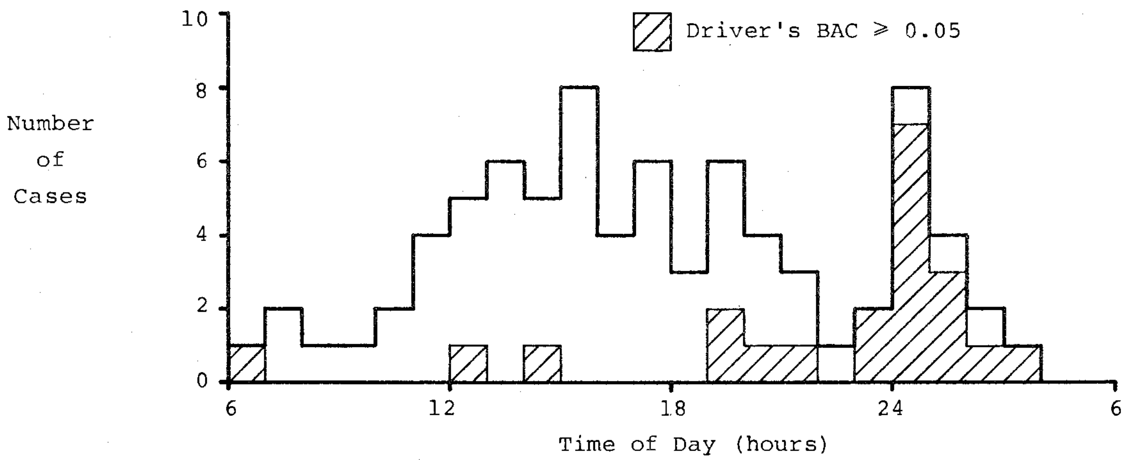


FIGURE 2.2: TIME OF DAY AND ALCOHOL INVOLVEMENT: CAR ACCIDENTS OCCURRING ON SATURDAY OR SUNDAY.

TABLE 2.2: INITIAL EVENT IN ACCIDENTS INVOLVING CARS

Initial Event	Number of Accidents	
Non-collision:		
Rollover	3	
Ran off road	1	4
Collision with object:		
Utility pole	17	
Large tree (at roadside)	9	
Fence	2	
Kerb	1	
House	1	
Planks falling from truck	1	31
Collision with parked vehicle:		
Car	9	
Medium truck	1	
Four wheel drive	1	11
Collision with pedestrian:		31
Collision with vehicle:		
Pedal cycle	15	
Motorcycle	40	
Car	113[1]	
Multi-purpose passenger vehicle	4	
Light truck	2	
Heavier truck	5	
Semi-trailer	2	
Bus	1	
Train	1	183
Miscellaneous:		
Jack-knife (trailer)	1	
Passenger fell out	1	2
Total		262

Note: [1] Includes four collisions with stationary cars.

3. CHARACTERISTICS OF DRIVERS

Three hundred and seventy-five car drivers were active participants in the 262 accidents involving cars. The term "active participant" is used here, as in the earlier reports on the study, to distinguish between drivers who were operating a car that was moving, or had just stopped, immediately before the accident and persons who were in the driver's seat of a parked or stationary car. Another 28 persons who were driving multi-purpose passenger vehicles (five drivers), light trucks (five), medium trucks (five) and heavier vehicles (13 drivers) are included in this discussion of the characteristics of drivers because many aspects of their driving tasks are shared by car drivers. The 27 accidents that these 28 drivers were involved in are discussed in Report No. 5 in this series (McLean et al, 1979e). Fourteen of these 27 accidents were collisions with cars. This Chapter therefore deals with the characteristics of 403 drivers who were involved in 275 accidents.

3.1 DRIVERS : DEMOGRAPHIC CHARACTERISTICS

Age, Sex and Marital Status

The age and sex distributions of these drivers are shown in Tables 3.1 and 3.2 (the data on blood alcohol levels contained in these Tables are discussed in Section 3.2.1). The ages of the drivers ranged from 13 to 90 years. The minimum age at which a driver's licence can be obtained in South Australia is 16 years; the 13 year old was attempting to drive a car around the block with some friends after a party late at night. The 15 year old was driving a stolen car.

The age distributions were similar for male and female drivers (Tables 3.1 and 3.2). When compared with the numbers of licensed drivers, riders and permit holders (Australian Bureau of Statistics, 1976) in South Australia (data were not available on the number of drivers in the metropolitan area), it can be seen that drivers below 25 years of age were over-represented in the accident sample (Table 3.3). This comparison does not allow for variations in vehicle usage patterns with driver age or for any urban/rural differences in driver age distributions. Therefore it may not provide an accurate indication of the risk of being involved in an accident to which an ambulance is called, etc. But these and other factors related to exposure to the risk of being involved in an accident are not relevant to a simple assessment of the contribution which the various age groups of drivers make to the overall accident problem. Consequently it is of interest to note that elderly drivers were under-represented in these accidents, as is the case for all accidents reported to the police (Australian Bureau of Statistics, 1976).

Taking the number of drivers licensed in South Australia as a crude measure of exposure, males were twice as likely to have been involved in one of the accidents in this study than were female drivers (Table 3.4). As noted above, a comparison such as this does not allow for differences in distances driven, type of driving or time of day of travel, etc.

Within the accident sample, male and female drivers were involved in almost the same proportion of single vehicle accidents (14 per cent and 11 per cent respectively, Table 3.5). The median ages of the male and female drivers were very nearly the same in single vehicle accidents (23 and 22 years, respectively) and in all accidents (27 and 28 years), but male drivers were more likely to have been intoxicated by alcohol in both types of accidents.

Marital, Educational and Occupational Status

Information was collected on the marital, educational and occupational status of the drivers. The distributions of these three characteristics by age of driver were similar to those of the South Australian population (where adequate population data were available). In particular, there was no obvious bias towards an over-representation of unskilled, semi-skilled and skilled workers as there was for the motorcyclists in the accidents studied (McLean et al, 1979d, Section 3.1).

3.2 DRIVERS : PHYSIOLOGICAL CONDITION

3.2.1 ALCOHOL INTOXICATION

Self-Reported Drinking before the Accident

In the twelve hour period prior to the

TABLE 3.1: MALE DRIVERS : AGE AND BLOOD ALCOHOL CONCENTRATION

Age (years)	BAC (gm/100 ml)						
	Zero	0.01 - 0.04	0.05 - 0.07	0.08 - 0.14	0.15 +	Not Known	Total
15	1	-	-	-	-	-	1 (0%)
16	9	-	-	1	-	1	11 (4%)
17	9	1	-	1	-	1	12 (4%)
18	14	-	1	1	1	2	19 (6%)
19	13	-	2	1	-	2	18 (6%)
20	9	-	1	-	1	2	13 (4%)
21	11	1	2	-	2	1	17 (6%)
22	5	-	1	2	2	2	12 (4%)
23	6	-	1	1	4	4	16 (5%)
24	6	1	-	1	-	2	10 (3%)
25 - 29	28	-	-	4	3	7	42 (14%)
30 - 34	17	3	1	2	2	5	30 (10%)
35 - 44	17	2	1	1	2	6	29 (9%)
45 - 54	21	1	-	4	-	5	31 (10%)
55 - 64	14	-	1	-	2	2	19 (6%)
65 - 74	11	-	-	2	1	1	15 (5%)
75 - 84	5	-	-	-	-	1	6 (2%)
85+	2	-	-	-	-	-	2 (1%)
Not known	-	-	-	-	-	3	3 (1%)
Total	198	9	11	21	20	47	306 (100%)

TABLE 3.2: FEMALE DRIVERS : AGE AND BLOOD ALCOHOL CONCENTRATION

Age (years)	BAC (gm/100 ml) Zero	0.01 - 0.04	0.05 - 0.07	0.08 - 0.14	0.15 +	Not Known	Total[1]
13	-	-	-	-	-	1	1
14	-	-	-	-	-	-	-
15	-	-	-	-	-	-	-
16	1	-	-	-	-	-	1
17	5	-	-	-	-	-	5
18	4	-	-	-	-	-	4
19	5	-	-	-	-	1	6
20	4	-	-	-	-	1	5
21	5	-	-	-	-	1	6
22	5	-	-	-	-	2	7
23	3	-	-	-	-	-	3
24	1	-	-	-	-	-	1
25 - 29	15	-	-	-	-	1	16
30 - 34	8	-	1	1	-	3	13
35 - 44	5	-	-	-	-	-	5
45 - 54	11	-	-	-	2	2	15
55 - 64	4	-	1	-	-	-	5
65 - 74	2	-	-	-	-	-	2
75 - 84	1	-	-	-	-	-	1
85+	-	-	-	-	-	-	-
Not Known	-	-	-	-	-	1	1
Total	79	-	2	1	2	13	97

Note: [1] Numbers in this column are also percentages of the total.

TABLE 3.3: RATE OF INVOLVEMENT IN THIS SAMPLE OF ACCIDENTS BY AGE OF DRIVER

Age of Driver (years)	Licensed Population[1]	Accident Sample		Chi Square	p[3]
		Observed	Expected[2]		
< 20	63,671	78	38.48	40.59	***
20 - 24	91,920	90	55.56	21.35	***
25 - 34	168,309	101	101.73	0.01	n.s.
35 - 44	114,264	34	69.06	17.80	***
45 - 54	109,818	45	66.37	6.88	**
55 - 64	75,804	24	45.82	10.39	**
65 - 74	34,781	18	21.02	0.43	n.s.
75 +	8,184	9	4.95	3.31	n.s.
Not Known	-	4	-	-	-
Total	666,751	403	403	-	

Note: [1] Whole State, at June 30, 1976 (includes drivers, riders and permit holders).

[2] Sample calculation for < 20 age group: $63{,}671 \cdot \frac{403}{666{,}751} = 38.48$.

[3] Significance levels indicated thus: *** $p < 0.001$

** $0.001 \leqslant p < 0.01$

n.s. $0.05 \leqslant p$

TABLE 3.4: RATE OF INVOLVEMENT IN THIS SAMPLE OF ACCIDENTS BY SEX OF DRIVER

	Sex of Driver		
	Male	Female	Total
Accident Sample	306	97	403
Licensed Population[1]	404,940	261,811	666,751
Involvement Rate per 100,000	75.6	37.0	60.4

Note: [1] Whole State, at June 30, 1976 (includes drivers, riders and permit holders).

Chi square = 39.0, $p < 0.001$.

TABLE 3.5: TYPE OF ACCIDENT AND ALCOHOL INTOXICATION BY SEX OF DRIVER

Type of Accident	Alcohol Intoxication	Sex of Driver Male	Female	Total
Single Vehicle	Yes[1]	23	4	27
	No	16	7	23
	Not known	3	1	4
Sub-total		42	12	54
Other than Single Vehicle[2]	Yes	29	1	30
	No	192	73	265
	Not known	42	12	54
Sub-total		263	86	349
Total		305	98	403

Note: [1] BAC $\geqslant 0.05$

[2] Collision with another moving vehicle or with a pedestrian.

accident at least 102 of the 403 drivers had consumed some quantity of alcohol. Reports of independent witnesses suggested that another three drivers had been drinking before the accident. Firm evidence was not available since two of these drivers would not consent to be interviewed and the third denied any prior consumption of alcohol (one of the three drivers fled the scene of the accident, another alighted from the ambulance on the way to hospital and the third departed from the hospital casualty department before a blood sample could be taken). Within the group of 102 drivers, 70 had a positive blood alcohol reading when tested after the accident, and 19 had BAC readings of zero. None of these 19 drivers reported having had more than four drinks, and they all had stopped drinking at least one hour, and up to 12 hours, before the accident. No blood alcohol concentration was obtained for 13 other drivers who said that they had consumed alcohol prior to the accident.

Forty-two per cent of these 102 drivers had been drinking at hotels, 29 per cent at their own homes or at the homes of friends or relatives and 12 per cent at restaurants or clubs. One driver had been drinking in his car, and three more at various other places. The place of drinking was not known for 14 drivers.

The reported amounts of alcohol consumed by these drivers are shown in Table 3.6. These quantities are defined in terms of the number of glasses consumed, each glass being approximately equivalent in terms of alcohol content to one 8 oz. glass of beer.

TABLE 3.6: AMOUNT OF ALCOHOL DRIVERS REPORTED CONSUMING IN THE 12 HOURS BEFORE THE ACCIDENT

Reported Amount of Alcohol Consumed	Number of Drivers
1 glass	10
2 glasses	16
3 glasses	11
4 glasses	2
5 glasses	7
6 glasses	7
7 glasses	2
8 glasses	6
9 glasses	4
10 glasses	2
12 glasses	3
13 glasses	2
15 glasses	3
20 glasses	2
Amount unknown; but considerable quantity	3
Amount unknown[1]	42
Not applicable; had not been drinking	281
Total	403

Note: [1] Includes some drivers who may not have been drinking.

Blood Alcohol (BAC) Levels

The availability of blood and breath alcohol information from hospital, police and research team resources, is shown in Table 3.7. One driver who recorded a positive reading (0.02) on the research team's blood alcohol test was later taken to hospital where a blood test recorded a BAC level of zero. Another driver who was required to submit to a police Alcotest but was not then required to take a Breathalyzer test subsequently recorded a positive level (0.03) on the research team's Alcolmeter.

The blood alcohol levels are summarized in Table 3.8, and shown by the age and sex of the driver in Tables 3.1 and 3.2. Seventy drivers recorded positive blood alcohol levels, but the exact levels for three of these individuals are unknown. Positive BAC levels below 0.08 had been indicated on the police Alcotest for these three drivers. The remaining 277 drivers who were tested had blood alcohol levels of zero.

TABLE 3.7: AVAILABILITY OF BLOOD AND BREATH ALCOHOL INFORMATION FOR DRIVERS

	Hospital: blood sample	Police: breath sample	Research team: breath sample
Sample taken	118[1]	18[2]	215[3]
Sample not attempted	1	257	19
Sample refused	1	-	18
Sample not taken: other reason[4]	2	8	19
Sample not taken: Driver under 14 years of age	1	-	-
Not applicable: Other measure available or not admitted to hospital	280	119	132
Not known if sample attempted	-	1	-
Total	403	403	403

Notes: [1] BAC readings were not available for two of these drivers. One other driver was also tested by the research team.
[2] Includes four drivers whose Alcotest readings were below 0.08, one of whom was tested by the research team.
[3] Includes one driver who also submitted to a police Alcotest and one other driver who provided a hospital blood sample.
[4] Driver left the scene of the accident, or left the casualty department before treatment, etc.

TABLE 3.8: DRIVER BAC LEVEL BY TYPE OF ACCIDENT

BAC Level of Driver	Type of Accident: Single Vehicle	Type of Accident: Other than Single Vehicle[1]	Total
Zero	21	256	277
0.01 - 0.04	1	9	10
0.05 - 0.07	3	10	13
0.08 - 0.09	2	2	4
0.10 - 0.14	6	12	18
0.15 - 0.19	5	2	7
0.20 - 0.24	9	2	11
0.25+	2	2	4
Unknown	5	54[2]	59
Total	54	349	403

Note: [1] Collision with another active vehicle or with a pedestrian.
[2] Includes three drivers who had a positive BAC level which was below 0.08 on a police Alcotest.

The age distribution of the 70 drivers who had positive blood alcohol levels was similar to that for those drivers who recorded zero levels, suggesting that positive alcohol readings were not more prevalent among any particular age group. Also the age distribution was similar for those individuals who recorded higher alcohol levels (e.g. BAC $\geq$ 0.15).

As shown in Table 3.8, 57 drivers, or 16.6 per cent of the known cases, had a BAC $\geq$ 0.05, a level which may be associated with impairment of performance on driving or analogous tasks (44 drivers, 12.8 per cent, were above the South Australian legal limit of 0.08). Therefore it is conceivable that alcohol intoxication may have contributed to the accident involvement of at least 16 per cent of these drivers. Since another 16 drivers were known or were thought to have consumed alcohol prior to the accident, the true overall percentage of intoxicated drivers (BAC $\geq$ 0.05) in this sample of accidents may have been as high as 18 per cent.

When information regarding the quantity of alcohol consumed, and the period within which it was consumed, was available it generally coincided with expectations based on the recorded blood alcohol levels. (Although there was a considerable discrepancy between the reported quantity of alcohol consumed and the recorded level for six drivers, there were no grounds for suspecting that the recorded level may have been inaccurate.) Indeed, in each of these cases there was at least anecdotal evidence that pointed to the unreliability of the reported quantity of alcohol consumed. The association between the reported quantity of alcohol consumed and the recorded blood alcohol level is discussed later with reference to Table 3.10.

Among those drivers who were not conveyed to hospital, and hence were not required to provide a blood sample, were 41 who recorded positive BAC levels. Eighteen of these 41 drivers were detected by police breath alcohol tests, and 25 by tests conducted by the research team (one driver being tested by both the police and the research team). Twenty-three of these 41 drivers were above the legal limit of 0.08, but eleven of them, with BAC levels ranging from 0.09 to 0.23 were not detected by the police officers who attended the accident. If this result is representative of all accidents attended by the police, then police accident records may under-estimate the proportion of drivers exceeding the legal limit of 0.08 by about 25 per cent.

Usual Drinking Patterns

The usual frequency of alcohol consumption is listed in Table 3.9 for the intoxicated drivers (BAC $\geq$ 0.05) and for the other drivers in the sample. Excluding unknowns and persons who said that they never drank alcoholic beverages, the drivers who were above 0.05 were almost twice as likely to consume alcohol more frequently than once per week than were the other drivers (89 per cent and 43 per cent respectively; Chi square = 32.1, 1 d.f., $p < 0.001$). A pattern of frequent alcohol consumption was even more marked for the drivers who had a BAC above 0.15. They all said that they drank more frequently than once per week.

Drivers who were intoxicated (BAC above 0.05) usually consumed more alcohol per drinking session than did the other drivers (Table 3.10). Taking seven or more glasses per session as one category, and excluding those for whom a precise quantity was not available, the intoxicated drivers were more than three (3.2) times as likely to be in the heavy consumption category than were the drivers who were below 0.05 (48 per cent and 15 per cent respectively; Chi square = 15.6, 1 d.f., $p < 0.001$).

These results are consistent with those for motorcyclists and pedestrians in that persons who were involved in an accident when intoxicated had a self-reported history of regular and heavy consumption of alcohol (McLean et al, 1979 b and d). Furthermore, information was available which indicated that the behaviour of the drivers who had been drinking alcohol prior to the accident was not, for them, unusual. Among the 70 individuals who recorded positive alcohol levels (including three identified only by a police Alcotest) were 51, or 70 per cent, who occasionally or even regularly drove their vehicles after consuming quantities of alcohol which would be expected to result in a blood alcohol level greater than the legal limit of 0.08. Only five of the 70 drivers reported that they seldom behaved in this manner, while no information was available for the other 14 individuals.

At least 40 per cent of the 70 drivers with positive BACs considered that their driving performance suffered negligible or no impairment after consuming quantities ranging from ten to 20 glasses of some alcoholic beverage. By comparison, a pattern of occasional or regular drinking and driving was reported by about 15 per cent of that group of drivers who recorded blood alcohol levels of zero. Also, less than five per cent of these sober drivers subscribed to the view that their driving performance was immune from the effects of alcohol. The corresponding proportions for all the drivers in the sample of accidents, including those drivers for whom no alcohol levels were available, were 29 and eleven per cent respectively.

As for motorcyclists, it appeared that drivers who recorded alcohol levels in excess of the legal limit of 0.08 were more likely to be characterized by a history of previous licence suspensions. The available information indicates that 15 of the 37 drivers who recorded alcohol levels in excess of this level had incurred previous licence suspensions compared with 67 of the remaining 204 drivers. However, this result is not statistically significant (Chi square = 3.40, 1 d.f., $p < 0.10$).

TABLE 3.9: USUAL FREQUENCY OF ALCOHOL CONSUMPTION BY LEVEL OF INTOXICATION OF DRIVER

Usual Frequency of Alcohol Consumption	Alcohol Intoxication			Total
	No[1]	Yes[2]	Unknown	
Never	45	-	5	50
Hardly ever	9	-	1	10
Less than once/month	23	-	-	23
About once/month	18	-	3	21
About once/fortnight	17	2	6	25
About once/week	50	3	7	60
Two to four times/week	59	25	13	97
More than four times/week	30	16	8	54
Unknown	36	11	16	63
Total	287	57	59	403

Note: [1] BAC below 0.05 (including zero)
[2] BAC $\geq$ 0.05.

The Effects of Alcohol on Driving Performance : Possible Mechanisms

Drivers who were involved in single vehicle accidents in this sample were more likely to have been intoxicated than were those who were involved in other types of accident, a result which is similar to that reported for motorcycle riders in the companion report on motorcycle accidents. Twenty-seven (47 per cent) of the 57 drivers who were above 0.05 were involved in single-vehicle accidents (Table 3.8) yet only 21 (seven per cent) of the 286 drivers who were known to be below 0.05 (mostly BAC of zero) were involved in accidents of this type. This difference is unlikely to have arisen by chance (Chi square = 63.3, $p < 0.001$). Also, as shown in Table 3.8, high blood alcohol levels were more prevalent, both absolutely and in proportion, among drivers who were involved in single-vehicle accidents than among drivers involved in other accidents.

Alcohol Intoxication and Secondary Activities:

The term 'secondary activity' is used here to refer to some activity which is additional to the basic driving task, such as turning and talking to a passenger, attempting to retrieve or light a cigarette, extracting a wallet from a hip pocket, eating, or watching persons at the side of the road. A more detailed discussion of these activities is contained in Section 3.6.3. In this Section the frequency of secondary activity involvement is related to that of intoxication in accidents involving drivers of cars and commercial vehicles. The possible nature of the effects on driving, or riding, performance of the combination of intoxication and involvement in a secondary activity are discussed in the report on motorcycle accidents (McLean et al, 1979d).

Table 3.11 shows that, in single-vehicle accidents, intoxicated drivers were more likely to have been involved in some secondary activity just before the accident than were drivers who had a BAC below 0.05. A similar association, but far less marked and not statistically significant, was observed among drivers who were involved in other than single-vehicle accidents (Table 3.12).

As shown in Tables 3.11 and 3.12, information on the events immediately before the accident could not be obtained from nine intoxicated drivers involved in single vehicle accidents and from five who were involved in other types of accident. It is possible that some of these 14 drivers were engaged in a secondary activity.

Deliberate Crash into Roadside Object:

Two intoxicated drivers had problems of a psychiatric nature that either derived from, or were otherwise associated with, serious domestic problems. One of these drivers, who had a BAC of 0.24, admitted having deliberately steered off the road to the left to crash into a utility pole. Another driver could not be contacted for the follow-up interview, but information from friends and relations revealed a recent history of marital difficulties and two suicide attempts. He had a BAC of 0.20 when his car swerved to the right, crossing two opposing lanes, and hit a utility pole. It may be that a person who is experiencing

TABLE 3.10: USUAL AMOUNT OF ALCOHOL CONSUMPTION BY LEVEL OF INTOXICATION OF DRIVER

Usual Amount of Alcohol Consumption	Alcohol Intoxication			Total
	No[1]	Yes[2]	Unknown	
1 glass	18	-	-	18
2 glasses	44	1	5	50
3 glasses	21	2	5	28
4 glasses	15	3	4	22
5 glasses	13	4	4	21
6 glasses	14	4	2	20
7 glasses	3	2	-	5
8 glasses	3	3	-	6
9 glasses	2	1	-	3
10 glasses	7	1	4	12
12 glasses	6	1	-	7
15 glasses	1	4	-	5
16 glasses	1	-	-	1
20 glasses	-	1	-	1
Limited quantity : amount unknown	41	-	7	48
Variable quantity : 1 glass daily to > 10 glasses 1/week	2	5	2	9
Considerable quantity : amount unknown	3	10	-	13
Unknown amount	48	15	21	84
Not applicable (non-drinker)	45	-	5	50
Total	287	57	59	403

Note: [1] BAC below 0.05 (including zero).

[2] BAC $\geqslant$ 0.05.

TABLE 3.11: ALCOHOL INTOXICATION AND SECONDARY ACTIVITY INVOLVEMENT: DRIVERS IN SINGLE-VEHICLE ACCIDENTS

Secondary Activity Involvement	Alcohol Intoxication No	Yes[1]	Unknown	Total
No	11	3	1	15
Yes	8	15	1	24
Unknown	3	9	3	15
Total	22	27	5	54

Note: [1] BAC ≥ 0.05 (including zero).
Chi square (known cases only) = 10.2, $p < 0.01$.

TABLE 3.12: ALCOHOL INTOXICATION AND SECONDARY ACTIVITY INVOLVEMENT: DRIVERS IN OTHER THAN SINGLE-VEHICLE ACCIDENTS

Secondary Activity Involvement	Alcohol Intoxication No	Yes[1]	Unknown	Total
No	141	10	21	172
Yes	105	15	25	145
Unknown	18	5	9	32
Total	264	30	55	349

Note: [1] BAC ≥ 0.05 (including zero).
Chi square (known cases only) = 2.76, $p < 0.1$.

emotional difficulties is more likely to act in this way when intoxicated than when sober, but there was one other accident in this sample in which a sober driver may have driven deliberately into a utility pole. There was no other obvious explanation for the occurrence of this accident, and the person involved committed suicide, by a different means, on the following day. As with the two previous drivers, there was a history of considerable emotional problems.

Loss of Control of Car:

Five intoxicated drivers each lost control of their car when rounding a bend or when changing lanes. Two of these cars rolled over and the other three struck fixed objects at the roadside. It is arguable that these drivers may have been able to maintain control of their vehicles if they had not been intoxicated. Experimental data point to a mechanism that might account for such performance decrements. For example, the effects of reduced responsiveness or sensitivity in steering inputs when under the influence of alcohol presumably would be exaggerated at higher speeds. This possible mechanism is discussed in Report No. 4 in this series (McLean et al., 1979d) and by Mortimer and Sturgis (1975). Furthermore, any alcohol-induced impairment of the efficiency with which information is processed, such as a slowing of information accumulation and response organisation may be manifested in less accurate or controlled performance when the individual is subject to speed stress. Some form of interaction between these two effects seems to be the most plausible explanation for the performance of these drivers.

Performance Decrement without Loss of Control:

One driver whose car clipped the side of a motorcycle when overtaking (Accident 043) may have done so because his level of intoxication (BAC of 0.09) was sufficient to impair his responsiveness in steering wheel manipulation (mentioned above), his ability to maintain his lateral position and heading angle, and the effectiveness of his visual scanning to the front and sides of his car (Mortimer and Jorgeson, 1972).

Five intoxicated drivers were involved in collisions with other vehicles at signalised intersections. In each case independent reports suggested that the intoxicated driver's vehicle entered the intersection apparently well after the traffic signals had changed to red. This apparent failure to respond to either the yellow or red signals is consistent with difficulties that may be associated with deciding upon and initiating a new course of action while some pattern of responding (to a green signal, in this case) is in effect (Welford, 1958).

Another driver, with a BAC of 0.35, failed to see a car that was reversing out of a driveway ahead of him at night (Accident 188). The street lighting was of a generally low level and not uniform and it is possible that his scanning of the road ahead and also his dynamic visual acuity may have been adversely affected (Brown et al., 1975).

The risk of a collision occurring at four-way uncontrolled intersections is unlikely to be affected significantly by alcohol intoxication simply because almost all drivers, sober or intoxicated, approach these intersections at a speed which does not allow time for any effective avoiding action should another vehicle suddenly appear on the intersecting road (McLean, Offler and Sandow, 1980, Section 5.3). Nevertheless, any decrement in dynamic visual acuity resulting from intoxication would make the driver's task even more difficult at such locations. The ability to respond to information presented in the peripheral vision field when the central vision is already occupied with a task is also known to be adversely affected by alcohol intoxication (Von Wright and Mikkonen, 1970). Eleven intoxicated drivers were involved in eight of the 60 collisions at uncontrolled intersections or junctions.

This review of the possible mechanisms underlying the impairment of the performance of drivers when intoxicated is necessarily speculative, but it is presented here in the hope that it may facilitate the further development of an understanding of the nature of these mechanisms.

3.2.2 PRESCRIPTION AND NON-PRESCRIPTION DRUGS

The following information on the usage of drugs other than alcohol, or tobacco, is based on self-reporting by the drivers involved in these accidents. While this may have resulted in an underestimate of the true extent of such usage, in all accidents in which a driver was obviously impaired the reason for that impairment was known.

Table 3.13 lists the frequencies with which drugs were reported as having been used by these drivers, and the probable effects that the named drugs would have had on the driver's performance. Even allowing for possible under-reporting, it is clear that drugs of these types are a minor problem compared to alcohol.

Prescription Drugs

All but one of the 33 persons who were taking a prescribed drug were doing so for a minor medical condition. The other driver had taken insulin in the early morning and then missed his mid-morning meal. Hypoglycaemia ensued and the driver became dizzy and collapsed at the wheel. His car veered off the road to the left and crashed into a utility pole.

TABLE 3.13: PRESCRIPTION AND NON-PRESCRIPTION DRUGS USED BY DRIVERS[1]

Class of Drug	Effect on Driving Performance: No known effect	Beneficial	Detrimental	Total
Prescription	24	6	3	33
Non-prescription	4[2]	-	2	6
Illegal	-	-	1[3]	1
None	-	-	-	321
Drug usage not known	-	-	-	42
Total number of drivers				403

Notes: [1] Self-reported.

[2] Except when taken with alcohol (which was not the case for these drivers).

[3] Marihuana; detrimental effect possible, but unlikely to have been relevant in this case (see text).

Six drivers reported having taken prescribed tranquillizers. In each case it is probable that this would have had a beneficial effect on the performance of these formerly over-stressed individuals.

Two other drivers had taken prescribed anti-histamines and also consumed alcohol, thus compounding the detrimental effects that each of these drugs can have on driving performance.

Non-Prescription Drugs

Two drivers had taken non-prescription drugs which are not compatible with alcohol, a non-prescribed anti-histamine in one case and a tranquillizer in the other, and then consumed significant quantities of alcohol. Four other drivers had taken a tranquillizer but had not also consumed alcohol.

Illegal Drugs

One driver said that she had been smoking marihuana while drinking at an hotel. On admission to hospital after her car crashed into a utility pole she was found to have a blood alcohol level of 0.14. While this elevated reading is consistent with involvement in a single vehicle accident, it may be that the combination of marihuana and alcohol produced an effect on her driving performance even greater than that which would be expected to result from this blood alcohol level alone.

3.2.3 MEDICAL CONDITION AND FATIGUE

Medical Condition

Twenty-nine drivers reported that they had minor ailments at the time of the accident, while another six were apparently in poor health. Four drivers were at various stages of pregnancy. Another three drivers had psychiatric problems that were probably significant among those factors underlying their accident involvement; the relevant circumstances for these three individuals were discussed in the preceding section on alcohol under the heading 'Deliberate Crash into a Roadside Object'. No information was available on the general health of 37 drivers.

The disabilities of five drivers were of major significance in shaping their performance prior to the accident. One driver (Accident 007) had endured vomiting and diarrhoea throughout the day of the accident. He was driving home from the country and had almost reached his destination when he began to feel particularly ill. He became dizzy and lost control of his car, which veered across to the right hand side of the road and collided with a parked car. A second driver (Accident 270) ran off the road and collided with a utility pole after becoming dizzy. As noted previously, this person was a diabetic who had taken insulin a number of hours earlier, but after missing his morning meal suffered a hypoglycaemic attack. He said that he had had several minor dizzy spells prior to meals in the weeks preceding the accident. Following this accident, his doctor reduced his insulin intake. Another driver (Accident 070), who had a carcinoma of the lung and in fact died a couple of months after the accident, was involved in a collision with another car after entering an intersection without first stopping at a STOP sign. This person had not driven for a considerable period of time because of his health; his inappropriate behaviour on this occasion probably was due to his medical condition. The remaining two drivers in this group of five (Accidents 076 and 079) suffered from a serious arthritic condition in their legs which seemed likely to have been a major factor in the failure of either driver to take effective evasive action when confronted with an emergency situation.

The medical condition of three other drivers may have constituted at least a marginal disability, and may have been of greater significance. Two of these drivers, one of whom was suffering from a cold (Accident 017) and the other a headache (Accident 150), suggested that they might have proceeded with greater care into the intersection had they not felt some stress to complete their journey because of their medical condition. The state of arousal of the third driver (Accident 181) who was undergoing treatment for a nervous condition might have been an underlying factor in her hasty, and inaccurate, assessment of the likelihood of successfully crossing an intersection ahead of another vehicle travelling on the intersecting road.

Fatigue

A comparison of the driver's sleep patterns before the accident with those that he considered to be normal is taken here as a measure of fatigue. This measure may not be entirely satisfactory but it is based on information which is both quantifiable and readily obtainable. The recent sleep patterns of 329 drivers were rated as normal, with the number of hours slept per night ranging from six to twelve. Five drivers had slept for five, or less, hours on the night preceding the accident. However, because of the nature of their employment, this constituted a normal night's sleep, and usually it was supplemented by some additional hours during daylight. The recent sleeping patterns of another 12 drivers varied from their usual habits. Four of these people, however, had obtained at least six hours sleep on the night prior to the accident. The sleeping patterns of two others had been more intermittent than usual, but overall were probably equivalent to their normal patterns. No information on sleep patterns was available for 57 drivers.

Six drivers reported having had much less sleep than usual on the night preceding the accident. The actual hours slept by these people ranged from zero to four hours. The sleeping patterns of two of these drivers (Accidents 219, 231) had been affected by exacting employment requirements. Another driver (Accident 294) had been at a party for most of the night, and any fatigue effects were compounded by the interactive effects of the alcohol and drugs he had taken. For the remaining three drivers (Accidents 008, 104, 229) the lack of sleep was associated with personal circumstances of a particularly stressful nature. Two of them also had consumed significant quantities of alcohol prior to the accident.

3.3 DRIVERS: PHYSICAL CHARACTERISTICS

3.3.1 VISION

Static Visual Acuity

The Snellen Test of visual acuity was administered to 324 drivers during the follow-up interviews. Four drivers could not be tested in conditions similar to those at the accident site since their glasses were lost or broken in the accident,and a fifth person died as a result of injuries sustained in the accident. Another person could only be tested for righteye vision because of an injury to the left eye as a result of the accident. Seventy-four drivers were not tested for visual acuity. Scores ranging from 6:6 to 6:12 for both eyes were obtained by 307 drivers. Seventeen drivers recorded scores worse than 6:12 for at least one eye, with three drivers recording 6:36 for both eyes. Another two drivers were virtually blind in one eye. In all but four of these cases, however, the available information suggests that these limitations of visual acuity were not significant factors in the causation of these accidents.

Although it was difficult to assess the contribution of deficiencies in visual acuity, it seems likely that the performance of four drivers may have been impaired to some extent by such deficits. One of these drivers (Accident 071) recorded scores of 6:36 for both right and left eyes, and also recorded a breath alcohol reading of 0.21. His car collided with a parked car while travelling at night along an arterial road where the level of artificial illumination was relatively low and non-uniform. Another car, driven by a male aged 83 years (Accident 202), collided with the rear of an angle-parked truck that was protruding further into the carriageway than the other vehicles parked in the vicinity. This person recorded scores of 6:18 for each eye. A third driver (Accident 098) was turning right into the stem of a T-junction, through a space between traffic stationary at either side of the junction, when his vehicle collided with a motorcycle travelling from the opposite direction in the left hand lane. Although this driver's view of the motorcycle was restricted by the stationary traffic, it seemed possible that his limited visual acuity, as indicated by Snellen scores of 6:36 for each eye, may have contributed to the failure to detect that motorcycle. The accident happened in the late afternoon, half an hour before last light. The fourth driver in this group of four was turning right from the stem of a T-junction across the path of a vehicle approaching from the right in daylight (Accident 222). There were no apparent distractions or restrictions on her field of view that may have explained her failure to detect the approach of the other vehicle. She was not wearing her glasses at the time of the accident, and without them recorded scores of 6:36 for each eye on the Snellen test.

Corrective Lenses

At least 105 of the 403 drivers normally wore prescription glasses. Table 3.14 outlines those conditions for which these glasses were normally worn, and the frequency of wearing among these drivers at the time of the accident.

Apart from those individuals who normally wore glasses only for reading and consequently were not wearing them at the time of the accident, three drivers were not wearing their glasses prior to the accident. One of these drivers had been prescribed glasses for suspected glaucoma not long before the accident, and without these glasses showed no limitation of visual function. Another performed satisfactorily on the Snellen Test of visual acuity without her bifocals, but the third driver's vision was impaired to an extent that probably did contribute to her failure to see an approaching car (Accident 222). As noted above, this driver's uncorrected static visual acuity was 6:36 for each eye.

All but two of the drivers who were wearing prescription glasses had been using them for at least six months. The remaining two drivers had been using these lenses for two and three months respectively, and neither of them reported any difficulties of adaptation.

Sunglasses and Tinted Lenses

The 18 drivers who were wearing sunglasses at the time of the accident all said that they normally wore them when driving. They were all involved in daytime accidents. Twenty other drivers were wearing prescription glasses which had tinted or photosensitive lenses. While any reduction in the level of light reaching the eye is undesirable when driving at night (apart from sources of glare) the accidents in this sample did not include any in which tinted or photosensitive lenses played a causal role. Six of the 20 drivers (30 per cent) who were wearing glasses with these lenses were involved in accidents at night, as were 29 per cent of those whose spectacles were fitted with clear or non-tinted lenses.

There was no indication that spectacle frames, not even those formed from thick opaque plastic, were a relevant restriction on the field of view of the user in these accidents.

Colour Blindness

The Ishihara Test for Colour Blindness was

TABLE 3.14: WEARING OF CORRECTIVE LENSES[1] BY DRIVERS

Reason for Use of Corrective Lenses	Number of Drivers Wearing Corrective Lenses: Normal Use	Pre-accident use
Short sighted	40	40
Long sighted[2]	40	2
Short and long sighted (bifocals)	19	18
Astigmatism	2	2
Other and combinations of above	2	1
Condition unknown	2	1
Sunglasses (non-corrective)	18	18
Corrective lenses not worn	236	290
Use of corrective lenses not known	44	31
Total	403	403

Notes: [1] All spectacles.

[2] Normally worn only for reading or close work.

administered to 325 of the 403 drivers, and 13 were found to have some impairment of their colour vision. However, the circumstances of the accidents in which these drivers were involved were such that these impairments were unlikely to have been relevant.

3.3.2 HEARING

Although the hearing abilities of these drivers were varied, there was only one individual who revealed a marked deficit. However, it was unlikely that this hearing deficit was implicated in the causation of that accident. Less marked hearing deficiencies that characterized some other drivers also were not apparently relevant among those factors underlying their accident involvement.

3.3.3 FOOTWEAR

Three hundred and nineteen drivers were wearing what might be regarded as conventional footwear for driving; i.e. lace-up or slip-on shoes, boots, sandals or slippers. Among the rest were 17 drivers who were without shoes, ten wearing thongs, and 26 wearing platform shoes of varying dimensions. For 31 individuals no information regarding the footwear worn was available.

Despite the prevalence of footwear that might be considered to be inappropriate, impairment of the operation of the foot controls of the vehicle was indicated in only one instance. This driver, who was cramped by two passengers beside her in the front seat, reported after the accident that her initial attempt to apply the brake may have been impeded when the thong on her right foot became entangled slightly among the pedals. At a subsequent interview, however, the driver denied that her inappropriate responding prior to the accident derived in any way from such a factor.

It was difficult to identify instances in which inappropriate footwear was relevant, unless the driver or another occupant of the vehicle said that it could have been, as noted above. However, in all of the other cases in which the driver was not wearing appropriate shoes, etc., there were always other factors which accounted for any lapses in the driver's performance in this respect before the accident.

3.4 DRIVERS: PSYCHOLOGICAL CHARACTERISTICS

Journey Schedule

The possibility that some interference with the journey schedule may have influenced the driving behaviour of these individuals prior to the accident was examined for those drivers for whom the relevant information was available.

Ten drivers were behind schedule, although their schedules reportedly did not require rigid observance. The journeys of another two individuals were not progressing in accord with schedules that were quite rigid. However, it was considered that the accident involvement of only three of these 12 drivers might have been related to the fact that they were running late. Furthermore, the performance of each of these drivers apparently was subject to the influence of other factors that could have accounted for what appeared to be hasty and inappropriate behaviour.

Social Interactions before the Journey

Pre-journey social interactions that were other than routine in nature were only reported by eleven of the 346 drivers for whom the relevant information was available. Seven of these 11 drivers reported social interactions of an exciting nature prior to the journey, another three reported stressful interactions, while the remaining individual's interactions seemed to combine both these elements. In seven of these instances these social interactions appeared to have been significant in determining emotional states or reactions which, in part, shaped the driver's behaviour prior to the accident.

Emotional State before the Accident

There were 40 drivers who were assessed as having been emotionally aroused before they started on the journey or before the accident. After examination of all of the factors underlying the accident involvement of those 40 drivers, however, it was considered that the behaviour of only ten of them was likely to have been influenced adversely by their temporary emotional states. Seven of these drivers were excited either in response to preceding social interactions or forthcoming activities. Five of the seven attempted manoeuvres at speeds at which they were unable to maintain control of their vehicles, and one individual had not driven a car before. The seventh commenced a turning manoeuvre without yielding to traffic approaching from the opposite direction. Another two drivers were a little anxious as a result of delays in their journey, and their pre-accident behaviour reflected this anxiety when they responded on the basis of insufficient information. The tenth driver, whose mood was a mixture of excitement and anger, lost control of his car during a high speed chase of another vehicle.

Preoccupations before the Accident

In ten of the 53 cases in which it appeared that the driver was preoccupied before the accident the preoccupation was of a degree that could have had a detrimental effect on his driving behaviour. The preoccupations of two of these ten drivers were associated with stresses related to their employment. For the remaining eight individuals these stresses were related to domestic disputes, family illnesses and deaths, or other problems of a personal nature. All of these preoccupations had been enduring in their impact. Four of these drivers were intoxicated, as well as being preoccupied. Their blood alcohol levels ranged from 0.12 to 0.24.

The accident involvement of one of these ten drivers clearly was the result of a suicide attempt, and there were grounds for suspecting that at least one other driver's accident may have been the result of a possible 'pseudo' suicide attempt. Each of these two individuals, together with one other from this group of ten drivers, had a history of psychiatric treatment.

A number of other drivers recalled having preoccupations, some transient and others more enduring. However these preoccupations were not considered to have been significant among those factors which were related to the accident involvement of these drivers.

Incidents during the Journey

Unexpected incidents occurred during the journeys of at least 11 drivers. However, for four of them these incidents were related only indirectly to the eventual outcome, and apparently did not contribute to their behaviour before the accident. In another three cases these incidents were relevant in the sense that they foreshadowed the eventual outcome of the journey. One of these three drivers, who was severely intoxicated, had narrowly escaped being involved in a collision with another vehicle but, despite this 'near-miss' continued driving in an inappropriate manner. Another driver was arrested for driving under the influence of alcohol but had been released shortly before the accident even though he was extremely fatigued and still mildly intoxicated (BAC of about 0.08). The third driver, who apparently dozed off shortly before the accident, had felt drowsy some time earlier. However, she had turned off the car heater and wound down the window in an attempt to combat fatigue, and then continued with the journey.

For the remaining four of these 11 drivers these unexpected incidents apparently were related directly to the accident involvement. Three had been delayed unexpectedly during their journeys, for different reasons, and their inappropriate behaviour when attempting turning manoeuvres at intersections derived, at least in part, from their reactions to these delays. The fourth driver, who was intending to turn right at an intersection, encountered a stalled vehicle in his path. While he was manoeuvring around this vehicle, he failed to see a vehicle that was approaching the intersection from the opposite direction.

The responses of three of these four drivers prior to the accident were characterized by a failure to take account of restrictions on the field of view that were imposed by stationary traffic or roadside objects. Without any precautionary inspection, the fourth driver, whose journey had been delayed when he lost his way, commenced a right turn as soon as he had located the turn-off that he was seeking, even though in turning he moved across the path of an approaching vehicle.

3.5 DRIVERS: LICENSING AND EXPERIENCE

3.5.1 LICENSING

Type of Licence

The classifications of driving licence which may be obtained in South Australia are as follows:

Class 1. May drive
- (a) any motor car; or
- (b) any other motor vehicle the weight of which (excluding the weight of any trailer attached thereto) does not exceed 1780 kilograms except an articulated motor vehicle, a motor cycle, or a motor omnibus (minimum age of driver 16 years).

Class 2. May drive any motor vehicle except an articulated motor vehicle, a motor cycle, or a motor omnibus (minimum age of driver 17 years).

Class 3. May drive any motor vehicle except a motor cycle or a motor omnibus (minimum age of driver 18 years).

Class 4. May drive a motorcycle (minimum age of driver 16 years).

Class 5. May drive a motor omnibus (minimum age of driver 18 years).

The types of current licences held by the drivers in this sample of accidents are shown in Table 3.15. At least four drivers did not hold either a learner's permit or any full licence at the time of the accident. Two of these drivers were under 16 years of age and thus were not eligible to hold any driving licence. A third driver, aged 22 years, had never held either a learner's permit or full licence. The fourth person had held a licence a number of years previously, but had allowed it to lapse. Another individual held only a Class 4, or motorcycle, licence which was suspended at the time of the accident. One other driver held a Class 1 (car) licence that was currently under suspension.

TABLE 3.15: LICENCE CLASSIFICATIONS FOR DRIVERS IN THIS SAMPLE OF ACCIDENTS

Licence Classification	Number of Drivers
Class 1	267
Class 2	24
Class 3	6
Class 4	1
Class 1 and 4	27
Class 2 and 4	13
Class 3 and 4	2
Class 1 and 5	1
Class 3 and 5	1
Class 1 and 4 and 5	2
Class 2 and 4 and 5	1
Class 3 and 4 and 5	2
Other Australian State licence	15
Licence held, class not known	20
No licence held	4
Not known if licence held	18
Total	403

Eighty-four drivers had incurred at least one licence suspension prior to this accident, and 16 of them reported two or more suspensions. No information regarding previous suspensions was available for 54 individuals.

Three drivers held Class 1 learner's permits only, while another two drivers were operating on probationary licences issued by another State, one for motor cars and the other for articulated vehicles. One of these drivers holding a learner's permit had not complied with the requirement that a licensed driver be present in the vehicle.

Specific licence classification details were not available for 37 drivers, although it was known that at least 20 of them held the appropriate full licence. The remaining 355 drivers held full licences that were appropriate for the vehicles that they were driving at the time of the accident.

Only two drivers reported that there were any restrictions associated with their licences, and in both cases the restriction required the person to be wearing prescription glasses or contact lenses when driving. As noted in the earlier section on visual acuity, there were many more drivers who had poor vision (less than 6:12) and in four cases this defect probably contributed to the causation of the accident.

Most of these drivers had obtained their first driving licence in South Australia (274 drivers) or in another State in Australia (22 cases). Fifteen were first licensed to drive in the United Kingdom, eight in Europe and two in New Zealand. This information was not available for the remaining 78 drivers and was not applicable to the four drivers who had never been licensed.

Period Licence Held

Table 3.16 shows the length of time that the drivers in this sample held learner's permits or full licences appropriate to the class of vehicle being driven at the time of the accident. The frequency of involvement of individuals who had been licensed for less than two years was by no means as marked for the drivers of cars and other motor vehicles as it was for motorcyclists (McLean et al, 1979d). Less than 16 per cent of these drivers had been licensed for under two years, compared with 52 per cent for the motorcyclists. Also, the experience of those drivers who had been licensed for less than a year ranged evenly from less than one month up to twelve months, rather than being concentrated in the initial months as it was for the riders of motorcycles. Nevertheless, it was notable that drivers who had been licensed for less than five years comprised 36 per cent of those for whom this information was known. Population driving licence statistics relating to the period that the licence had been held were not available, but it does seem likely that this percentage indicates an over-involvement of inexperienced drivers in accidents.

When these data relating to driving experience are compared with the corresponding data for drivers involved in all reported accidents that occurred within approximately the same area of metropolitan Adelaide during the same period of 1976-77 (South Australian Department of Transport, 1978), a similar trend to that observed for motorcyclists is apparent (Table 3.17). Drivers who had held a relevant licence for less than two years were over-represented in the accident sample studied (Chi square = 13.5, 1 d.f., $p < 0.001$).

This comparison does not relate to the risk of being involved in an accident but it does indicate that there is a marked difference between the length of driving experience of the drivers in this sample and of those in all reported accidents.

This difference may be associated with other differences between the sample and the population of accidents, notably the fact that the sample included only accidents to which an ambulance had been called. It could be that these inexperienced drivers, by virtue of their inexperience, age and factors such as drinking habits, might be more likely to be involved in accidents that are severe enough, in terms of injuries or vehicle damage, for someone to call an ambulance. Similarly, the over-representation of drivers with 50 to 60 years driving experience (Chi square = 21.2, 1 d.f., $p < 0.001$) could reflect a greater susceptibility to injury of these individuals and hence a greater likelihood that an ambulance would be called to an accident of a given damage severity.

Another possible explanation of these data is that drivers with less than two years experience were more likely to have been in pre-1971 vehicles (which comprised 57 per cent of the sample) than were the more experienced drivers (Chi square = 4.75, 1 d.f., $p < 0.05$), and so they may have been at higher risk of being injured in an accident because of the absence of seat belts in the oldest cars and the generally lower level of safety features. Although there was a suggestion that these inexperienced drivers were more likely to have been driving vehicles that were first registered before the compulsory installation of seat belts, the difference was not statistically significant. Similarly, when actual seat belt wearing behaviour, based on objective evidence together with driver's reports, was examined, 42 per cent of those drivers with less than two years experience were not wearing belts compared to 27 per cent of the remaining drivers, but once again this difference was not statistically significant.

Inexperience as a Cause of Accidents

There were at least nine accidents in which a lack of driving experience was a factor in the causation of the accident. All of these drivers were either attempting to turn at an intersection or to negotiate a bend in the road when they lost control of their cars and collided with stationary vehicles or with roadside objects. All but one of these drivers was unfamiliar with the accident environment and their inexperience was demonstrated both by the fact that they were unable to control their cars and, in particular, by their having attempted the manoeuvre at a speed which was too fast for the location or prevailing conditions.

Three of these nine drivers had never held a driving licence, and indeed two were ineligible because of their age. One of these two individuals previously had not driven a car on the road. A fourth driver was the holder of a suspended motorcycle licence, but had not held a licence to drive a motor car. Another of these drivers held a learner's permit, while the remaining four drivers had been licensed for less than three months.

3.5.2 DRIVER TRAINING

Information on the nature of the driving instruction that they had received was available for 285 out of the 403 drivers. Forty-nine had been trained by commercial driving instructors and 13 drivers had undertaken a driving course conducted by the Road Safety Council of South Australia, or some course of a similar type. The remaining individuals had been instructed

TABLE 3.16: PERIOD RELEVANT DRIVING LICENCE HELD

Period Licence Held (Years)	Number of Drivers
Less than 1 year	36
1 to < 2	27
2 to < 3	25
3 to < 4	28
4 to < 5	16
5 to < 10	58
10 to < 20	80
20 to < 30	42
30 to < 40	24
40 to < 50	9
50+	16
Long period (no. of years unknown)	6
Not applicable (not licensed)	4
Period not known	15
Not known if licensed	17
Total	403

TABLE 3.17: PERIOD RELEVANT LICENCE HELD BY DRIVERS IN ACCIDENT SAMPLE AND COMPARABLE ACCIDENT POPULATION

Period relevant Licence held (yrs)	Number of Drivers			
	Sample	% of known cases	Population	% of known cases
1	36	10.0	284	6.2
1 < 2	27	7.5	228	5.0
2 < 3	25	6.9	318	7.0
3 < 4	28	7.8	270	5.9
4 < 5	16	4.4	263	5.8
5 < 6	16	4.4	233	5.1
6 < 7	8	2.2	187	4.1
7 < 8	14	3.9	151	3.3
8 < 9	10	2.8	159	3.5
9 < 10	10	2.8	112	2.5
10 < 11	15	4.2	180	4.0
11 < 21	69	19.1	1044	23.0
21 < 31	45	12.5	620	13.6
31 < 41	19	5.3	313	6.9
41 < 51	12	3.3	148	3.3
51 < 61	10	2.8	32	0.7
61+	1	0.3	6	0.1
Unknown	38	-	1858	-
Total	399[1]	100.0	6406	100.0[2]

Notes: [1] Four drivers did not have a driving licence.

[2] Percentages may not add to 100 because of rounding error.

TABLE 3.18: OWNERSHIP AND FREQUENCY OF USE OF ACCIDENT-INVOLVED VEHICLE

Owner of Vehicle	Number of Vehicle Ownership	Used Regularly[1]
Driver or close relative	332	332
Employer	47	44
Friend of driver	12	11
Rental firm	1	1
Casual acquaintance	1	-
Stolen car	1	-
Ownership/usage not known	9	
Total	403	388

Note: [1] By the driver who was involved in the accident.

by relatives or friends, or had taught themselves.

There were no statistically significant differences between the self-reported accident and violation histories of those drivers who had received formal training and those who had not. However, these data do not provide an adequate basis for an assessment of the respective merits of these various types of driving instruction because they include only drivers who have been involved in an accident.

3.5.3 FAMILIARITY WITH THE VEHICLE

The ownership of the vehicles involved in these accidents and the frequency with which the accident-involved driver used them are shown in Table 3.18.

Regardless of ownership, all but ten of these drivers either used the vehicle on a regular basis, or used it, or a similar vehicle, sufficiently often that they could be regarded as being familiar with the vehicle. Furthermore, the accident involvement of eight of these ten drivers was not considered to be related to any lack of familiarity with the vehicle.

However, there were two cases in which the driver's lack of experience with the vehicle did contribute to the causation of the accident. One of these drivers was travelling in a large truck that was owned by his employer. He had used this vehicle only on a few occasions, and his lack of familiarity with manoeuvring a vehicle of such dimensions was demonstrated when he was overtaking another vehicle at a location adjacent to which a pedestrian was standing at the centre of the road. Although he considered that there was sufficient space to overtake the other vehicle without endangering the pedestrian, the protruding external rear vision mirror of the truck struck the pedestrian on the head. The other driver was not licensed to drive a car, but she had some experience of driving her fiancee's car in and out of a driveway, and for short distances in the street. On this occasion she was undertaking a slightly longer journey, and for the first time in her experience of driving that vehicle the automatic transmission changed from first to second gear. The change in engine tone and the brief lurch of the vehicle that accompanied this gear change startled the driver, causing her to look down in an attempt to locate the source of this unexpected variation in the vehicle's performance. As she was doing so, the car veered off the road to the left and collided with a tree.

Although a number of drivers reported that recently they had been using another vehicle, with the exception of the first case that was discussed in the preceding paragraph there was no evidence to suggest that this recent experience in a different vehicle interfered with the performance prior to the accident of any of these drivers.

3.6 DRIVERS: ANALYSIS OF ERRORS

3.6.1 VISUAL DISTRACTIONS

For 350 drivers there was no evidence, nor any reports, of environmental distractions that may have affected the performance of these participants. No information regarding this possibility was available for another 44 drivers. There were nine individuals whose performance prior to the accident apparently was subject to the influence of a distracting stimulus or event. Among these nine individuals were five drivers whose accident involvement clearly was related to their response to such a distraction. The vehicles driven by two individuals collided with off-road objects after the drivers had been distracted by events that took place within the car. One of these drivers was distracted by a young child vomiting within the car (Accident 067). The attention of the other, an unlicensed and most inexperienced driver (Accident 241) was diverted by the response of her vehicle to an automatic transmission gear change, a response that this person previously had not experienced when driving. Two other drivers (Accidents 097 and 047) were distracted by the unusual activity or gestures of people near the roadside, and subsequently they collided with the rear of stationary vehicles. The fifth individual (Accident 169), who had been waiting for some time at a priority road junction, was distracted by an adjacent vehicle that unexpectedly accelerated rapidly into the intersection. In an almost reflex manner, the driver also began to enter the intersection, without having ensured that the priority road was free of approaching traffic.

3.6.2 FAILURE TO ACCOMMODATE TO A VISUAL RESTRICTION:

Outside the Vehicle

For at least half of these participants, there were either temporary or permanent aspects of the physical environment beyond the vehicle that may have restricted the field of view of the driver. Table 3.19 summarizes the nature of these restrictions, and indicates the proportion of those restrictions that were considered relevant to the pre-accident performance of these individuals. The accident involvement of at least 120 individuals was related to the failure to take account of a restriction of their field of view imposed by some feature, whether transient or permanent, of the physical environment beyond their vehicle.

Within the Vehicle

For 45 drivers there were also potential visual restrictions within the vehicle itself. Table 3.20 outlines the nature of these restrictions and highlights those restrictions that were considered to be relevant to the performance of these individuals preceding the accident. The performance of 21 of these 45 drivers was considered to have been influenced by their failure to take account of such restrictions but for 15 of the 21 failure to take account of a restriction beyond the vehicle was a more critical factor underlying their accident involvement. Thus, there were six individuals for whom the failure to accommodate to a visual restriction within the vehicle was of major significance. In five of these cases, the significant restriction derived from the vehicle structure to the rear of the driver, while in the other it was due to the placement of baggage at the rear of the vehicle. Two of these vehicles were attempting U-turns, another two were pulling out from the kerb, and the remaining two were changing lanes. It remains somewhat subjective, however, as to the extent to which the accident involvement of these drivers reflected some interaction between visual restrictions due to vehicle design features, and failure to make adequate inspections for traffic approaching from the rear.

Taken together, these data suggest that the accident involvement of at least 126 drivers (i.e. 31%) was related at least in part to a failure to accommodate to a visual restriction when performing the manoeuvre that preceded the accident.

3.6.3 SECONDARY ACTIVITIES:

Within the Vehicle

At least 106 drivers had been engaged in some secondary activity within the vehicle prior to the accident, and the nature of these activities are shown in Table 3.21. It is considered that the primary task (driving) performance of 47 of these 106 drivers was impaired significantly as a result of this secondary activity involvement, although for three of these drivers the precise nature of the secondary activity could not be determined.

Outside the Vehicle

Table 3.22 summarizes the nature of those secondary activities in which these drivers were involved outside the vehicle. Although at least 75 drivers were engaged in such activities prior to the accident, an associated impairment of driving performance was identified for only 37 individuals. Among these 37 drivers were twelve who also were engaged in a more minor secondary activity within the vehicle. Although there was a strong suggestion that the performance of another two individuals had suffered from their involvement in some secondary activity focused outside the vehicle, an adequate description of the nature of these activities was not available.

Collectively, it appears that the efficiency of the performance of at least 86 drivers (21 per cent) may have been impaired prior to the accident through their involvement in a secondary activity, either within, or extending beyond, the vehicle. (In assessing the relevance of secondary activities only the most significant one from Tables 3.21 and 3.22 is listed as relevant for a given driver.)

3.6.4 INADEQUATE MONITORING OF RELEVANT ENVIRONMENT

Seventy drivers, despite the absence of limitations on their fields of view, either

TABLE 3.19: FREQUENCY OF POSSIBLE AND RELEVANT VISUAL RESTRICTIONS OUTSIDE VEHICLE FOR DRIVERS OF CARS AND OTHER VEHICLES

Visual Restriction	Frequency Visual Restriction	Frequency Relevant Visual Restriction
None	188	-
Moving traffic	27 (1)	16 (1)
Stationary traffic	49 (1)	29 (8)
Parked vehicles	15 (11)	7
Roadside objects (man-made)	10 (7, 2)	- (5, 2)
Roadside objects (trees etc.)	17 (11)	9 (10)
Objects on or beyond the property boundaries	79 (15)	59 (10)
Other than the above	5	-
Unknown	13	-
Total	403	120

Note: Numbers in perentheses indicate second or third visual restriction.

TABLE 3.20: FREQUENCY OF POSSIBLE AND RELEVANT VISUAL RESTRICTIONS WITHIN THE VEHICLE FOR DRIVERS OF CARS AND OTHER VEHICLES

Visual Restriction	Frequency Visual Restriction	Frequency Relevant Visual Restriction
None	341	-
Vehicle structure ahead of driver	5	2
Vehicle structure behind the driver (including mirror efficiency)	12	8
Windscreen misted, soiled etc.	25	9
Sunvisors	1	1
Accessories, ornaments	2	1
Vehicle occupant	- (1)	-
Unknown	17	-
Total	403	21

Note: Number in parentheses indicates second visual restriction.

TABLE 3.21: FREQUENCY OF SECONDARY ACTIVITY ENGAGEMENT INSIDE VEHICLE FOR DRIVERS OF CARS AND OTHER VEHICLES

Secondary Activity	Frequency Secondary Activity	Frequency Relevant Secondary Activity
None	246	-
Listening to radio etc.	32 (2,1)[1]	3 (2)
Monitoring dials, gauges, etc.	2 (2)	2 (2)
Smoking	1	-
Lighting cigarette etc.	2	2
Retrieving dropped cigarette, etc.	1	1
Reaching for other object within vehicle	2	2
Looking for object within vehicle	1	-
Eating, drinking	4	3
Verbal interaction with passengers	53 (6)	24 (6)
Physical interaction with passengers	1	1
Looking at passenger	5 (1)	5 (1)
Closing eyes, dozing	2	1
Unknown[2]	51 (2)	3 (1)
Total	403	47

Note: [1] Numbers in parentheses indicate second or third secondary activity (additional to the cases listed for that activity).

[2] Unknown cases include some in which the driver was thought to have been engaged in a secondary activity but its precise nature could not be determined.

TABLE 3.22: FREQUENCY OF SECONDARY ACTIVITY ENGAGEMENT OUTSIDE VEHICLE FOR DRIVERS OF CARS AND OTHER VEHICLES

Secondary Activity	Frequency Secondary Activity	Frequency Relevant Secondary Activity
None	288	-
Looking for address, signpost, etc.	7	4
Attempting to follow path of other vehicle	7	3
Monitoring activity of other vehicle or pedestrian	44	20
Interacting with occupants of other vehicle	3	2
Interacting with pedestrians	2	1
Watching activity in mirror	2	2
Other than the above	10	5
Unknown	40	2
Total	403	39

failed to inspect adequately the approach paths or the manoeuvres of other traffic involved in these accidents, or did not monitor closely the traffic routes in which they themselves were travelling.

3.6.5 FAILURE TO OPERATE APPROPRIATE VEHICLE CONTROLS (e.g. lights, indicators, etc.)

The available information suggests that another two drivers failed to provide appropriate indication of their intended manoeuvres and furthermore, that this failure clearly was implicated in their subsequent accident involvement. Both drivers were making unsignalled right turning manoeuvres, one into a car park (Accident 255) and the other into a driveway entrance (Accident 212), when they were struck by an overtaking vehicle.

3.6.6 VEHICLE DEFECT

A discussion of vehicle defects and their relevance in these accidents appears in Section 4.2 of this Report. Among those defects that were considered of relevance in that Section are a number that have not been included here. Although those defects may have been related to the specific nature of severity of the outcome, it was considered that other factors were of greater significance in determining the participant's accident involvement. The following discussion of vehicle defects is included in this Chapter because the driver can be held responsible for the roadworthiness of his vehicle.

There were eight cases in which a vehicle defect was considered to be particularly relevant among the pre-accident circumstances. In two instances the relevant defect was associated with brake inadequacies and in another three instances with inadequate, mismatched, or flat tyres. An electrical fault that was caused by an oil leak resulted in another vehicle stalling while in the path of an approaching vehicle. A heavy truck with an inoperative left rear indicator lamp turned left across the path of a motorcyclist who was overtaking on the left side. It is reasonable to assume that the motorcyclist may not have undertaken this manoeuvre if the indicator had been operating. The remaining case involved a serious mechanical failure that precipitated a loss of control of the vehicle and a subsequent rollover. An insecure load, rather than a defect of the vehicle itself, was critical in one other accident. A car that was beginning to exit the stem of a T-junction in order to make a right turn stopped when the driver noticed a truck approaching from his right. Meanwhile, the truck driver had braked, but although he halted his vehicle before reaching a position adjacent to the car, some wooden planks slid from the truck and struck the car driver in the face.

3.6.7 INAPPROPRIATE RESPONSE TO EXTRA-ORDINARY ENVIRONMENTAL CONDITIONS

The accident involvement of three drivers apparently derived, at least in part, from an inappropriate response to somewhat unusual circumstances. In one case, although the effective carriageway width was reduced markedly by the presence of a large truck parked parallel with conventionally parked vehicles (Accident 091), a driver approached this narrow gap without any reduction in vehicle speed. While preoccupied with manoeuvring through this gap at a speed probably in the vicinity of the speed limit, the driver did not detect the slight encroachment into his path of another vehicle from a parked position to the left, and consequently his vehicle clipped the front of that other vehicle. The second case involved a driver who had been waiting at a T-junction on a major road intending to turn right into the main road (Accident 172). After she had been waiting at the junction for some time, another driver in a vehicle to the rear began sounding the horn. The leading driver apparently panicked and began to turn, and in so doing crossed the path of an approaching car that had been obscured from her view by parked vehicles. The third driver had approached an intersection controlled by traffic lights during minimal volume traffic conditions (Accident 099). He stopped in response to the red phase, expecting quite reasonably that his vehicle crossing the sensor would initiate a change of phase. When, after a couple of minutes, the phase did not change, he began to cross the intersection against the traffic lights. However, he had not inspected the intersecting road adequately and was struck by a vehicle proceeding through the intersection with the green phase.

3.6.8 FAILURE TO RESPOND APPROPRIATELY IN EMERGENCY SITUATION

The accident involvement of at least 18 drivers arose partly from inappropriate response made in emergency situations. Among them were four drivers who were unable to control the vehicle when it began to slide, or reacted in such a way as to exaggerate such a loss of control (Accidents 058, 062, 132 and 233). Two of these drivers had been licensed for less than a year. Another five individuals, either by their failure to swerve or alter course or by swerving inappropriately, ensured the eventual outcome of their manoeuvres (Accidents 075, 080, 200, 218 and 290). Two drivers first sounded the horns of their vehicles to warn other drivers, and then braked, when an immediate braking response would have been more appropriate (Accidents 164 and 173). Another two drivers mistakenly accelerated instead of braking when they realized that they may have been travelling too fast as they attempted to turn left at an intersection (Accidents 041 and 236). One of these drivers was unlicensed, and the other held only a learner's permit.

On the other hand, four drivers applied the brakes to slow down or stop when it would have been more appropriate to complete the manoeuvre that had been commenced. Two of these drivers stopped across the paths of approaching vehicles (Accidents 274 and 278) and the other two lost control of their vehicles when they applied the brakes strongly after entering a bend in the road at a relatively high speed (Accidents 168 and 293). One of the latter two drivers was unlicensed, and the other had been licensed for less than a year. The remaining driver collided with a kerb, then an oncoming car, and then continued for some distance across vacant land adjoining the road before plunging into a river (Accident 265). After the relatively minor impact with the other vehicle, the driver apparently failed to take any corrective action. Nevertheless it is possible that this failure to respond may have been related to injuries, such as concussion, that were sustained in the accident.

3.6.9 TRAVELLING TOO FAST TO RESPOND APPROPRIATELY

At least 26 drivers were travelling too rapidly to take effective action when a collision became imminent or, alternatively, to maintain control of their vehicles during the manoeuvres that preceded their accidents. Eleven drivers, eight of whom were travelling on priority roads and all but one of whom had priority, were travelling at speeds at least equivalent to, and in most cases probably considerably greater than, the legal limit of 60 km/h. When confronted with a possible collision none of these individuals was able to take effective evasive action despite sustained and hard braking. One other driver was turning right into the stem of a T-junction quite rapidly, and was unable to implement effective avoiding action when he detected a pedal cycle travelling toward his path (Accident 028). Another eight drivers crashed their vehicles as they negotiated bends or corners in roads at speeds either exceeding the speed limit or in excess of speeds at which such manoeuvres could be negotiated safely. Similarly five other individuals crashed after losing control when making lane changing manoeuvres at speeds reportedly well in excess of the 60 km/h limit (Accidents 100, 163, 233 (2), 237). The remaining individual was driving a car with attached trailer on a descending road. As the vehicle speed increased, the overloaded trailer began to wobble to such a degree that the driver lost control of the car (Accident 046).

Although these drivers ranged in age from 15 to 46 years, drivers aged less than 25 years were more prevalent in this group than among the remaining drivers (Chi square = 5.48, df = 1, $p < 0.05$). Finally, although the reported accident records of these drivers did not point to an increased likelihood of prior accident involvement, they apparently were more likely to have a history of one or more traffic violations (Chi square = 5.11, df = 1, $p < 0.05$). The available information did not point to any other important differences with regard to the variables examined between these and other drivers in the sample. Similar characteristics were also reported among motorcyclists for whom this error was identified as significant among the pre-accident circumstances. This lends support to the conclusion made in the corresponding section of the motorcyclist report that in many cases the behaviour of these individuals prior to the accident may be a reflection of inappropriate, yet typical, driving patterns.

3.6.10 OTHER FACTORS

Nine drivers apparently only erred in their failure to observe a traffic control or rule. Five of these individuals entered traffic light controlled intersections either late in the amber phase or during the red phase, and their vehicles collided with other vehicles making right turns across their paths (Accidents 050, 086, 123, 152 and 170). A sixth driver entered an intersection after reportedly mistaking the onset of a turn left signal light for that of the green through phase (Accident 024). Another individual was driving a vehicle that struck a pedestrian at a pedestrian crossing (Accident 305), and the remaining two individuals became involved in collisions while manoeuvring inappropriately in an attempt to park (Accidents 021 and 262).

The accident involvement of at least 14 drivers was thought to be related to the behaviour of some other road user who did not become involved in these accidents, although all but two of these drivers still were considered to have erred prior to the accident. The critical aspects of the uninvolved road users' responses were varied. Six drivers were encouraged by the uninvolved person to proceed, although traffic conditions were inappropriate. In five of these cases the driver was proceeding through a space between stationary vehicles in response to a signal from the uninvolved person who apparently had not checked adequately all approaches to the site. The manoeuvres of another six drivers were shaped, or even predetermined, by the legally inappropriate manoeuvres of uninvolved vehicles. The responses of the two remaining drivers were influenced in one case by the sudden directional change of a pedal cycle (Accident 290), and in the other by the glare of oncoming headlights on high beam (Accident 230).

Insufficient information regarding the pre-accident circumstances of 33 drivers has prevented any classification in terms of these error categories. Sixteen of these drivers were not interviewed, nine were unable to recall the events preceding the accident, and another died as a result of injuries sustained in the collision. There was insufficient or conflicting information regarding the events preceding the accidents of the remaining seven individuals. No errors were identified for 95 drivers but this does not necessarily mean that none were committed by these drivers.

3.7 ACCIDENT CAUSATION : A SUMMARY

Table 3.23 summarizes those physiological and psychological factors underlying the performance of these drivers, and also those errors that were considered to be significant among the pre-accident circumstances. Again it should be emphasized that since only limited information was available for a number of individuals, this summary table embodies the most conservative estimates of the representation of these factors.

3.8 DRIVERS : LEGAL ASPECTS

3.8.1 TRAFFIC CONTROLS

There were 128 drivers who were involved in accidents at sites where traffic controls were located. It was considered that the actions of 32 of these drivers rendered them liable to prosecution. The details of the apparent violations and the nature and consequences of resulting prosecutions are summarized in Table 3.24.

Eight of these drivers entered a signalised intersection in opposition to a red signal. In five cases the driver was either distracted or engaged in a secondary activity and thus was not attending sufficiently to the status of the signals. Among these was one driver who was unfamiliar with the location and not aware of the presence of the intersection. A sixth driver was stationary at a set of traffic signals and intended to continue straight across the intersection. When a green turn left arrow appeared the driver perceived this as a signal to proceed and in doing so collided with a car crossing from his left. Another driver who had approached a set of signals showing red stopped, and, after waiting for some time for the signals to change, decided to proceed despite the red signal. In doing so he did not adequately monitor for cross traffic and his vehicle collided with another on the intersecting road. The

TABLE 3.23 FREQUENCY OF OCCURRENCE OF CONTRIBUTING FACTORS AMONG 403 DRIVERS

Nature of Contributing Factor[1]	Number of Drivers	Percentage of Total
Physiological and Psychological		
Inappropriate footwear	1	0.2
Visual defect	4	0.6
Alcohol intoxication	57	9.2
Prescription drug effects	3	0.5
Non-prescription drug effects	3	0.5
Medical condition: minor disability	4	0.6
major disability	5	0.8
Fatigue	6	1.0
Emotional stress, preoccupation	20	3.2
Lack of familiarity with accident vehicle	2	0.3
Lack of familiarity with accident site	20	3.2
Driver Errors		
Visual distraction	5	0.8
Failure to accommodate to a visual restriction	126	20.3
Secondary activity	86	13.9
Inadequate monitoring of relevant environment	70	11.3
Failure to operate appropriate vehicle controls	2	0.3
Vehicle defect	8	1.3
Inappropriate response to extraordinary environmental conditions	3	0.5
Failure to respond appropriately in emergency situation	18	2.9
Travelling too fast to respond appropriately	26	4.2
Failure to obey traffic signal or rule only	9	1.5
Response of uninvolved participant	14	2.3
Insufficient information available	33	5.3
No apparent error	95	15.3

Note: [1] These categories are not mutually exclusive.

TABLE 3.24: NATURE AND CONSEQUENCES OF VIOLATIONS OF DRIVERS AT TRAFFIC CONTROLS

Violation details	Violation: Fail to give way	Disobey traffic lights	Disobey STOP sign	Fail to give way and Without due care
Number committed	22	8	1	1
Number charged	10[1]	4[2]	1	1
Not known if charged	2	2	-	-
Fine: < $50	10[1]	3[2]	-	1
$50-$100	-	1	1	-
Suspension: None	9[1]	4[2]	1	1
< month	1	1	-	-

Notes: [1] One driver also charged under driving without due care.

[2] Two drivers charged under driving without due care.

remaining driver, a male aged 90 years, apparently was slow to detect the end of the green phase, with the result that his vehicle was involved in a collision with a pedestrian who was beginning to cross the road at the far side of the intersection.

A further 24 drivers were involved in a collision after passing either a GIVE WAY or a STOP sign. Of these, 22 were aware of and understood the meaning of the control. The other two drivers failed to detect the presence of a STOP sign and were struck from the left while proceeding through the intersection. None of the other drivers failed to stop at a STOP sign.

The legality of the responses of twelve drivers was not clear. Among them were ten who entered signalised intersections during or after a phase change and collided with oncoming vehicles that were turning right. Due to conflicting reports from participants and witnesses, however, the precise status of the traffic signals at the time of entry of the vehicle into the intersection could not be verified. Nevertheless two of these ten drivers were prosecuted for driving without due care. Although the remaining two of the twelve drivers in this category were involved in collisions with pedestrians on pedestrian crossings, there was an indication in each case that the pedestrian was behaving less cautiously than was appropriate.

Of those 32 motorists who clearly contravened the requirement of a traffic control, 16 were charged. Another four may have been charged but the relevant records were not available.

3.8.2 OTHER TRAFFIC RULES

Excluding those who responded inappropriately at traffic controls, there were 170 drivers who apparently failed to observe one or more traffic rules as defined by the Road Traffic Act. These breaches and the ensuing consequences for the drivers are summarized in Table 3.25. Vehicle defects are listed only if the defect was considered a primary factor in the causation of the accident. This table includes ten cases in which the driver registered a breath alcohol level exceeding the 0.08 legal limit on the research team's Alcolmeter, but was not tested by the police. Another driver recorded a BAC in excess of the legal limit but no legal action was taken. Five other intoxicated drivers are not listed in the Table as having committed an alcohol-related offence. Two of these were not tested by the police but were prosecuted under another section of the Act. Two rode to hospital in an ambulance with their injured wives, but since they did not require treatment themselves blood samples were not taken. The remaining individual escaped prosecution because an administrative technicality was breached. There also were three drivers who, according to witness reports, were affected by alcohol. Although two were taken from the accident scene by ambulance, they disappeared before being treated at hospital and consequently blood samples were not taken. For apparently the same reason the remaining individual fled from the scene of the accident.

TABLE 3.25: NATURE AND CONSEQUENCES OF VIOLATIONS BY DRIVERS OF TRAFFIC RULES[1]

Violation	Number Committed	Number Charged	Unknown if Charged	Violation Details: Fine (dollars) ≤50	50<100	≥100	Unknown	Suspension (months) ≤1	1<6	6<12	≥12	Unknown
Fail to give way	46	26	2	21	5	-	-	-	-	-	-	-
Without due care	41	20	2	16	3	1	-	2	1	-	-	-
Fail to stand	26	13	1	11	2	-	-	-	-	-	-	-
DUI	3	2	1	-	-	2	-	-	-	1	1	-
Exceeding 0.08	12	10	-	4	4	2	-	1	5	3	1	-
Exceeding 0.08 and: without due care	18	12	1	1	4	6	1	1	5	4	1	1
driving without licence	1	1	-	-	-	1	-	-	-	-	-	-
driving under suspension	1	1	-	-	-	1	-	-	-	1	-	-
fail to give way	1	-	-	-	-	-	-	-	-	-	-	-
disobeying traffic lights	1	-	-	-	-	-	-	-	-	-	-	-
Exceeding speed limit	5	-	-	-	-	-	-	-	-	-	-	-
Changing lanes to endanger	3	3	-	2	1	-	-	-	-	-	-	-
Without due care and: driving without licence	1	1	-	-	1	-	-	-	-	-	-	-
fail to stand	1	1	-	1	-	-	-	-	-	-	-	-
Insecure load	1	-	-	-	-	-	-	-	-	-	-	-
Overloaded trailer	1	-	-	-	-	-	-	-	-	-	-	-
Vehicle defect	8	-	-	-	-	-	-	-	-	-	-	-
Total	170	90	7	56	20	13	1	4	11	9	3	1

Note: [1] This table excludes those drivers who are listed in Table 3.24 as having violated the requirement of a traffic control.

Only two drivers did not understand the relevant traffic rule. One was an elderly woman who thought she had priority over traffic approaching from her left when entering the carriageway from a petrol station. The other, an elderly male, considered that in the absence of a traffic control he did not have an obligation to yield to the vehicle on his right.

Of the 170 drivers who clearly contravened a traffic rule 91 were prosecuted. Details of proceedings relating to offences committed by another seven drivers were not available. Limited or contradictory information regarding the pre-accident circumstances prevented a reliable assessment of the legality of the actions of a further 24 individuals.

3.8.3 PROSECUTIONS

In summary there were 202 motorists who were considered to have disobeyed a traffic control or violated some other traffic rule prior to the accident. At least 95 of these were not charged with any violation of the Road Traffic Act. Thus, just over half of the 50 per cent of motorists who committed a breach of the Road Traffic Act were prosecuted, and of the total number of motorists involved in the accidents investigated, only 26 per cent were penalised for a violation arising from the accident.

4. THE CAR

This Chapter deals with matters relating directly to the cars that were involved in this sample of accidents. Certain characteristics of these cars are presented in Section 4.1. Sections 4.2 and 4.3 contain reviews of the role of vehicle factors in accident and injury causation respectively. The relevance of the Australian Design Rules for Motor Vehicle Safety (ATAC, 1979) to these accidents is considered in Section 4.4.

4.1 TYPES OF CARS

There are more cars (386) included here than there are drivers of cars (375) in the previous Section. This is because there were 11 drivers of stationary or parked cars who were not considered to have been involved as active participants in their accidents.

Body Style

The body styles represented in the accident sample are listed in Table 4.1. More than two-thirds of the cars were four-door sedans.

Year of Manufacture

The distribution of the cars by year of manufacture is shown in Table 4.2. The median age of these cars is six years. By chance, there were no 1977 model cars involved in the 47 accidents studied after January the first of that year.

4.2 THE CAR: VEHICLE FACTORS IN ACCIDENT CAUSATION

4.2.1 DEFINITION OF A VEHICLE DEFECT

Defects are defined here in two ways: firstly, those failures of a component or components which may render a car unroadworthy or, at least, diminish its level of roadworthiness, and secondly; a failure to comply with a legal requirement for the condition or equipment specification of a passenger car. The former definition can be illustrated by, say, the failure of a braking system in the absence of any prior warning of a fault in the system. The latter definition includes the fitting of tyres of a size other than those approved by the manufacturer of the car, or operating a car with tyres that do not have the required depth of tread.

These two definitions of a defect by no means exhaust the range of vehicle factors that can be important in accident causation. For example, in Accident 191 the driver's view of the pedestrian who was standing in the centre of the road was impaired by glare from oncoming headlights which was accentuated by vinyl plasticizer deposits on the inside of the windscreen of his car. The location or method of actuation of the minor controls can also be important if they confuse the driver and so contribute to his being involved in an accident (there were no cases in which this was evident in this study).

We have concentrated on those defects which are covered by the two definitions listed above; the former category because it includes factors of obvious importance, and the latter because it relates to the relevance of legal requirements and hence may provide some information on the likely value of a compulsory vehicle inspection program.

4.2.2 IDENTIFICATION AND CLASSIFICATION OF VEHICLE DEFECTS

Identification of Defects

Even though each car was inspected at the scene of the crash and then again later, in an examination that lasted more than two hours in many instances, in general no attempt was made to dismantle components. Consequently, whenever the braking system was found to have been in poor condition, by means of a test of the resistance to application of the brake pedal, we noted that fact and looked for damage to the system caused by the crash and for any leaks from the cylinders, lines and other components of the system. The level, and condition, of the fluid in the master cylinder was also noted. A more detailed examination of the braking system would have been of value, but the time required to have done this would have meant that basic information on other systems of the vehicle could not have been collected at all.

While this approach probably has resulted in an underestimate being made of the incidence of potential defects in the braking system of some of the cars in these accidents, we believe that those accidents in which such a defect played a role have been identified. This is because an assessment of the likely importance of the condition of the brakes was made on the basis of the general circumstances of the accident, and this assessment often indicated that the performance of the brakes on the car could not have been relevant to the causation of the accident. A similar approach was used in assessing the relevance of other systems on the vehicle in each accident.

Classification of Vehicle Defects

If a vehicle defect was thought to have been implicated in any way, it was classified as follows:

Major causal factor; without which the accident probably would not have occurred.

TABLE 4.1: BODY STYLE OF CARS

Body Style	Number of Cars
Sedan : 2 door	45
: 4 door	261
Hatchback : 2 door	6
Hardtop : 2 door	14
Station wagon : 2 door	3
: 4 door	32
Convertible	3
Utility	11
Panel van	11
Total	386

TABLE 4.2: CARS : YEAR OF MANUFACTURE

Year of Manufacture	Number of Cars	Cumulative %
1976	16	4.2
75	32	12.6
74	31	20.7
73	27	27.8
72	35	37.0
71	23	43.0
70	32	51.4
69	31	59.6
68	24	65.9
67	19	70.9
66	16	75.1
65	26	81.9
64	23	87.9
63	14	91.6
62	10	94.2
59 - 61	12	97.4
Pre 59	10	100.0
Not known	5	-
Total	386	-

Significant causal factor; without which the accident may not have occurred.

Possible causal factor; A minor causal factor, without which the accident may still have occurred.

The frequency of defective cars in this sample, and the relevance of these defects, are listed in Table 4.3. Although 166 cars had at least one defect (there was a total of 217 individual defects) there were only three cars in which the defect was definitely the major factor in the causation of the accident.

The frequency of defects, and their relevance, by vehicle system are listed in Table 4.4. Some of these defects were in the same car, or in cars involved in the same accident, and so there are more defects noted in Table 4.4 than in Table 4.3. Even so, it is apparent that vehicle defects,

TABLE 4.3: CARS : FREQUENCY AND RELEVANCE OF DEFECTIVE CARS

Condition of Vehicle		Number of Cars
No defects		206
Defect/s:	not relevant to crash	147
:	possibly relevant	5
:	significant causal factor	11
:	major causal factor	3
Not inspected		14
Total		386

TABLE 4.4: CARS : VEHICLE SYSTEMS HAVING RELEVANT DEFECTS

Vehicle System[2]	Number of Defects[1]		B/A (%)
	Total (A)	Relevant (B)[3]	
Brakes	13	8	61
Tyres	141	10	7
Suspension	25	1	4
Steering	6	1	17
Miscellaneous (relevant only)	-	4	-

Note: [1] More than one defect, or relevant defect, in some cars.
[2] Systems having no relevant defects are not listed.
[3] Major, significant and possible causal factors.

TABLE 4.5: FREQUENCY AND RELEVANCE OF TYRE DEFECTS[1]

Type of Defect	Number of Defects		B/A (%)
	Total (A)	Relevant (B)	
Inadequate tread depth	111	7	6
Incorrect tyre size/s (ADR24)	14	1	7
Mismatched tyres	16	2	13
Total	141	10	7

Note: [1] Incorrect tyre pressures are not included here (see text) although often present, rarely played a role in the causation of these accidents. This may be due, at least in part, to the fact that these accidents occurred in mostly dry conditions on level, straight roads in a metropolitan area. A study based on higher-speed crashes in a rural area might reveal a greater contribution from defects in the cars.

4.2.3 RELEVANT DEFECTS

In this Section the nature of each of those defects that played a role in the causation of the accident is described in general terms. A detailed description of each defect that was relevant to the causation of the accident is contained in Appendix 2.

Braking System

The high percentage of relevant defects in the braking system (Table 4.4) is to some extent to be expected since there is often the possibility that the crash would have been avoided had the car decelerated more rapidly before the impact. However, this percentage is, to some extent, inflated because braking system defects which were not relevant in the accident would not have been identified had there been no external evidence of the defect, such as a 'soft' brake pedal, leaking fluid or obviously inoperative components. (By comparison, all tyres having inadequate tread depth were readily identifiable.)

There were no accidents in which a brake system defect was rated as a major causal factor. Those accidents in which a brake defect was relevant are described in Appendix 2 (Accidents 048, 050, 053, 109, 161, 168, 187 and 205).

Tyres

The tyre defects listed in Table 4.4 relate to inadequate tread depth, the fitting of tyres other than those specified for the car in ADR 24 (Australian Design Rule for Motor Vehicle Safety, see Section 4.4) and mismatching tyres (for vehicle not covered by ADR 24). The frequencies of all defects and of those that were relevant are shown in Table 4.5.

Inadequate Tread Depth

The legal requirement for tread depth in South Australia is that the tread be visible around the full circumference of the tyre. In this investigation 'inadequate' tread depth was defined in terms of the Australian Transport Advisory Council (ATAC) Draft Regulation No. 802 which requires a minimum tread depth of 1.5 mm, although a tyre with tread having at least 1 mm of tread depth remaining and otherwise in good condition (uniform depth of tread, etc.) was not rated as 'inadequate' in this respect in this study. Inadequate tread depth was the most common defect recorded for the cars in this sample of accidents. It was a major causal factor in two accidents (062 and 132) and a significant causal factor in five others (047, 087, 119, 168 and 237); all of which are described in Appendix 2. In considering the significance of the tread depth figures it is important to remember that the study was carried out in a particularly dry year and out of the 261 accidents involving a car only 16 (six per cent) occurred on wet surfaces. Furthermore, of the seven accidents in which inadequate tread depth was a relevant factor, four occurred on wet or damp roads.

Incorrect Tyre Size/s (ADR 24)

The low ratio of relevant defects/total defects for ADR 24 infringements is partly due to our strict interpretation of the ADR requirement, e.g. if a vehicle was placarded for a 185SR14 tyre and was fitted with a 175SR14 tyre it was noted as a defect even if the 175SR14 had a maximum load rating equal to or greater than the minimum value shown on the placard. The only defect considered to be relevant was rated as "significant". It was a case in which there was a gross mismatch of front and rear tyre sizes (Accident 108).

Mismatched Tyres

There were 13 cases of mismatched tyres in which radial and crossply tyres were fitted to the same axle. In one of these 13 accidents this defect was assessed as being a major causal factor (Accident 132) and one other as being a significant factor (Accident 108). The other three of the 16 defective cases (see Table 4.5) involved tyres being fitted to wheel rims which were too wide for the particular size of tyre. There were two cars on which crossply tyres were fitted to the rear wheels and radials to the front but in neither case was this a factor in the causation of the accident (143, 195).

Incorrect Tyre Pressures

Tyre pressures were measured for all vehicles at the scene of the crash, but any deviation from the recommended pressures, although recorded, was not coded and is not in the computer file. There was only one accident (189) in which an incorrect (very low) tyre pressure was thought to have been relevant, in that it probably contributed to the driver losing control of his car on a bend, and to the eventual rollover.

Suspension

The most common defect, in the legal sense, was the fitting of modified wheels which increased the wheel track by more than 25mm. No accidents were thought to have been caused by this modification. The only relevant defect in this suspension group arose from an incompetently executed modification to the rear springs, which came adrift and caused the car to roll over (Accident 291).

Steering

Five of the six steering defect cases involved the fitting of small steering wheels with one case (Accident 237) being assessed as a relevant defect. The other type of steering defect was excessive play in the steering box but the one case in this type was not a relevant factor in that accident.

Miscellaneous Relevant Defects

There were three miscellaneous relevant defects, plus the one case in which low tyre pressures were relevant. In one accident (121) the windscreen wiper operating mechanism had been removed before the accident. This was rated as a possible causal factor because we could not be certain that it was actually raining at the time of the accident, rather than at about that time. In the second of these three accidents an opaque plastic strip across the top of the windscreen of a car probably was a factor in the driver not noticing a Stop sign which was set well to the left of his central field of view (Accident 053), and in the third case an oil-soaked distributor was a probable cause of a car stalling as the driver attempted a right turn across oncoming traffic (Accident 012).

4.2.4 DEFECTS BY AGE OF VEHICLE

Table 4.6 lists the age distributions of all of the cars in this sample and of those cars which had a relevant defect and any defect.

The proportion of cars that have one or more defects increases with the age of the car, as shown in Table 4.7, which is based on the data of Table 4.6. This trend is statistically significant ($Z = 3.6$, $p < 0.001$, see Snedecor and Cochran, 1967, Section 9.11). The trend for the proportion of relevant defects is somewhat more marked (Table 4.7), but this result is not statistically significant ($Z = 1.55$, $p = 0.12$).

4.2.5 IDENTIFICATION OF DEFECTS BY THE POLICE

Only a small proportion of the drivers whose cars had a relevant defect were aware or subsequently learnt of the contribution the defect played in the accident. This failure to learn from their experience is related to the fact that none of the cars with relevant defects were issued with defect notices by the investigating police officer. Less than 50 per cent of the 386 cars were recorded by the police on the accident report form as having been inspected, and in only two cases were the police-identified defects relevant to the causation of the accidents.

4.2.6 COMPARISON WITH DEFECT RATES IN OTHER STUDIES

A study in Indiana of the role of vehicle defects in accidents (Institute for Research in Public Safety, 1973a) found that vehicle defects or failures were found to have definitely played a causative role in not less than six per cent of the accidents investigated and to have probably played a role as "either causal or severity-increasing factors" in not less than 14 per cent of the accidents.

The defect rate in these accident-involved vehicles was compared with the rate for a control sample of vehicles whose owners responded to a mass advertising campaign and brought their vehicles in to a centrally-located inspection facility. In general, the accident involved vehicles did have a higher proportion of defects than did the vehicles in the control sample but the differences were not consistently in the one direction and were not large in most cases (Institute for Research in Public Safety, 1973b). On page 48 of the second volume of the final report on the Indiana study (1973b) the observation is made that "With respect to several components of well established safety significance, the outage rates among both the accident and the general population were excessively high, indicating the need for either more frequent or more effective PMVI" (Periodic Motor Vehicle Inspection). By this reasoning there was little to be gained from comparing the accident and the control groups if "excessively high" defect rates among the accident vehicles and the control vehicles would be that more effective motor vehicle inspection would have little effect on the accident rate.

An in-depth study conducted in Melbourne (Consultative Council on Road Accident Mortality, 1978) found that in a sample of accidents to which an ambulance was called there were two accidents out of 166 (1.2 per cent) in which "defects in cars were highly probably causative" and nine accidents (5.4 per cent) "where defects are possibly causative" (ibid, p.77). The corresponding percentages based on the 304 accidents in the Adelaide in-depth study were 1.0 per cent and 5.3 per cent. These results do not suggest that there is a need for more rigorous motor vehicle inspection programs.

TABLE 4.6: INCIDENCE AND RELEVANCE OF DEFECTIVE CARS BY AGE OF CAR

Age of Car (years)	With Relevant Defect	With Any Defect (B)	Total (C)	Ratio B/C (%)
Less than one year	-	1	16	6
1	-	12	32	38
2	1	8	31	26
3	2	13	27	48
4	1	7	35	20
5	1	6	23	26
6	3	18	32	56
7	-	17	31	55
8	2	7	24	29
9	1	13	19	68
10	1	7	16	44
11	1	14	26	54
12	-	10	23	43
13	2	9	14	64
14	2	8	10	80
15	1	4	4	100
16+	1	12	18	67
Unknown	*[1]	*	5	*
Total	19	166	386	43

Note: [1] Vehicle not inspected for defects.

TABLE 4.7: INCREASE IN PROPORTION OF DEFECTIVE CARS WITH AGE OF CAR

Age of Car (years)	Number of Cars: With Relevant Defect (A)	With Any Defect (B)	Total (C)	Ratio A/C (%)	Ratio B/C (%)
Less than 5	5	59	164	3.0	36
5 to less than 10	7	50	122	5.7	41
10 or more	7	57	95	7.4	60
Total	19	166	381	5.0	44

4.3 THE CAR: VEHICLE FACTORS IN INJURY CAUSATION

This Section contains information on the frequency with which various components or objects in the car injured the occupants. More detailed discussions of some aspects are included in Section 4.4 on the Australian Design Rules for Motor Vehicle Safety.

The following information on the objects that were thought to have caused injury is based on the data recorded in the Crash Injury Data File. The identification of such objects often was not a straightforward task and so provision exists in this code to record up to four objects contacted for each injury. In practice it was exceptional for more than two objects to be associated with one injury but the degree of confidence that the correct object had been identified varied from 'certain' through 'probable' to 'possible'. The last of these three ratings was assigned when the object recorded appeared to be the most likely cause of the injury but there was no clear evidence of such an association.

Later in this Chapter, in the discussion of the performance of the Australian Design Rules in Section 4.4, more stringent criteria have been adopted and the cases that are reviewed in connection with each Rule are those in which there was evidence of an occupant having contacted the relevant object, regardless of whether or not an injury resulted. One consequence of these two approaches is that the number of times a given object was contacted usually does differ in the data presented in the two Sections.

4.3.1 OBJECTS CAUSING INJURY

Table 4.8 lists the objects struck, when known, for the 858 injuries sustained by the 347 injured car occupants who were injured (out of a total of 738 car occupants). In some cases more than one object was contacted; this Table lists the first object struck except when it was obvious that the injury was caused by the second object. The number of contacts listed in each row of Table 4.8 includes all three of the confidence levels noted above, with the number of those that were rated as 'possible' being shown again separately in parentheses.

Forty-seven per cent of the objects struck were located at the front of the passenger compartment, 19 per cent at the sides and 22 per cent were interior furnishings, including seat belts, but not counting other occupants who were struck.

The leading causes of injury, taken from Table 4.8, are listed in Table 4.9. The instrument panel was the most frequent cause of injury, followed by the doors (including the A, B and C-pillars), the steering wheel and column and the front seats (mostly the back of the front seat). Seat belts were the fifth most common cause of injury, but in almost all of these cases there was reason to believe that the injuries so caused would have been replaced by other, more severe, injuries had the belt not been worn. The injuries from contact with the windscreen glass were also relatively minor with some exceptions as noted later in this Section. Other occupants were thought to have been the direct cause of injury, as they were thrown against one another in the crash. The final cause of injury to be listed in Table 4.9, the header area, includes the internal sunvisors and the area above the windscreen.

Objects Causing Severe Injuries

Just over five per cent (48 out of 858) of the injuries sustained by the car occupants were rated as severe or worse using the Abbreviated Injury Scale (Committee on Medical Aspects of Automotive Safety, 1971). Concussion, with a period of unconsciousness of more than 15 minutes, or a displaced fracture of a long bone, such as a tibia, are both rated as severe injuries on this scale.

Table 4.10 lists the objects which were known to have caused severe injuries. The 48 such injuries were inflicted on 28 car occupants who were involved in a total of 25 accidents. The instrument panel was the leading cause of severe injuries, with the ranking of other causes being similar to that in Table 4.9. The number of occupants injured is listed in Table 4.10, and it can be seen that some of them received more than one severe injury, as exemplified by the five injuries for one person in the row labelled 'Penetrating objects: other vehicle'; this other vehicle was a deisel rail car.

4.4 THE AUSTRALIAN DESIGN RULES FOR MOTOR VEHICLE SAFETY

The Australian Design Rules for Motor Vehicle Safety (ADRs) specify performance requirements for certain safety-related components or systems in passenger cars and other motor vehicles.

One of the main aims of the study was to assess the performance of the relevant ADRs. This does not mean that only information which was directly related to an ADR was collected, or that the examination of the cars was conducted solely with this aim in view (Sections 4.2 and 4.3 of this report contain some of the more general information on vehicle roadworthiness and crashworthiness). Furthermore, it is emphasised that this review of the performance of the ADRs is not intended to be a statistical evaluation of their effectiveness, but rather a summary of observations made on their performance in serious accidents in a metropolitan area.

TABLE 4.8: OBJECTS CAUSING INJURY TO CAR OCCUPANTS

General Location or Type of Object	Specific Object Contacted	Frequency of Injury: Number of Injuries	Frequency of Injury: % of Total Known Objects
Front of Passenger Compartment:	Instrument Panel:		
	upper	17	2.5
	middle	1 (1)[1]	0.1
	lower	65 (4)	9.4
	beneath	8	1.2
	specific area not known	11 (1)	1.6
	ash tray	2	0.3
	control knobs and levers	5	0.7
	glove compartment	15	2.2
	ventilation outlets	2	0.3
	radio	3	0.4
	Add-on radio, tape deck, air conditioner, etc.	3	0.4
	Parcel tray	8	1.2
	Parking brake: frontal location	4	0.6
	Transmission selector level	5 (1)	0.7
	Steering: wheel	73 (9)	10.6
	column	20 (2)	2.9
	specific area not known	1	0.1
	Windscreen	60 (8)	8.7
	Mirror/s	8 (1)	1.2
	Sunvisors and/or header area	11	1.6
	Hardware: specific item not known	6	0.9
Inside Passenger Compartment:	Front seat/s: back	73 (10)	10.6
	cushion	3	0.4
	Head restraint/s	2	0.3
	Seat belt: webbing	58	8.4
	hardware	12 (1)	1.7
	Flying glass	3	0.4
	Loose object	3	0.4
	Other occupant	14 (3)	2.0

Continued ....

TABLE 4.8 - continued

General Location or Type of Object	Specific Object Contacted	Frequency of Injury: Number of Injuries	Frequency of Injury: % of Total Known Objects
Sides of Passenger Compartment:	Surface of side interiors	67 (4)	9.7
	A-pillar	12 (1)	1.7
	B-pillar	9	1.3
	C-pillar	1	0.1
	Window: glass	24 (3)	3.5
	frames	4	0.6
	Arm rests	12	1.7
	Hardware	3	0.4
Roof of Passenger Compartment:	Roof side rails	5	0.7
	Roof	2	0.3
Floor of Passenger Compartment:	Foot controls	8 (2)	1.2
	Floor	5	0.7
	Console	1	0.1
	Parking brake, floor mounted	1	0.1
Rear of Passenger Compartment:	Rear window glass	1	0.1
	Rear window header area	1	0.1
Exterior surface of case vehicle:	Bonnet	3	0.4
	Side roof rail (exterior)	2	0.3
Penetrating objects:	Other vehicle	9 (2)	1.3
	Non-vehicular object	4	0.6
Other Vehicle:	Side exterior	1	0.1
Ground (road surface):		16	2.3
Other than the above:		4	0.6
No contact:		11	-
Object not known:		156	-
Total		858	100.0[2]

Notes: [1] Possible contacts are shown again in parentheses, as well as in row total.

[2] Column percentages do not sum to 100.0 because of rounding errors.

TABLE 4.9: LEADING CAUSES OF INJURY TO CAR OCCUPANTS

Cause of Injury	Per Cent of All Known Objects Struck
Instrument panel	18.7
Doors and side interior	15.6
Steering assembly	13.6
Front seats	11.3
Seat belts	10.1
Windscreen	8.7
Side windows	3.5
Other occupants	1.7
Header area	1.6
Other objects	15.2
Total Known	100.0

TABLE 4.10: OBJECTS CAUSING SEVERE[1] INJURY TO CAR OCCUPANTS

General Location or Type of Object	Specific Object Contact	Frequency of Severe Injury: Number of Injuries	% of Total Known Objects	Number of Occupants
Front of Passenger Compartment:	Instrument Panel:			
	upper	5	12.2	3
	lower	4	9.8	4
	Steering: wheel	4	9.8	2
	column	2	4.9	1
	Windscreen	2	4.9	2
Inside Passenger Compartment:	Front seats: back	2	4.9	2
	Seat belt: webbing	3	7.3	2
	hardware	1	2.4	1
Sides of Passenger Compartment:	Surface of side interiors	4	9.8	4
	A-pillar	1	2.4	1
Roof of Passenger Compartment:	Roof	1	2.4	1
Exterior Surface of Case Vehicle:	Bonnet	2	4.9	1
	Side roof rail (exterior)	2	4.9	1
Penetrating objects:	Other vehicle	5	12.2	1
	Non-vehicular object	1	2.4	1
Other vehicle:	Side exterior	2	4.9	1
Object not known:		7	-	1
Total		48	100.1	

Note: [1] AIS $\geq$ 3.

4.4.1 ADR 1: REVERSING SIGNAL LAMPS

The intention of this Australian Design Rule is to require lights at the rear of a vehicle which will warn pedestrians and other road users that the vehicle is about to move or is moving in the reverse direction, and which during the hours of darkness will aid the driver in reversing manoeuvres.

Effective date: 1 January, 1972.

(The effective dates listed refer to passenger cars and passenger car derivatives.)

The number of cars fitted with reversing lamps is shown in Table 4.11 together with the number that were subject to the requirements of ADR 1. There were no accidents in the study in which the presence or absence of reversing lamps was a relevant factor. In Accident 188 a 1967 Toyota Crown reversed out from a private driveway onto a poorly lit arterial road. The Toyota was hit by a car which was approaching from its left. The reversing lights on the Toyota were not operative, but it was unlikely that, had they been illuminated, the driver of the other car would have been able to see them because they would not have been visible from the side. The ADR does not require that reversing lamps be visible in any direction other than directly to the rear. There may be a case for requiring side marker lamps to be fitted to cars, as in the United States under Federal Motor Vehicle Safety Standard (FMVSS) 108.

4.2.2 ADR 2: DOOR LATCHES AND HINGES

The intention of this Australian Design Rule is to specify requirements for side door locks and side door retention components including latches, hinges, and other supporting means, to minimise the likelihood of occupants being thrown from a vehicle as a result of impact.

Effective date: 1 January, 1971.

Table 4.12 lists the number of cars that were subject to ADR 2. The frequencies of latch and hinge failures and claimed compliance with ADR 2 are shown in Table 4.13 for two types of loading: cases in which the car was hit on the side but not on the door, the loading on the latch and hinges being due to the inertia of the occupant and, in some cases, also to deformation of the body shell or interior of the car, and for direct impacts on the outside of the door. In each category in Table 4.13 in which latches or hinges failed, those cars that complied with ADR 2 had lower failure rates than those that pre-dated the introduction of this ADR, even though many of the cars in the latter group were fitted with latches and hinges which appeared to be similar to those on ADR 2 cars.

Hinge Failures

The seven cases of hinge failure among the pre-ADR 2 cars included one case in which the upper hinge assembly was torn away from the B-pillar, four failures of one hinge (three upper and one lower, all on left hand front doors) and two failures of both hinges.

The two cases in which both hinges failed involved Morris Mini 850 sedans. These two cars were first registered in 1962 and 1966 and were the only Minis which were hit on the door in the accidents in the study. Figure 4.1 shows one of these doors after it had been struck from the side by a heavy motorcycle (Accident 038). The upper hinge was broken off and the lower hinge was torn away from the door panel. The latch, which incorporated no longitudinal restraint, separated and the door was completely detached from the car.

All but one of the single hinge failures resulted from severe side impacts. The exception was a case in which a minor side impact by another car fractured the lower hinge on the left rear door of a 1967 Ford Prefect. The higne failed at the point of its attachment to the B-pillar (Accident 012, Figure 4.2).

The single case of a hinge failure on an ADR 2 car occurred when a 1976 VK Valiant sedan was struck on the left side by a 1962 EJ Holden sedan (Accident 187). The cars were aligned at right angles to each other on impact and the Valiant was travelling considerably faster than the Holden (72 km/h and 45 km/h respectively, from computer reconstruction of the collision using the SMAC program (Simulation Model for Automotive Collisions; McHenry, 1971). Figure 4.3 shows that the deformation of the side of the Valiant was greater longitudinally than laterally, and so the loading on the lower hinge of the rear door, from the front bumper bar of the Holden, was primarily parallel to the side of the car. The resulting fracture of the hinge is shown in Figure 4.4.

Latch Failures: No External Impact on Door

No ADR 2 latches failed in cars struck on the side when there was no direct impact on the outside of the door, but four pre-ADR 2 latches released in collisions of this type. In each of these four cases the person sitting adjacent to the opened door was ejected from the car. Two of these persons were seriously injured:

Accident 083: an intersection collision between a 1959 Austin Lancer and a 1965 Toyota Crown. The front of the Austin hit the left side of the Toyota near the front wheel, and the Austin was rotated anti-clockwise. The

TABLE 4.11: NUMBER OF CARS WITH REVERSING LAMPS AND SUBJECT TO ADR 1

Reversing Lamps	Subject to ADR 1	Number of Cars
Yes	Yes	119
Yes	No	131
Yes	Not known	14
No	No	122
Total		386

TABLE 4.12: NUMBER OF CARS SUBJECT TO ADR 2

Subject to ADR 2	Number of Cars
Yes	142
No	231
Not known	13
Total	386

TABLE 4.13: PERFORMANCE OF DOOR LATCHES AND HINGES BY TYPE OF LOADING AND ADR 2 COMPLIANCE

Door Component	Type of Loading[1]	ADR 2 Compliance			
		Yes		No	
Latch	From inside car	(0/45)[2]	-	(4/76)	5.3%[3]
	From outside car	(3/49)	6.1%	(33/85)	38.8%
Hinges	From inside car	(0/45)[2]	-	(0/76)	-
	From outside car	(1/49)	2.0%	(7/85)	8.2%

Notes: [1] Data relate only to doors which were subjected to impact loading.

[2] Number of failures (of latch or hinges, as listed) divided by the number of loaded doors.

[3] Per cent failed.

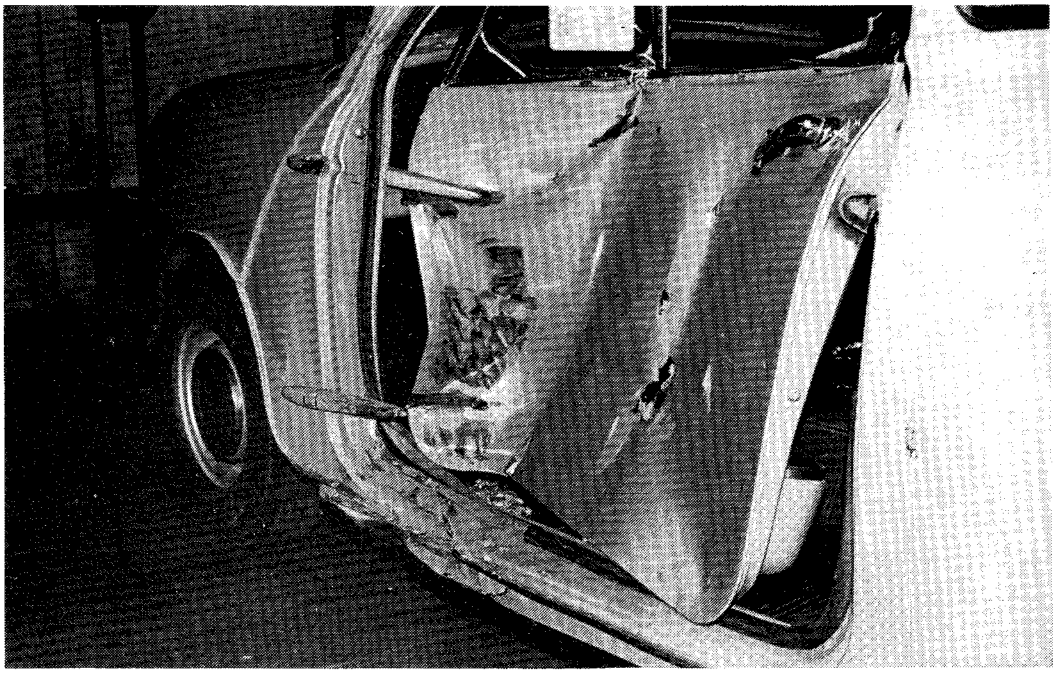


FIGURE 4.1: Hinge failures and latch separation (Accident 038)

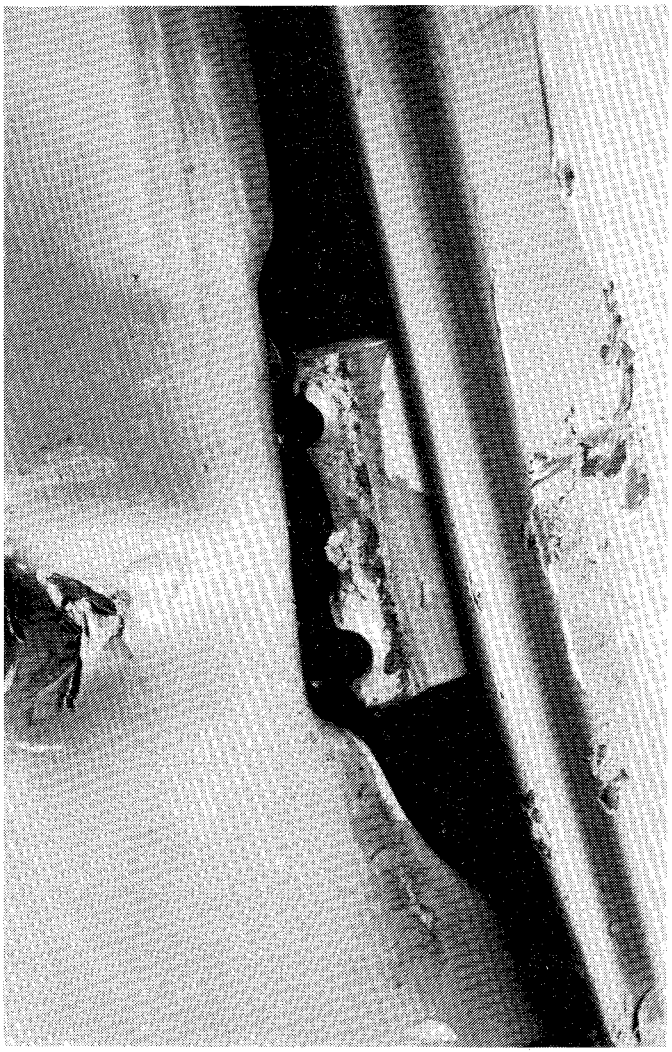


FIGURE 4.2:

Lower hinge fractured at point of attachment to B-pillar (Accident 012)

FIGURE 4.3:

Damage resulting from a right angle collision with another car (Accident 187, see also Figure 4.4)

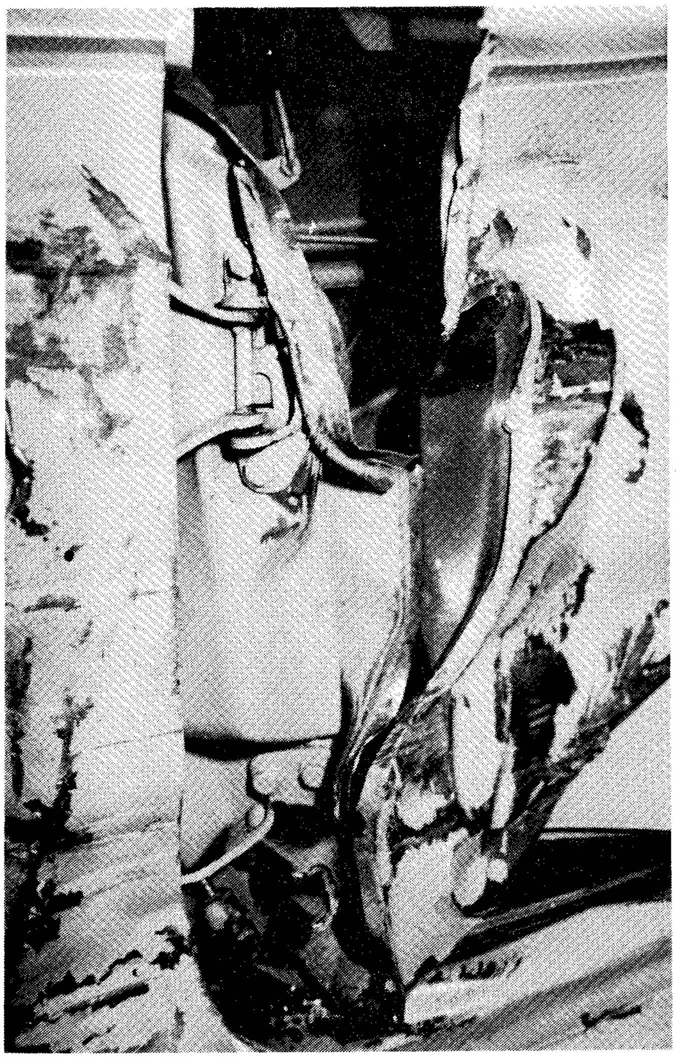


FIGURE 4.4:

Fractured lower hinge on rear door (see also Figure 4.3)

Austin driver's door came open and the driver was thrown out and crushed between the sides of the two cars as they came together, pivoting about the initial impact areas. The driver sustained concussion, and a crushed chest, with rib fractures, a right pneumothorax and pulmonary contusion, and fractures of the right wrist and clavicle.

Accident 126: another intersection collision, this time between a 1971 VW Beetle and a 1965 HD Holden sedan. The Volkswagen was struck on the right rear wheel. The driver's door came open and he was ejected, receiving fractures of three ribs and a stable chip-fracture of vertebra D9, together with facial abrasions, when he hit the road surface.

The remaining two cases of failure of a pre-ADR 2 latch and consequent ejection also occurred in intersection collisions (Accidents 170 and 220). The latch failures were in another Austin Lancer and VW Beetle. A child was ejected through the right rear door of the 1962 Austin, and the left front passenger in the 1965 Volkswagen was ejected through the left door. They both sustained abrasions and contusions and one was concussed.

The door latches on the two Austins incorporated a form of longitudinal restraint, which failed. The Volkswagens were early models which lacked any provision for longitudinal restraint in the door latches.

Latch Failures: External Impact on Door

The latch failed, or separated, on 3 per cent of the 85 doors on pre-ADR 2 cars that were struck in a collision with another vehicle or with a fixed object (Table 4.13), whereas the corresponding failure rate for ADR 2 cars was six per cent of 49 doors. This difference in proportion failed is most unlikely to have arisen by chance (Chi square = 14.1, $p < 0.001$).

Because of their relevance to recent design practice the three failures of ADR 2 latches are presented here in detail:

Accident 169: An ADR 2 latch on a 1975 Ford Cortina TD separated, without sustaining significant damage, when the trailing edge of the driver's door was struck by the left front corner of a 1969 HK Holden sedan. The Holden approached the Cortina at an angle of about 45° from the rear at a closing speed of about 35 km/h. There was considerable deformation of the side of the Cortina (Figure 4.5 with the driver's door being forced inwards through the door opening, the undamaged latch having separated (Figure 4.6). The latch was in locked position and there was no apparent deformation of either the door striker or the latch.

The possibility of the latch being opened by the deformation of the rod connecting the latch release lever to the interior door handle was considered, but rejected on the grounds that if this had occurred the latch would have been found in the open position. Further examination of the latch revealed a small area of deformation on the outer corner of the fixed latch plate that engages the door striker. The nature of this deformation suggested that the door latch had become disengaged from the striker by moving inwards. The possibility of this occurring was checked and it was found that the design of the latch permitted about 15° of rotation (in an anti-clockwise direction) from the normal closed position (as shown in Figure 4.6). This rotation occurred as the latch moved inwards, towards the centre of the car, relative to the striker mounted on the B-pillar and it resulted in separation of the latch without damage to the latch components. This mode of release can only occur when, as in this crash, the door is forced inwards through the door opening. The driver of the Cortina sustained fractures of the right side of his pelvis. He was wearing an inertia reel seat belt and the reel had locked, as intended, in the impact.

Accident 230: Separation occurred between the main body of the driver's door latch and that part of the latch that carries the longitudinal load when a 1976 Chrysler Galant GC sedan was struck on the driver's door by a 1972 Holden HQ sedan (Figure 4.7). The left hand corner of the Holden struck the middle of the driver's door on the Galant, with the Holden approaching from the rear of the Galant at an angle of about sixty degrees. The estimated speeds of these cars on impact were 25 km/h for the Galant and 50 km/h for the Holden, with the resultant impact velocity being about 40 to 45 km/h.

The extent of the intrusion into the passenger compartment is shown in Figure 4.8, whilst evidence of the severe longitudinal load can be seen in the amount of deformation of the door striker mounting plate (Figure 4.9). The four slots through which the staked attaching lugs of the keeper plate were pulled are shown in Figure 4.10. The keeper plate (Figure 4.11) was found at the accident site about 15 metres away from the vehicle.

The door retention system failed at the sheet metal of the C-pillar in the third case involving failure of an ADR 2 door latch (Accident 173).

Accident 173: A 1975 Chrysler Lancer LA sedan was proceeding through an inter-

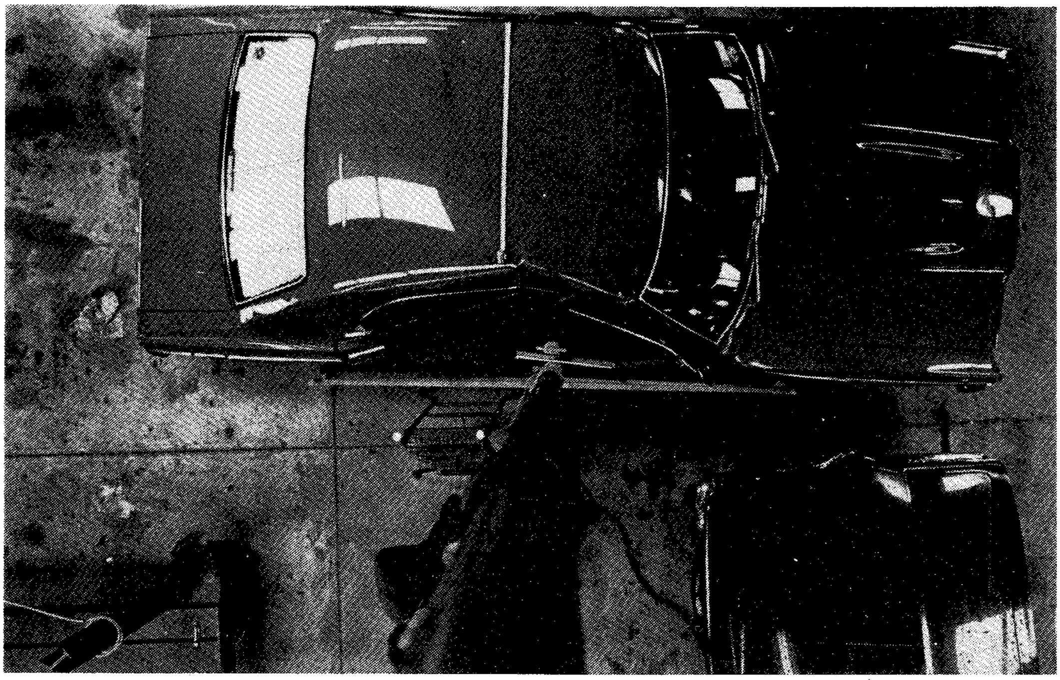


FIGURE 4.5: Deformation of side of Ford Cortina in a two-car collision (Accident 169, see also Fig. 4.6)

FIGURE 4.6: Separation of door latch without significant damage to the latch (see Fig. 4.5)

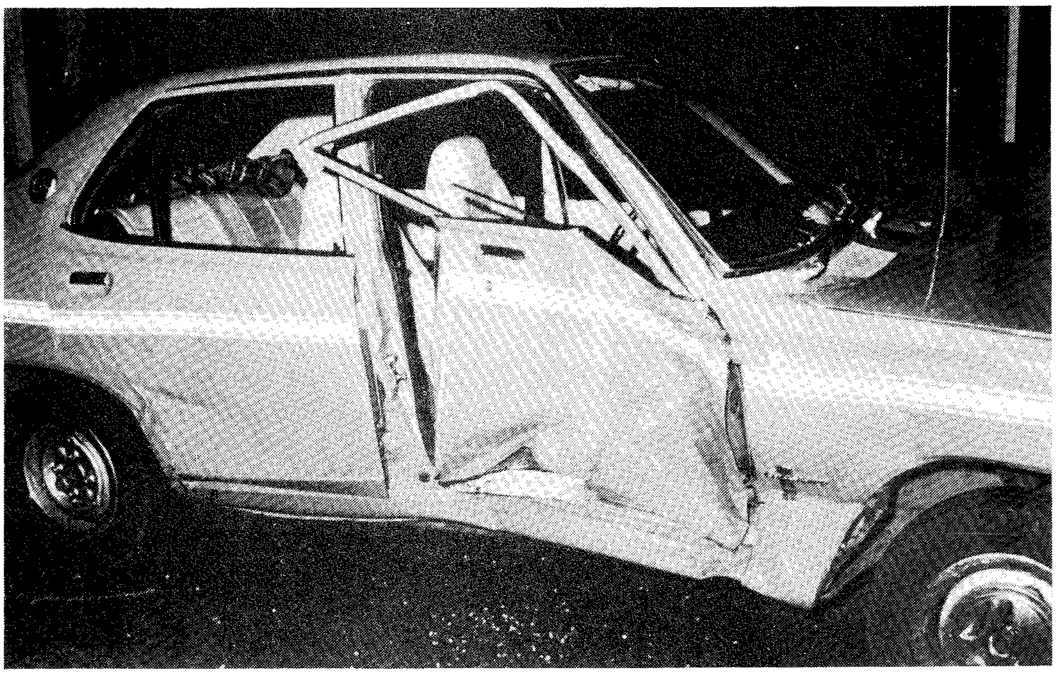


FIGURE 4.7: Damage resulting from a two-car collision. Note separation of door latch (Accident 230, see also Figures 4.8 to 4.11)

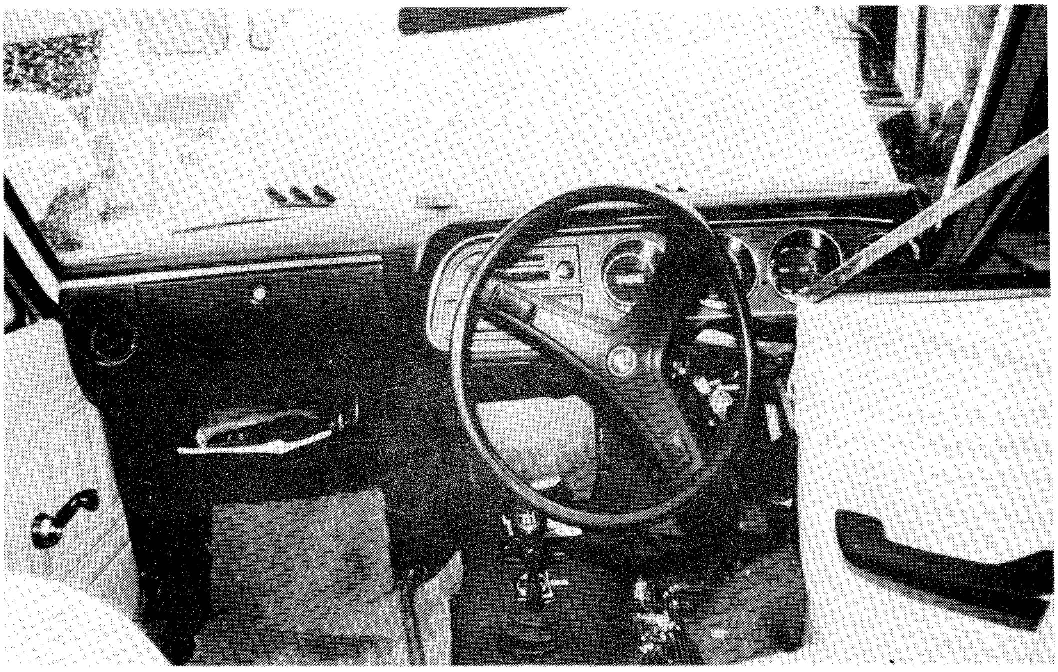


FIGURE 4.8: Extent of intrusion of damaged door (see Figures 4.7 to 4.11)

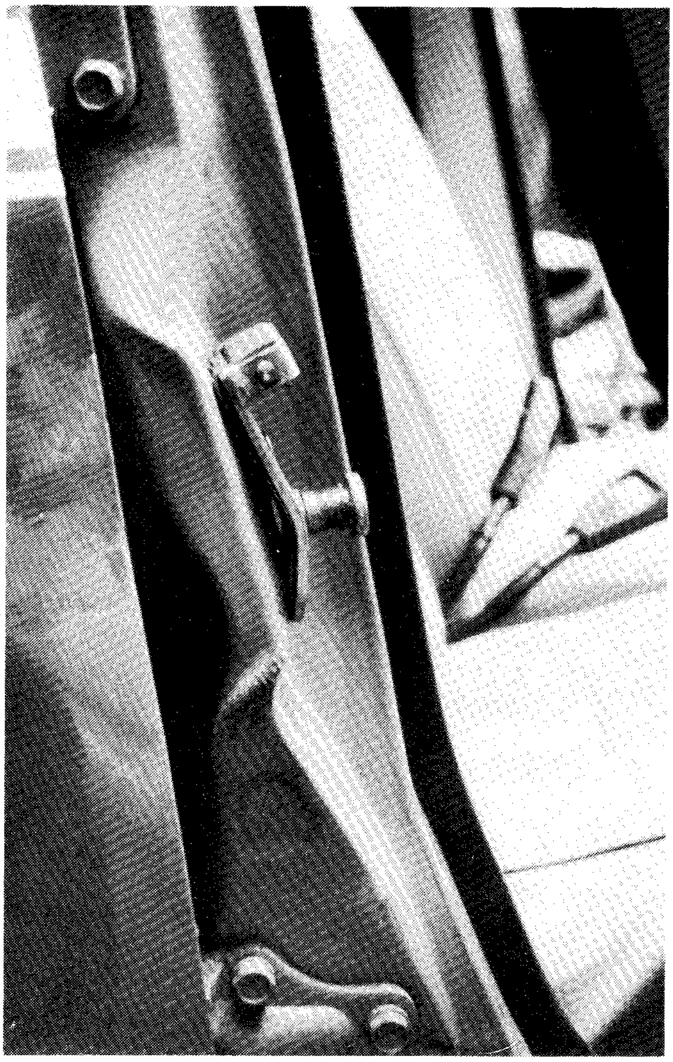


FIGURE 4.9:

Deformation of striker mounting plate (See Figures 4.7 to 4.11)

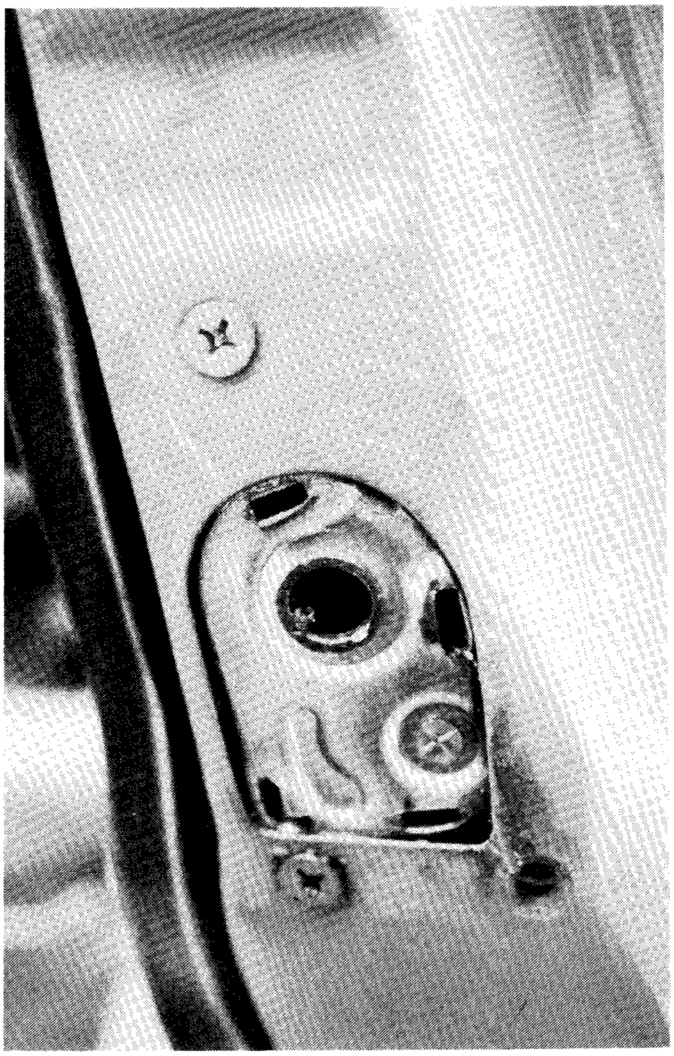


FIGURE 4.10:

Slots through which the staked attaching lugs of the keeper plate were pulled (See Figures 4.7 to 4.11)

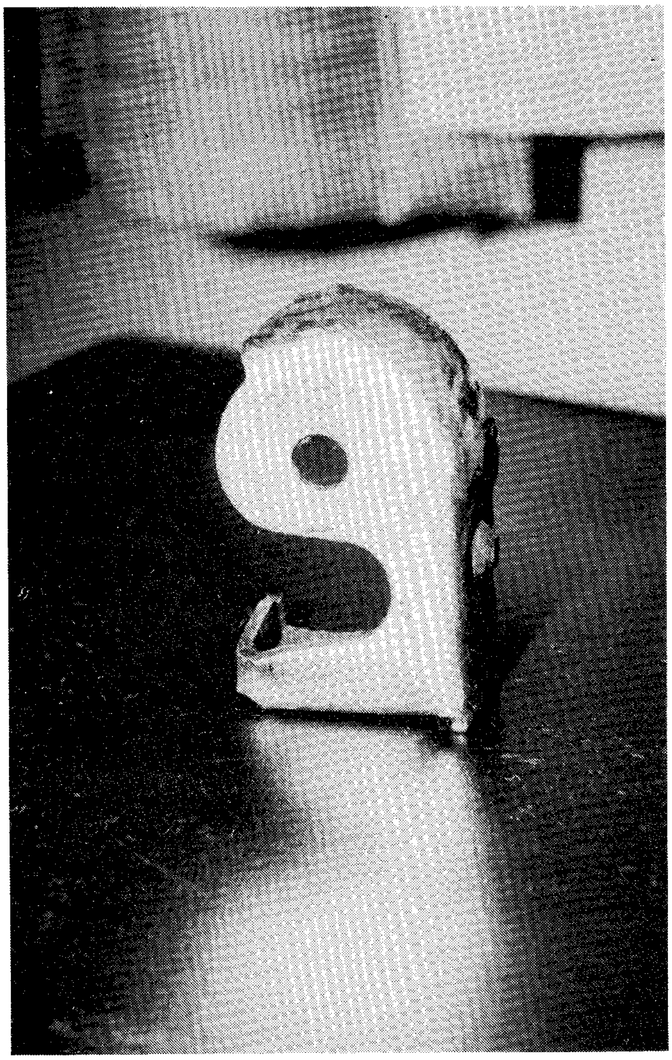


FIGURE 4.11:

Keeper plate detached from latch (See Figures 4.7 to 4.10)

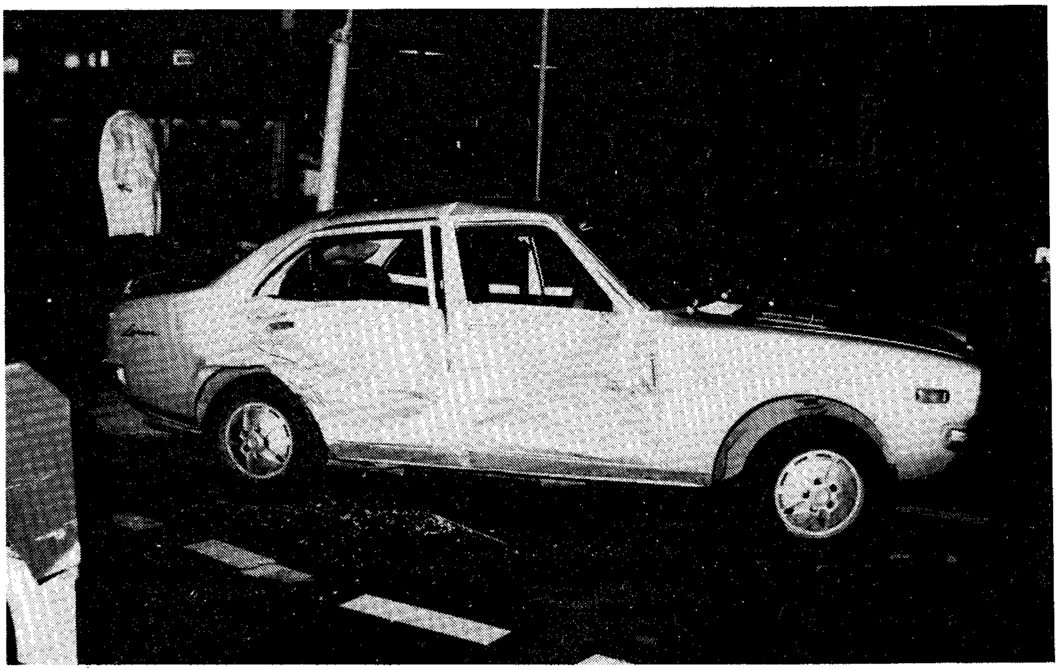


FIGURE 4.12: Deformation resulting from a collision with a HQ Holden sedan (Accident 173, See also Figures 4.13 to 4.15)

section when a 1973 Holden HQ sedan, which had been waiting to make a right turn, moved off. The right hand front corner of the Holden struck the Lancer on the driver's door in the region of the A-pillar. As the vehicles came together the deformation extended to the right hand rear door of the Lancer and to the centre of the bonnet of the Holden. The impact speed of the Lancer was stated to have been 55 km/h. The impact speed of the Holden was not known but in view of the standing start before the right turn was commenced and the small amount of damage to the Holden (it was driven off immediately, and identified later by the police), it is estimated that its speed on impact would not have been greater than 20 km/h.

The deformation of the right hand side of the Lancer is shown in Figures 4.12 and 4.13. The latch itself on the right hand rear door did not separate (i.e. the striker was retained in the latch) but the striker plate was torn from the body sheet metal to which it was attached (Figures 4.14 and 4.15).

Ejection Through Side Doors

Six car occupants were completely ejected through a side door, all as a consequence of collisions at intersections (Table 4.14). One other person was partially ejected through a side door, again in an intersection collision. The five cars involved were all produced before ADR 2 was introduced. Two of them, both Austin Lancers, had a form of longitudinal restraint incorporated into the door latches. The remaining three had latches which lacked any longitudinal restraining device. Table 4.14 lists information on the location and direction of the impact on each car, the seating position of the ejected occupant and the door which opened. Only one of these occupants had a seat belt available (the driver in Accident 083) and that belt was not worn. The ejected drivers in Accidents 083 and 126 sustained critical and severe injuries, respectively. In Accident 083 the driver was crushed between the two cars as they slammed together after the initial impact.

Discussion

The information presented in this Section indicates that ADR 2 door latches and hinges were less likely to fail in these accidents than were those that were fitted to pre-ADR 2 cars. Furthermore, the one failure of an ADR 2 door hinge and the three ADR 2 latch failures (Table 4.13) all occurred as a consequence of a direct external impact on the door, a loading condition that the ADR is not intended to meet. Nevertheless, latch or hinge failure can increase the risk of ejection and thereby increase the risk of severe or fatal injury. The extent of the effect on injury severity of the greater intrusion into the passenger compartment resulting from the release of a door latch (as in Accident 189) is less well established but there is little doubt that there is a positive association between injury severity and the degree of intrusion (eg: Hartemann, F., Thomas, C., Foret-Bruno, J.Y., Henry, C., Fayon, A., and Tarriere, C., 1976). Therefore these failures of latches and hinges should be of concern.

The failure of the Cortina door latch (Accident 169) does appear to be due to a design characteristic that can readily be modified. While recognizing that, at some stage as the loading due to a collision increases, some components of the side structure of the car are likely to fail, the two other latch failures, to a Chrysler Galant (Accident 230) and a Chrysler Lancer (Accident 173) are worthy of further investigation to determine whether the mode of failure might be eliminated. A similar comment applies to the failure of a door hinge on a Valiant sedan (Accident 187).

In summary, the accidents investigated revealed no inadequacies in door latches or hinges that complied with ADR 2 and that were submitted to the type of loading envisaged by the intent of ADR 2. The fact that failures did occur under other loading conditions indicates that ADR 2 does not solve the problem of such failures (it was not intended to do so) and so further investigation of the frequency, mechanism and consequences of latch and hinge failures of this type is recommended.

4.4.3 ADR 3: SEAT ANCHORAGES FOR MOTOR VEHICLES

The intention of this Australian Design Rule is to establish requirements for seats, their attachment assemblies, and their installation to minimise the possibility of failure by forces acting on the seat as a result of vehicle impact.

Effective date: 1 January, 1971.

The number of cars in the study that were subject to ADR 3 is listed in Table 4.15.

This ADR is based on the United States' Standard FMVSS No. 207 and the Economic Commission of Europe (ECE) Regulation No. 17. FMVSS No. 207 in turn is based on the Society of Automotive Engineers (SAE) Recommended Practice for Motor Vehicle Seating Systems (SAE J879b). It appears that ADR 3 is in effect an endorsement of what was already recommended practice within the automobile industry. This recommended practice, and ADR 3, does not appear to allow for loading conditions on seats and seat anchorages that are commonly encountered in accidents.

The compliance test requirements of

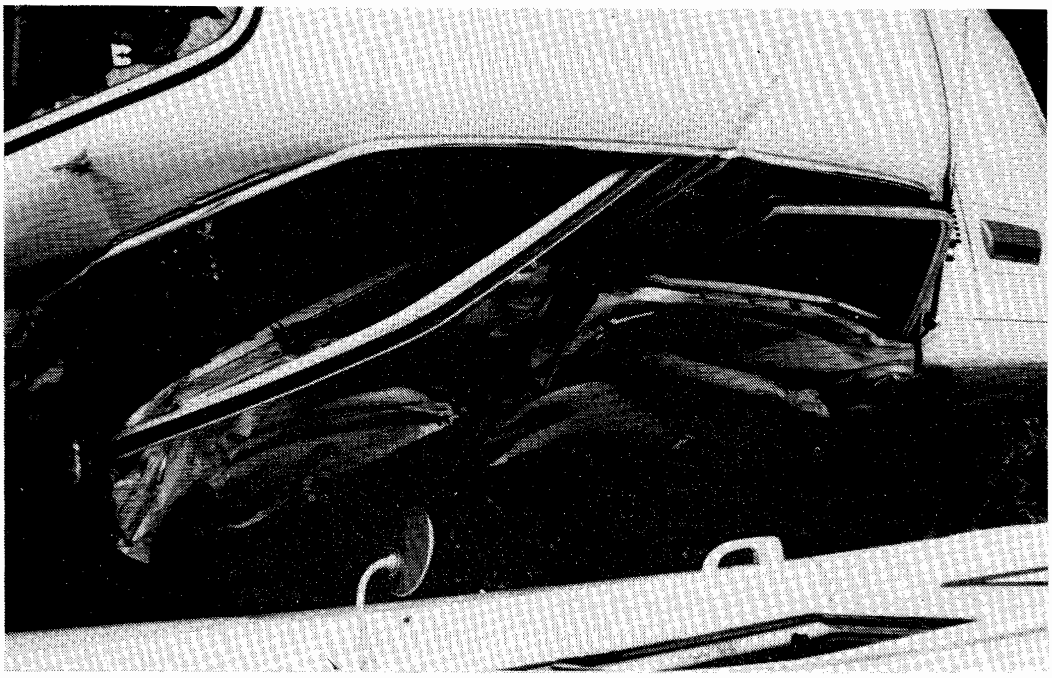


FIGURE 4.13: Top view of damage to car shown in Figure 4.12.

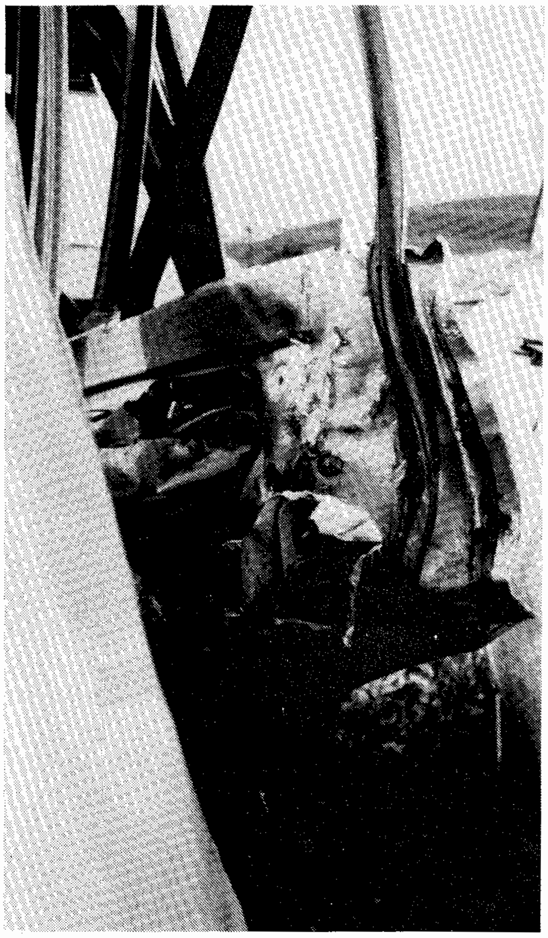


FIGURE 4.14:
Sheet metal torn from body by striker plate of door latch (See Figures 4.12 to 4.15)

FIGURE 4.15:
View of side of striker plate (See Figures 4.12 to 4.14)

TABLE 4.14: EJECTION THROUGH SIDE DOORS

Accident Number	Make and Year of Car	Impact		Ejected Occupant		Degree of Ejection
		Location	Direction	Seated Position	Door Opened	
055	Morris Oxford 1956	Both left doors	From left	Driver	Left front	Partial
083	Austin Lancer 1959	Right front mudguard	From right	Driver	Right front	Total
				Rear seat	Right rear	Total
				Rear seat	Right rear	Total
126	VW Beetle 1971	Right rear	From right	Driver	Right front	Total
170	Austin Lancer 1962	Left rear	From left	Rear seat	Right rear	Total
220	VW Beetle 1965	Left front mudguard	From left	Front left	Left front	Total

TABLE 4.15: NUMBER OF CARS SUBJECT TO ADR 3

Subject to ADR 3	Number of Cars
Yes	142
No	231
Not known	13
Total	386

ADR 3 specify that the seat structure and the seat anchorages should be able to withstand the inertia force generated by the seat assembly during a 20g impact in the fore or aft direction. No provision is made for other loads that often are imposed on the seat in front or rear impacts (with the exception of a clause relating to seat belts that are anchored to the seat structure). These loads may derive from the movement during the collision of unrestrained occupants or luggage, for example, and in the case of a rear impact from the inertia of the occupant of the seat. The situation is potentially worse in station wagons and panel vans which provide cargo areas immediately behind the passenger compartment but are only required to provide a seat assembly with enough strength to prevent it from collapsing under its own inertia load in a severe collision.

In order to assess the performance of seat assemblies in the collision configuration that is addressed by ADR 3 the incidence of seat back failure (either bending or collapse) was tabulated for cars that were damaged on the front or rear of the vehicle. In a frontal impact belt usage by the driver was noted to allow for the possibility that a seat belt might effectively have restrained the forward movement of the seat back as well as the forward movement of the driver. The presence or absence of an unrestrained occupant in the right rear seat, behind the driver, was also noted.

Seat Back Failure in Frontal Impacts

Table 4.16 lists the frequency with which the back of the driver's seat was bent forwards in collisions in which the front of the car was damaged (excluding collisions with pedestrians, pedal cyclists and motorcyclists).

Table 4.16 also contains information on belt usage by the driver, occupancy and belt usage for the seat behind the driver, and whether or not the vehicle manufacturer claimed compliance with ADR 3 ('claimed compliance' is referred to here because, for the reason noted in the discussion of the derivation of ADR 3, it is likely that many of the pre-ADR cars were designed to SAE J879b and hence would have complied with ADR 3).

From Table 4.16 it can be shown that the percentage of seat back failures among otherwise undamaged seats in frontal impacts was less (6.7 per cent of 45 cases) among the ADR 3 cars than among the pre-ADR 3 cars (12.7 per cent of 79 cases). This difference in failure rates, although not statistically significant (Chi square = 1.09, 1 d.f., $p > 0.25$) is closely associated with a greater difference in the proportion of cases in which an unrestrained rear seat occupant was present. The ADR 3 cars had an unrestrained rear seat occupant present in 6.7 per cent of the 45 cases but the corresponding percentage for the 79 pre-ADR 3 cars was 20.2. This difference in rear seat occupancy is important because the presence of an unrestrained occupant in the seat behind the driver was the best predictor of failure of the back of the driver's seat in a frontal impact (eg: Figure 4.16). When there was no unrestrained rear seat occupant present the back of the driver's seat was bent forwards in 4.8 per cent of the 105 cases whereas the added load imposed on the driver's seat by a rear seat occupant being thrown against it resulted in failure of the seat back in 42.1 per cent of the 19 such cases. (This difference is highly significant statistically; Chi square = 24, $p < 0.001$). This suggests that there was little or no difference in the performance of ADR 3 and pre-ADR 3 cars with regard to the relative frequency with which the driver's seat back was bent forwards in frontal impacts, a result that would be expected from the derivation of ADR 3.

Belt usage by the driver appears to have had little effect on the incidence of seat back failure, although the number of cases of failure is small. Considering only cases in which there was no unrestrained occupant seated behind the driver and ignoring any differences, however slight, that may exist between ADR 3 and pre-ADR 3 cars in this regard, 4.6 per cent of the seat backs were bent forward in the 65 cases in which the driver was belted and 5.0 per cent in the 40 cases in which the driver was not restrained. (Belt usage throughout this discussion and in Table 4.16 is listed for those occupants for whom adequate information was available. In the absence of adequate information the case has been omitted.)

Seat Back Failure in Rear Impacts

Twenty cars were struck on the rear, two of them by motorcycles. Table 4.17 lists the number of occupied front seating positions for 18 of these cars (excluding the two that were struck by motorcycles), the frequency of failure of the seat back and claimed compliance with ADR 3.

The percentage of seat backs that failed was higher among the pre-ADR 3 cars than among those in the ADR 3 group (eight failures in ten cases and eight in 14 respectively). However the number of cases is small and there was an indication that the pre-ADR 3 cars were involved in more severe collisions. The mean estimated impact speeds were 42 km/h (for the pre-ADR 3 group) and 26 km/h. One ADR 3 car, a 1971 Valiant Charger, had the reclining mechanism welded so as to fix the driver's seat in a normal driving position. This had been done because the seat back failed in normal use. The back of the passenger's seat in this car rotated backwards in the crash but the driver's seat back remained in place.

Damage to Seat Anchorages

Table 4.18 lists the failure rates of seat

TABLE 4.16: FAILURE OF DRIVER'S SEAT BACK IN FRONTAL IMPACTS: CONTROLLING FOR BELT USAGE, REAR SEAT OCCUPANCY AND COMPLIANCE WITH ADR 3

	ADR 3				Pre-ADR 3				
Rear seat occupant[1]:	Yes		No		Yes		No		
Driver belted[2]:	Yes	No	Yes	No	Yes	No	Yes	No	Total
Seat Damage:									
Seat not damaged	2	1	33	6	3	5	29	32	111
Seat back bent forward	-	-	2[3]	1	2[3]	6[3]	1	1	13
Adjusters damaged	-	-	-	-	-	-	1	1	2
Adjusters separated	-	-	-	-	-	1	-	1	2
Mountings separated	-	-	1	-	-	-	2	1	4
Total	2	1	36	7	5	12	33	36	132

Notes: [1] Unrestrained occupant in rear seat behind driver.
[2] Cases in which belt usage was not confirmed are excluded.
[3] Includes one case in which seat adjusters were also damaged.

TABLE 4.17: SEAT BACK FAILURE IN REAR IMPACTS BY ADR 3 COMPLIANCE

Occupied Seat	Seat Back Performance	ADR 3	Pre-ADR 3	Total
Driver's [1]	No failure	3[2]	2	5
	Bent back	5	7	12
Left front Passenger's	No failure	1	-	1
	Bent back	2	1	3
Total		11	10	21

Notes: [1] Performance of seat back not recorded in one case.
[2] Includes one seat that had been modified (see text).

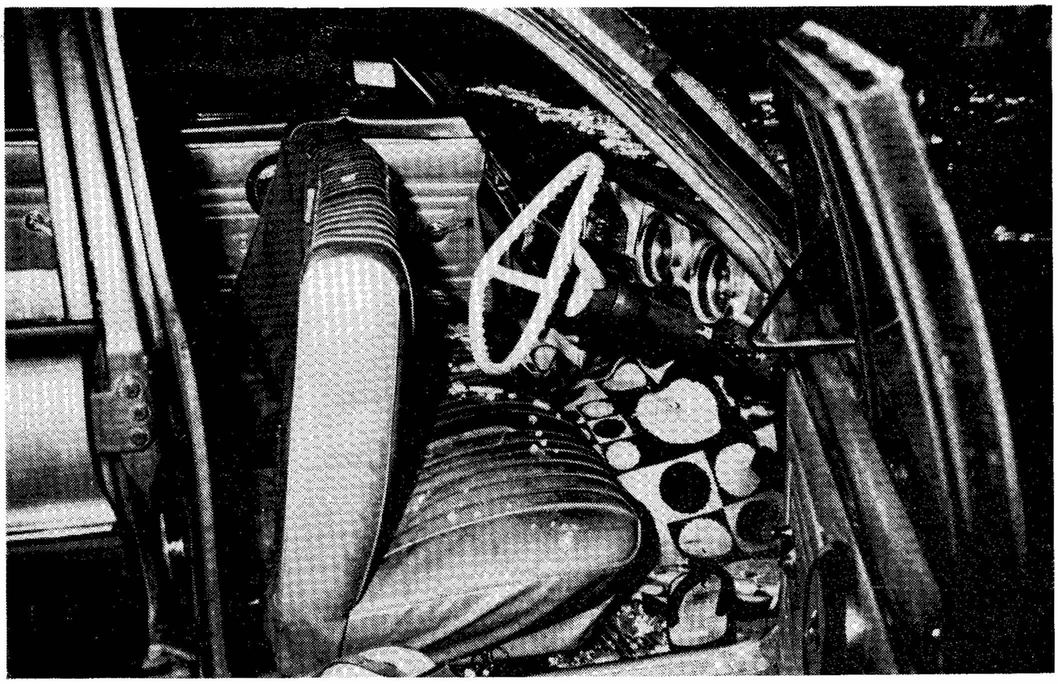


FIGURE 4.16: Damage to front seat of 1968 XY Ford Falcon following collision with a tree. Seat loaded by unrestrained rear seat occupants (Accident 236).

FIGURE 4.17:

Electronic organ in the cargo area of a Holden panel van pushed the seat back forwards in a frontal collision (Accident 066, see also Figure 4.18) anchorages for front, side and rear impacts for ADR 3 and pre-ADR 3 cars. "Failure" of a seat anchorage here refers to any damage to the seat adjustment mechanism or separation of the seat from the floor, either at the mountings or at the seat adjustment. The compliance test for ADR 3 does not require that the seat adjustment mechanism be functional after the test but damage to this mechanism is listed here as failure of an anchorage because it can impede the extrication of an injured person from a car.

There are two general conclusions that are suggested by the data in Table 4.18: the failure rate of seat anchorages was greater in side impacts than in front or rear impacts and the ADR 3 cars appeared to have lower overall failure rates than did the pre-ADR 3 cars (this latter difference may be partially attributable to other factors, as discussed below). Furthermore, in side impacts the anchorages of the seat adjacent to the impact were more likely to be damaged than were those of the seat on the far side. However, considering only the failure rates for the driver's seat, the ADR 3 cars had higher seat anchorage failure rates in three of the four impact location classes.

The difference in the overall failure rates is strongly influenced by the results for the relatively large number of cases in the frontal impact category and yet that category contains only two driver's seat anchorage failures in the ADR 3 group and 14 in the pre-ADR 3 group. As noted in the discussion of seat back failures, the presence of an unrestrained rear seat occupant can greatly increase the loading on the front seat in a frontal collision. This information is presented in Table 4.16 for most of the 16 anchorage failure cases and it can be seen that, in the absence of an unrestrained rear seat occupant, there was less difference in the ADR 3 and pre-ADR 3 seat anchorage failure rates (5.6 per cent and 8.7 per cent respectively) than was indicated by Table 4.17.

Examples of Seat Failures

The discussion of forward bending of the seat back emphasised the importance of the loads imposed by unrestrained occupants in the rear seat. In three accidents the front seat was loaded by an object being carried behind it. Figure 4.17 shows the extent of forward bending of the back of the front seat of a 1972 HQ Holden panel van (Accident 066). The 17 year old male driver sustained a bruised chest and a sprained neck when an electronic organ pushed the seat back forwards in a frontal collision. The driver was wearing a seat belt. The extent of the damage to the front of the car is shown in Figure 4.18.

While the rearward bending of a seat back in a rear impact may not in itself be injurious the resulting lack of effective restraint from a seat belt may expose the occupant to injury in a subsequent collision. This occurred in Accident 029 in which a 1970 Fiat 124 coupe was struck in the rear by a 1972 HQ Holden one-ton utility. The rear of the Fiat was severely damaged (Figure 4.19) in this collision which was followed almost immediately by a frontal collision with a Torana sedan that was in front of the Fiat, both cars being initially stationary waiting to turn right at a T-junction.

The driver of the Fiat, a 40 year old male, was wearing a static 3-point seat belt. When the seat back gave way (Figure 4.20) the sash of the belt slipped from across his chest to across his abdomen (Figures 4.21 and 4.22). This meant that when his car crashed into the car in front his upper torso was no longer restrained and he was thrown forwards, diagonally across the car (Figure 4.23). He struck his head on the window sill of the passenger's door and came to rest lying head downwards in the passenger's footwell, with the seat belt still around his lower torso. He sustained severe concussion with residual neurological complications. This case is also reviewed in the discussion of the design rule relating to seat belts (ADR 4 to 4C). It has been presented here to emphasise the fact that the value of a seat belt as a restraining device is dependent on the integrity of the seat in a collision.

Summary: ADR 3

As noted in the introduction to this review of the data relating to ADR 3, the rule does little more than to require that all manufacturers comply with a level of performance that was recommended practice in the automobile industry before the rule was introduced. This in itself would not be an adverse criticism of the rule if the recommended level of performance was adequate. The frequency of seat failures in the rarely-severe collisions involving cars in the accidents in this study indicates that there is a need for a revision of the adequacy of the level of performance required by this Design Rule.

4.4.4 ADR 4, 4A, 4B AND 4C: SEAT BELTS

The intention of this Australian Design Rule is to define standards for seat belts to restrain vehicle occupants under impact conditions. (ADR 4, 4A)

The intention of this Australian Design Rule is to define standards for seat belts to restrain vehicle occupants under impact conditions and to facilitate fastening and correct adjustment. (ADR 4B, 4C)

Effective dates:
- 4: Front seats, 1 January, 1969
  Rear seats, 1 January, 1971
- 4A: 1 January, 1974
- 4B: 1 January, 1975
- 4C: 1 January, 1976

TABLE 4.18: SEAT ANCHORAGE FAILURE RATES BY POINT OF IMPACT AND ADR 3 LISTING

Point of Impact[1]	ADR 3 Listing	Seat Anchorage Failure Rate (%)[2] Driver's Seat	Seat Anchorage Failure Rate (%)[2] Passenger's Seat	Number of Cars
Front	ADR 3	3.0%	1.5%	67 (62.6%)[3]
	pre-ADR 3	12.2	7.8	115 (66.1)
Driver's side	ADR 3	38.5	7.7	13 (12.1)
	pre-ADR 3	29.4	17.6	17 (9.8)
Passenger's side	ADR 3	20.0	26.7	15 (14.0)
	pre-ADR 3	19.2	34.6	26 (14.9)
Rear	ADR 3	16.7	-	12 (11.2)
	pre-ADR 3	12.5	-	16 (9.2)
Total	ADR 3	9.3	5.6	107 (100.0)
Total:	pre-ADR 3	15.5	12.1	174 (100.0)

Notes: [1] Excludes rollovers, miscellaneous and secondary impacts and collisions with pedestrians, pedal cycles and motorcycles.

[2] Separation of mountings or adjusters, or damage to adjusters.

[3] Percentage of relevant ADR or pre-ADR total.

TABLE 4.19: SEAT BELT AVAILABILITY BY LEGISLATIVE REQUIREMENT

Seat Belt Availability	Legislative Requirement: None[1]	S.A. (1967)	ADR 4	ADR 4A	ADR 4B	ADR 4C	Total
Never fitted	41	1	-	-	-	-	42
Belt removed	6(5)[2]	2	1(-)	-	-	-	9(7)
Belt unusable	5	1(3)	-(1)	-	-	-	6(9)
Belt fitted and usable	77[3]	82	99(98)	23	9	37	327(326)
Unknown	-	-	2	-	-	-	2
Total	129	86	102	23	9	37	386

Notes: [1] No seat belts required before 1967. Anchorages required from 30 June, 1964.

[2] Number in parentheses refers to left front passenger seating position if different from driver's.

[3] Belt fitted but no seat for left front passenger in one car.

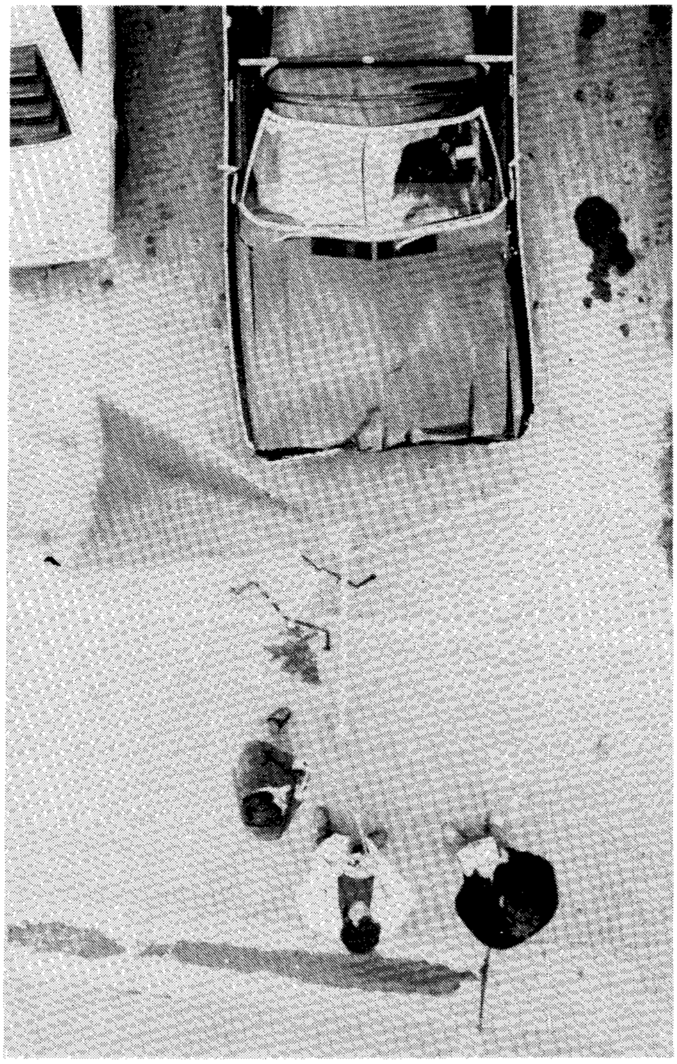


FIGURE 4.18:

Extent of damage to Holden panel van in Accident 066 (see Figure 4.17)

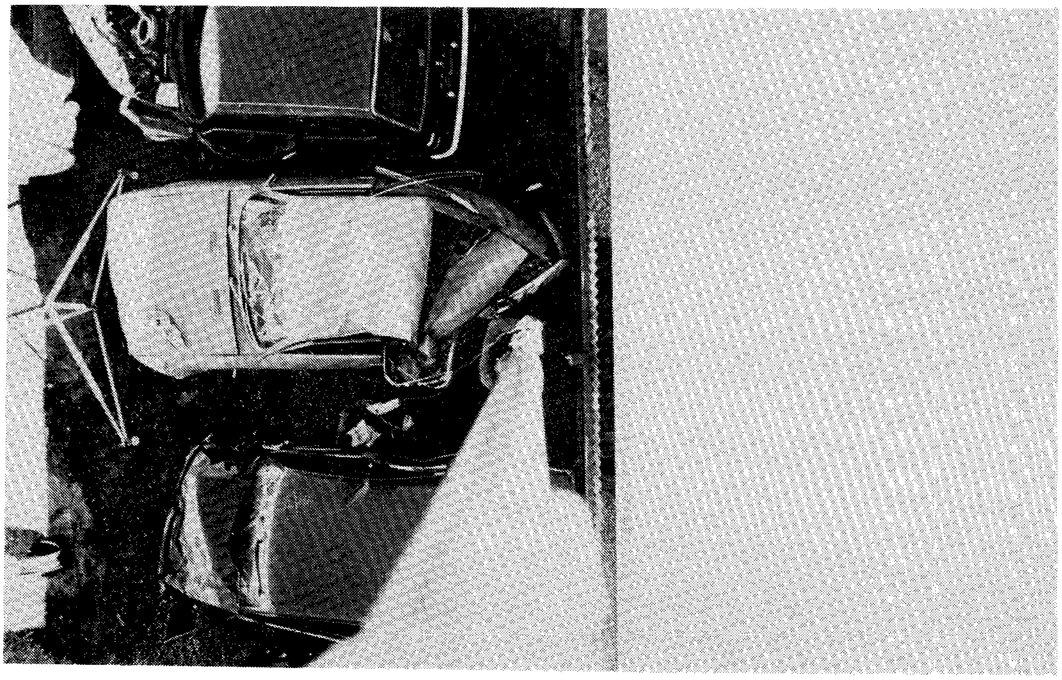


FIGURE 4.19: Extent of damage to Fiat 124 coupe in Accident 029 (see also Figures 4.20 to 4.23)

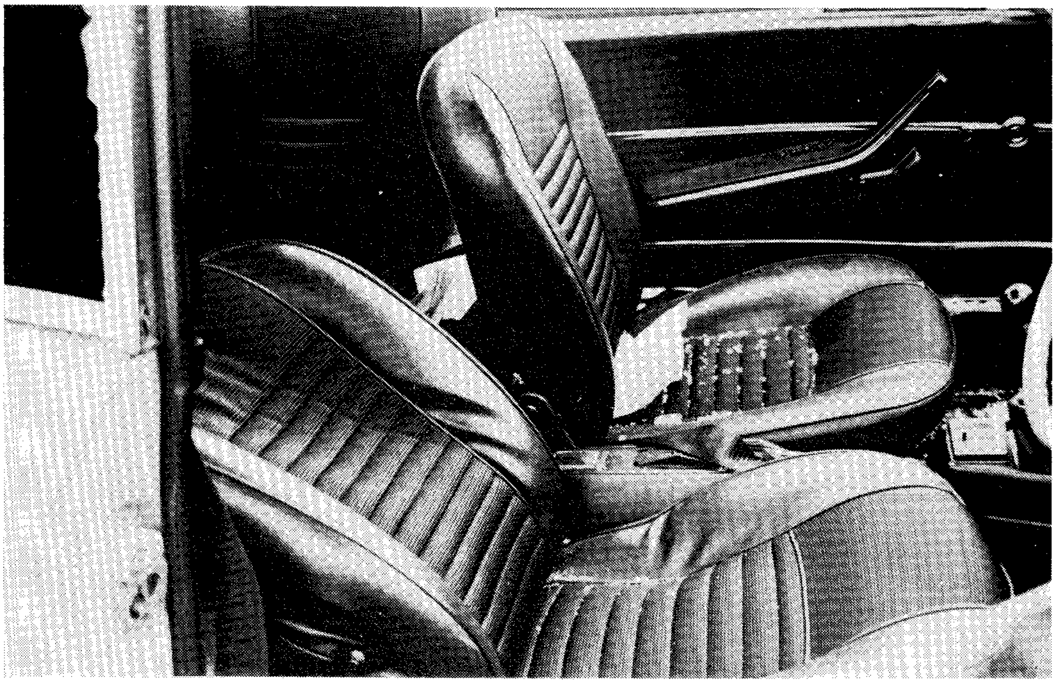


FIGURE 4.20: Damage to back of driver's seat Accident 029 (See Figures 4.19 and 4.21 to 4.23)

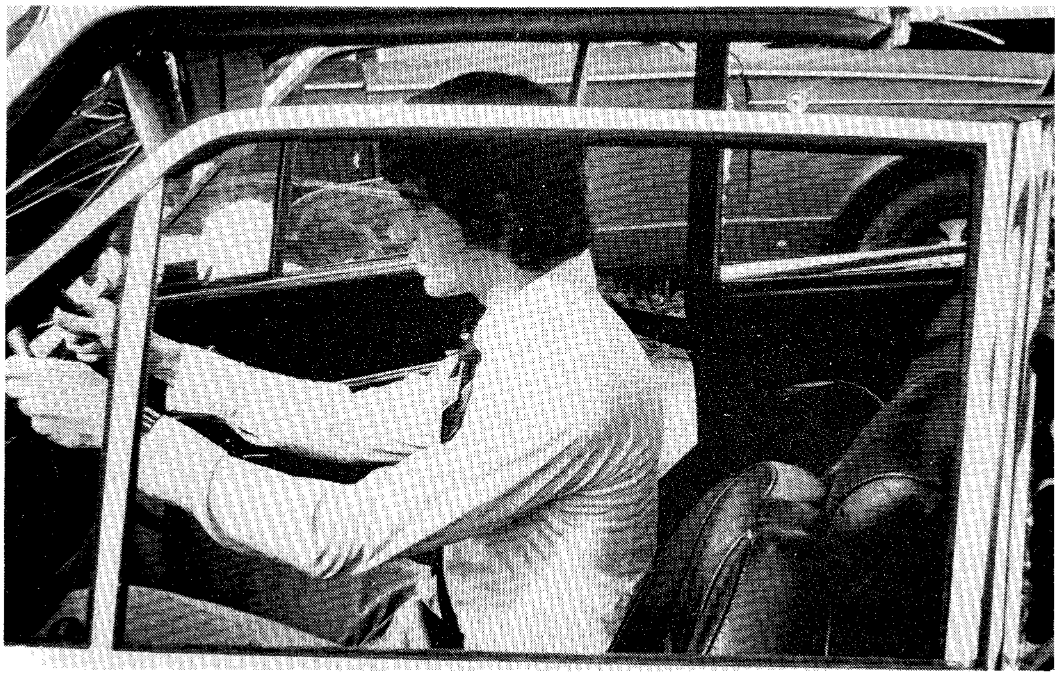


FIGURE 4.21: Approximate normal seating position for driver in Fiat 124 coupe (See Figures 4.19 to 4.23)

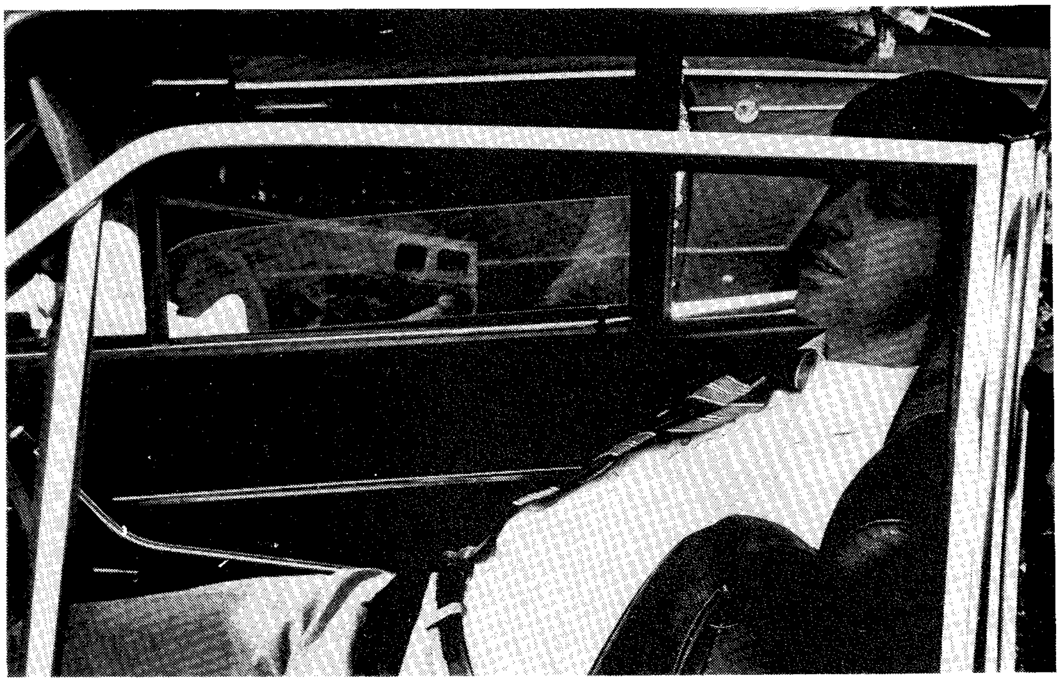


FIGURE 4.22: Approximate position of driver following rearward movement of seat back in rear impact (See Figures 4.19 to 4.23)

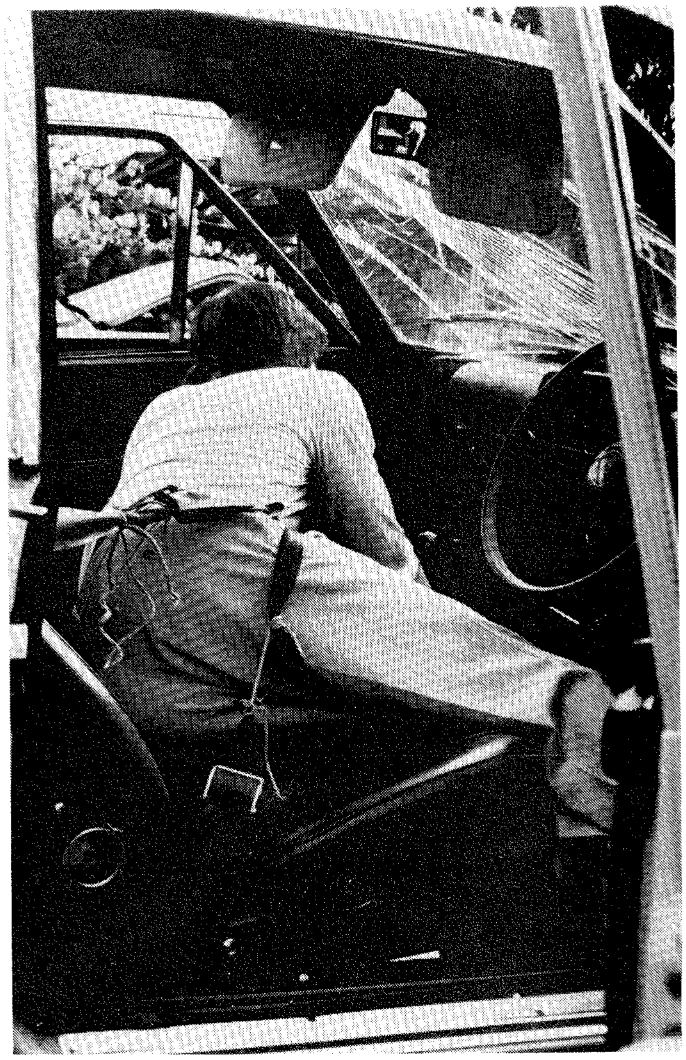


FIGURE 4.23:

Approximate position of driver during frontal collision following a rear impact (see Figures 4.19 to 4.22). Seat belt was cut to release injured driver; it is shown here joined with cord to illustrate location of belt.

ADR 4 required the fitting of seat belts incorporating non-detachable upper torso restraint. The Rule was modified, in ADR 4A, to require a dynamic rather than a static test and to ensure that the buckle remained at the side of the body. ADR 4B contained several new requirements, of which the most obvious was that the belts for the driver and left front passenger should incorporate emergency locking retractors. With the introduction of ADR 4C these retractors were required to have two sensing devices, one actuated by the forces acting on the vehicle and the other by the force applied to the belt (one sensing device was permitted by ADR 4B). Subsequent amendments to ADR 4C addressed the strength of a belt assembly when the strap is fully extended and prohibited the use of non-locking retractors, among other items. A description of the requirements at each stage of this Design Rule is contained in the specifications for the Rule and, in summary form, in Milne (1979).

Seat Belt Availability and Usage

In South Australia, under legislation contained in the Road Traffic Act, passenger cars first registered after 1 July, 1964 were required to be fitted with seat belt anchorage points for the driver and the left front passenger. Two anchorage points, for a lap belt, satisfied the requirements of the legislation. From 1 January, 1967, passenger cars being registered for the first time were required to be fitted with seat belts in these two seating positions. Again, the type of belt was not specified but three-point belts were the most common type. This legislation, together with favourable publicity for seat belts, resulted in belts being fitted to many cars in South Australia well before the introduction of ADR 4 in January, 1969, as shown in Table 4.19.

Before examining vehicles with seat belts it is of interest to note the occupants for whom a belt system was not available. Table 4.20 shows the distribution by year of vehicles which had never been fitted with belts or had belts which had been removed or damaged. As expected belt availability in the earlier cars was low. Only 35 per cent of the cars manufactured before 1964 were fitted with a usable seat belt. The incidence of belt removal was distributed fairly evenly over the period 1961 to 1971, while damaged seat belts were more often found in the earlier (pre 1966) vehicles.

Belts No Longer Available or Usable

There were several cases where effective seat belts were no longer available in cars in which they had formerly been effectively functioning. As shown in Table 4.21 these fall into three categories, cases where belts had been removed, belts with defective hardware and belts which were no longer usable. The latter category refers to cases where half the belt had been removed, tongues or anchor plates were missing, or belts were not anchored to the vehicle. The three instances of defective hardware were found in cars involved in Accidents 109 and 122. The 1962 Volkswagen 2 door sedan in Accident 109 was fitted with Hemco lap-sash seat belts in the driver and left front passenger positions. The buckles of both belts were marked 10/62 and neither would retain the tongue when an attempt was made to engage the tongue in the buckle. The car carried no left front passenger at the time of the accident and it appears highly probable that the driver's belt was not worn. The driver sustained minor injuries to the forehead, knee and ankle.

In Accident 122, a Renault 16 TL was fitted with a compliance plate dated 6/72 and indicating compliance with ADR 4. Lap-sash seat belts were fitted to four outboard seating positions and a lap belt was fitted to the rear centre position. The defective buckle was found at the left front position and was marked BW 2B2, the defect being non-retention of the tongue by the buckle. The buckle was dismantled and the inability to retain the tongue was found to be due to the failure of a spring element which is designed to keep the latch plate in engagement with the tongue. This spring element can be seen at the centre of the buckle in Fig. 4.24, the lower right arm of the component being missing. The belt assembly was not worn by the occupant and, according to the driver, had been broken for some months.

Belt Failure

The only case of a seat belt failing during a collision occurred when a 1959 Volkswagen two-door sedan was struck from the left side at the front (Accident 239). The stitching securing the driver's belt to the floor anchorage failed allowing the belt to run through the loop. Subsequent analysis revealed that the strength of the Nylon 66 stitching had been degraded prior to the collision. This is consistent with the spillage of acid on the stitching and it may be relevant to note that in this model of car the battery was situated beneath the rear seat on the right hand side. Despite this failure the driver was uninjured.

Belt Availability and Usage for each Seating Position

Table 4.22 shows the seat belt availability and usage patterns for the six principal seating positions. Belts were commonly fitted for the driver (85.2 per cent) and left front passenger (81.8 per cent) but were less frequently fitted in other positions (32.4 per cent). Of the 14 occupants seated in the centre of the front seat only four had belts available.

The wearing rate, when a belt was available, was considerably greater for the drivers (79.1 per cent) than for the

TABLE 4.20: YEAR OF CAR WITHOUT SEAT BELT FOR DRIVER OR LEFT FRONT PASSENGER (SEAT OCCUPIED)

Year of Manufacture	Number of Cars						Total[1]
	Driver			Left front passenger			
	Belt never fitted	Belt removed	Belt damaged	Belt never fitted	Belt removed	Belt damaged	
Pre-1961	13	1	1	7	-	-	18
1961-1963	12	2	1	8	-	-	28
1964	9	-	2	4	-	1	23
1965	4	2	1	2	1	1	26
1966	-	1	-	1	-	1	16
1967	1	-	-	-	2	1	19
1968	-	2	1	-	-	-	24
1969	-	-	-	-	-	-	31
1970	-	-	-	-	-	-	32
1971	-	1	-	-	-	-	23
1972	-	-	-	-	-	1	35
1973-1976	-	-	-	-	-	-	106
Unknown	2	-	1	1	-	-	5
Total	41	9	7	23	3	5	386

Note: [1] Total number of vehicles for that year of manufacture.

TABLE 4.21: NUMBER OF BELTS REMOVED, UNUSABLE OR DEFECTIVE BY SEATING POSITION

Reason for Unavailability of Belt	Seating Position[1]					
	Driver	Centre Front Passenger	Left Front Passenger	Right Rear Passenger	Left Rear Passenger	Total
Belt Removed	9	4	7	-	-	20
Belt Unusable	5	-	6	1	1	13
Defective Hardware	1	-	2	-	-	3

Note: [1] Not necessarily occupied at the time of the accident.

TABLE 4.23: ADR COMPLIANCE AND SEAT BELT USAGE BY DRIVER

ADR Compliance	Seat Belt Usage by Driver			
	Belt Available Usage Confirmed	Belt Worn	Belt Not Worn	% Belts Worn
Pre-ADR	73	47	26	64.3
ADR 4 & 4A	115	97	18	84.3
ADR 4B & 4C	28	27	1	96.4
Total	216	171	45	79.1

TABLE 4.24: ADR COMPLIANCE AND SEAT BELT USAGE BY LEFT FRONT PASSENGER

ADR Compliance	Seat Belt Usage by Left Front Passenger			
	Belt Available Usage Confirmed	Belt Worn	Belt Not Worn	% Belts Worn
Pre ADR	35	23	12	65.8
ADR 4 & 4A	39	22	17	56.5
ADR 4B & 4C	15	13	2	86.7
Total	89	58	31	65.1

TABLE 4.22: SEAT BELT AVAILABILITY AND USAGE BY POSITION OF OCCUPANT

Seat Belt Status	Position of Occupant												All occupants	
	Driver		Centre front passenger		Left front passenger		Right rear passenger		Centre rear passenger		Left rear passenger			
	Total	%	Total	%	Total	%	Total	%	Total	%	Total	%	Total	%
Belt available	327/384	85.2	4/14	28.5	144/176	81.8	12/40	30.0	8/30	26.7	22/58	38.0	517/702	73.6
Belt usage not confirmed	111/327	33.9	1/4	25.0	55/144	38.2	2/12	16.7	5/8	62.5	6/22	27.3	180/517	34.8
Belt worn	171/216	79.1	1/3	33.3	58/59	65.1	2/10	20.0	0/3	-	3/16	18.7	235/337	69.7
Belt not worn	45/216	20.8	2/3	66.6	31/89	34.8	8/10	80.0	3/3	100.0	13/16	81.3	102/337	30.0
Overall wearing rate	171/273	62.6	1/13	10.0	58/121	47.9	2/38	5.3	0/25	-	3/52	5.7	235/522	45.0
= Belt worn / Total-usage not confirmed														

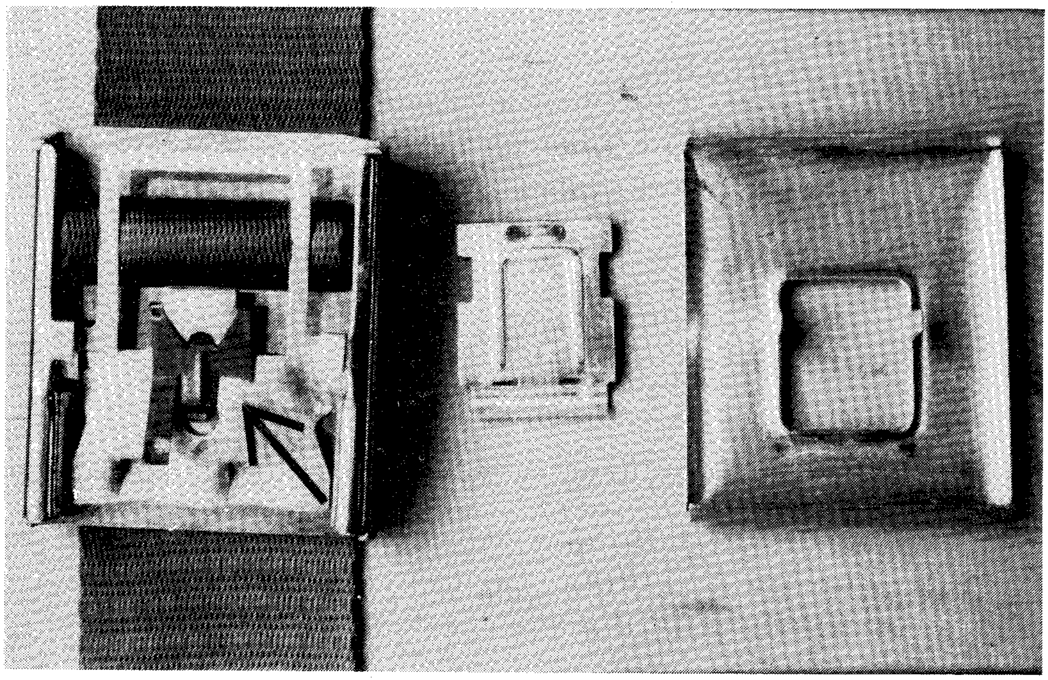


FIGURE 4.24: Components of defective buckle of a seat belt fitted to a 1972 Renault 16TL. The H-shaped spring has the lower right leg missing (arrowed). (Accident 122)

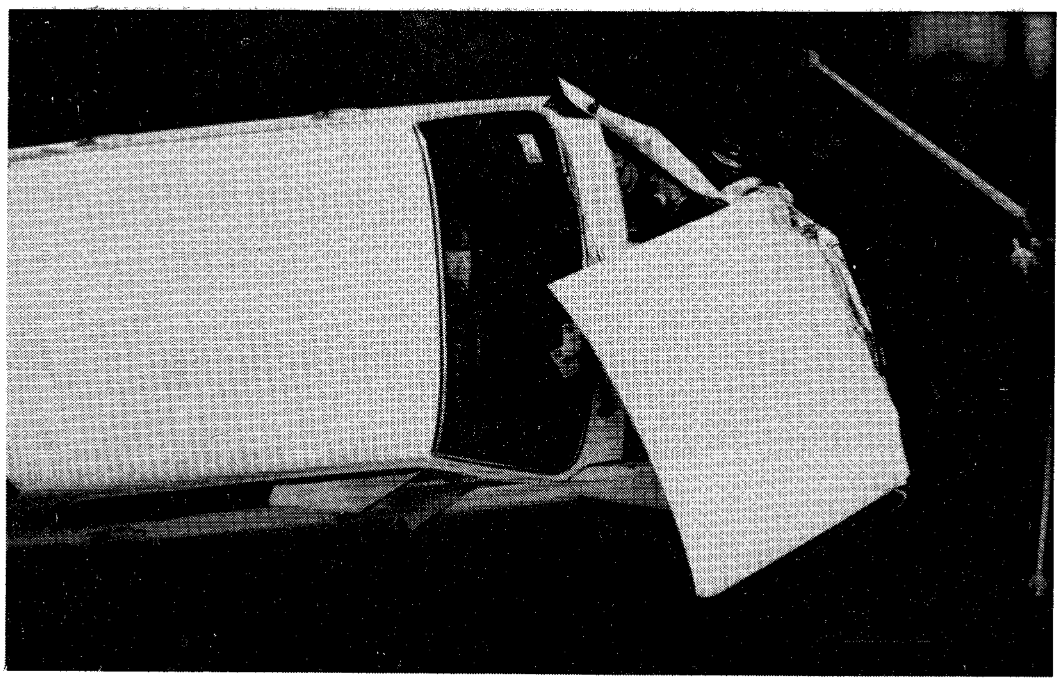


FIGURE 4.25: Overhead view of damage to Mazda involved in Accident 061 (See Figures 4.26, 4.64)

left front passengers (65.1 per cent), which was in turn greater than for the remaining positions (18.8 per cent). It is possible that passengers in the centre front and rear seating positions were accustomed to not having a belt provided and hence were not in the habit of using it when seated in those positions. In addition, the decision of rear seat passengers not to fasten the belt provided could be influenced by the lack of obvious potentially injurious hardware directly in front of them.

These results are comparable with those of the seat belt survey conducted in the Adelaide metropolitan area in 1976 (Road Traffic Board, 1976). The belt availability for drivers was 84.9 per cent which is similar to that found in this study (85.2 per cent). However the Road Traffic Board figures for belt usage by drivers with belts available was 90.1 per cent whereas that for this study was 79.1 per cent and the corresponding percentages for passengers were 71.3 per cent and 52.9 per cent respectively. It would appear an unfortunate fact that, for some reason, those who choose not to wear a seat belt are more likely to be involved in a vehicle accident.

Effect of the ADRs on Seat Belt Usage and Mode of Wearing

In the following comparisons ADRs 4 and 4A have been grouped together since the main difference in these rules was the introduction of dynamic testing in ADR 4A and this was unlikely to have affected the acceptability of the belt to the user. In addition ADR 5A, which dictated the geometry of the seat belt, was common to both these rules. Similarly ADR 4B and 4C are grouped together, these rules requiring retractor belt systems for the two outboard front seating positions. A further requirement for these belt systems is that the belt should be able to be fastened with a one handed operation. Again the comfort of the belt system is dependent on the location of the anchorage points and a closer control of this design feature was provided through ADR 5B, which was introduced concurrently with ADR 4B.

ADR Compliance and Seat Belt Usage

The effect of the development in the design of seat belts through the introduction and revision of the ADRs on usage rates is shown in Tables 4.23 and 4.24. A Chi-square test on the data of Table 4.23 (Chi-square = 16.6, df = 2, $p < 0.001$) demonstrates that the driver belt wearing rate is not independent of the selected groupings (Pre ADR, ADR 4 and ADR 4A, ADR 4B and 4C). The same test on the data for left front passengers (Table 4.24) does not give an adequate level of confidence to enable the same conclusion to be drawn (Chi square = 4.26, df = 2, $p < 0.1$). However given the care which was taken to gather a representative sample, it would not be unrealistic to conclude that ADR 4B/4C/5B belt systems have a higher wearing rate than do the other groupings.

ADR Compliance and Mode of Wearing

To examine further the possible benefits of the seat belt ADRs the mode of wearing is tabulated against the belt system groupings (Tables 4.25 and 4.26). In these Tables the wearing mode 'incorrectly' covers cases in which the belt was adjusted so that the buckle was located on the abdomen, three cases in which the webbing was twisted and one case in which a belt tidy (a non-locking webbing storage device) was fitted. In the other modes 'loosely' means that the occupant would have been assessed as being able to move the restrained shoulder forward between 50mm and 150mm. Movement less than 50mm was noted as 'correctly worn' and movement greater than 150mm was noted as 'very loosely worn'.

From the data in Tables 4.25 and 4.26 it can be seen that the ADR 4B, 4C 'inertia reel' belt was worn correctly in all cases whereas as few as 45 per cent of drivers having pre-ADR belts and no more than 61 per cent of the corresponding left front passengers were wearing static belts correctly.

Belt Characteristics and Occupant Injury Severity

Occupant Injury Severity by Belt Usage and Mode of Wearing

Table 4.27 shows the average injury severity for those who were known to have been wearing a seat belt and for those who were unrestrained. This shows that both drivers and left front seat passengers who wore belts were, on average, considerably less severely injured than were those who were unrestrained. In addition there is a progression of increasing injury severity with an increasing degree of looseness of a static belt. In fact it appears that a car occupant who wears a static seat belt very loosely may be little or no better off than one who wears no belt at all.

ADR Compliance and Injury Severity

The relative performance of the three groups of belts is shown in Table 4.28 in terms of the average level of injury severity. Collisions with pedestrians, pedal cycles and motorcycles, which generally involve small impact forces, were excluded from this Table. The injuries sustained by those wearing inertia reel belts (ADRs 4B and 4C) were, overall, less severe than those wearing static belts. This may have been because the former belts are self adjusting whereas the static belts were frequently worn loosely, this mode of wearing being associated with higher average injury severity (Table 4.27).

Injuries Caused by a Seat Belt

Most of the seat-belt induced injuries were minor abrasions or contusions to the front of the chest or abdomen but there were four

TABLE 4.25: ADR COMPLIANCE BY MODE OF BELT WEARING BY DRIVER

ADR Compliance	Mode of Belt Wearing by Driver								Total	
	Worn Correctly		Worn Loosely		Worn Very Loosely		Worn Incorrectly			
Pre-ADR	21	44.6%	14	29.7%	9	19.1%	3	6.3%	47	100%
ADR 4 & 4A	56	57.7%	22	22.6%	10	10.3%	9	9.3%	97	100%
ADR 4B & 4C	27	100%	-	-	-	-	-	-	27	100%
Total	104	60.8%	36	21.1%	19	11.1%	12	7.0%	171	100%

TABLE 4.26: ADR COMPLIANCE BY MODE OF BELT WEARING BY LEFT FRONT PASSENGER

ADR Compliance	Mode of Belt Wearing by Left Front Passenger								Total
	Worn Correctly		Worn Loosely		Worn Very Loosely		Worn Incorrectly		
Pre-ADR	14	60.8%	8	34.7%	1	4.3%	-	-	23
ADR 4 & 4A	11	50%	5	22.7%	5	22.7%	1	4.5%	22
ADR 4B & 4C	13	100%	-	-	-	-	-	-	13
Total	38	65.5%	13	22.4%	6	10.3%	1	1.7%	58

TABLE 4.27: SEAT BELT USAGE AND MODE OF WEARING BY AVERAGE INJURY SEVERITY

Belt Wearing	Driver		Left Front Passenger		Total	
	Number	Average ISS[1]	Number	Average ISS[1]	Number	Average ISS[1]
Worn correctly	103	1.5	38	1.2	144	1.4
Worn loosely	37	2.2	13	2.4	50	2.3
Worn very loosely	19	3.5	6	6.2	25	4.1
Worn incorrectly	12	2.4	1	0.0	13	2.2
Total worn	171	2.0	58	2.0	229	2.0
Available, not worn	44	4.4	31	2.6	75	3.7
No belt available	56	3.0	32	4.5	88	3.5
Total not worn	100	3.6	63	3.6	163	3.6

Note: [1] ISS is the Injury Severity Score which is the sum of the squares of the numerical ratings assigned to the three most severely injured body regions, using the Abbreviated Injury Scale (AIS) to rate the severity of each injury.

TABLE 4.28: INJURY STATUS BY BELT USE AND ADR CLASSIFICATION: CAR DRIVER AND LEFT FRONT PASSENGER

	Type of Occupant and Injury Status							
	Driver				Left Front Passenger			
Belt Use and ADR Classification	No. of Drivers	Not Injured or First Aid at Scene	Medical Attention	Hospital Admission	No. of Passengers	Not Injured or First Aid at Scene	Medical Attention	Hospital Admission
Belt Available: Not Used	38	45%	32%	24%	27	33%	30%	37%
Pre-ADR Belt Used	37	59%	24%	16%	19	47%	37%	16%
ADR 4/4A Belt Used	69	65%	23%	12%	19	53%	26%	21%
ADR 4B/4C Belt Used	21	71%	14%	14%	12	58%	33%	8%

Note: Accidents involving a collision with a pedestrian, pedal cycle or motorcycle are not included in this Table.

severe injuries that were caused by the belt system, albeit under unusual circumstances in one case, and four injuries of moderate severity.

The moderate injuries comprised two fractured sternums and two fractured clavicles. In each case the occupant was restrained by a static belt. Two of the cars involved are shown in Figures 4.27 and 4.31. The drivers, both males in their early twenties, height 183 cm and weight about 70 kg, sustained a fracture of the right clavicle. A 22 year old female driver's sternum was fractured when a car that she was driving relatively slowly veered off the road and struck a tree, and a 92 year old woman received a similar injury when the car in which she was a passenger crashed into the car in front.

The four severe injuries were inflicted on two drivers and one left front passenger. The 45 year old male driver (height 173 cm and weight 70 kg) of a 1961 Volkswagen sustained a fractured sternum, complicated by rib fractures, from the loading transmitted by the sash of a static 3-point belt when his car struck the side of an Austin 1800 that was performing a U-turn (Accident 016). There may also have been some chest contact with the rim, but not the hub, of the steering wheel.

Figure 4.25 shows a 1969 Mazda 1200 four-door sedan that turned right in front on an oncoming 1974 Chrysler Centura sedan (Accident 061). The driver of the Mazda, a 22year old male, height 170 cm and weight 57 kg, was wearing a static belt firmly, but incorrectly, adjusted. The buckle was high up on his abdomen, as shown in Figure 4.26, and the loads transmitted by the buckle and webbing tore the mesentery of the driver's small intestine and ruptured his spleen, which was later removed surgically. The driver was the owner of the car and normally wore the belt adjusted in this way (a form of adjustment that has largely been eliminated by the requirements of later ADRs).

Neither of the above two drivers (Accidents 016 and 061) sustained any other major injury.

The remaining two severe injuries caused by a seat belt were to the left front passenger (a 21 year old male, 163cm tall and weight 62 kg) of a 1969 Holden HT station sedan that crashed into a steel and concrete utility pole (Accident 096, Figures 4.27 to 4.29). The movements of this passenger in the crash were unusual because he had only a stub remaining of his left arm as a consequence of a birth defect. He was wearing a static lap-sash belt that was slightly loose in the lap section and with the sash very loose (the adjustment of the belt was deduced from impact loading marks on the webbing). The buckle was located on the right side of his abdomen, as evidenced by the imprint of the buckle on the surface of the abdomen after the crash (Figure 4.29).

On impact, the passenger's upper torso slid from behind the sash of the belt because of the twisting effect of the unbalanced inertia of the right arm and the slackness of the sash of the belt. The sash then slid down onto the abdominal wall and the webbing slid through the tongue of the buckle assembly allowing the lap section of the belt to loosen and ride up onto the abdomen. The displacement of the belt in this manner resulted in fractures to the first lumbar vertebra (without neurological involvement) and internal injuries (tears in the transverse mesocolon). The displaced belt also failed to prevent the passenger from striking his face on the dashboard, an impact that inflicted very severe facial injuries.

The injuries sustained by the passenger in Accident 096 would have been prevented, or greatly reduced in severity, had the belt webbing not been free to run through the tongue of the buckle and loosen the lap section of the belt. In this particular case it can be argued that the belt assembly may have functioned well if the occupant had not lacked a normal left arm. However in Accident 029 a driver slipped from behind the sash of his belt and received very severe head injuries when the webbing slid through the tongue of the buckle and loosened the lap section of the belt (see Section 4.4.3 and Figures 4.19 to 4.23). The belt systems involved in these two cases complied with ADR 4 but the running loop is an integral part of current inertial reel belt systems that comply with ADR 4C. Therefore there may be value in a review by the Advisory Committee on the Safety of Vehicle Design (ACSVD) of this aspect of ADR 4C.

These cases of injuries caused by seat belts have been reviewed to point to the above potential weakness in the current ADR and as a reminder that seat belts reduce the severity of injury but do not necessarily afford complete protection. The extent to which they do reduce the level of injury severity is illustrated by the experience of the driver of a car that crashed into a utility pole in an accident (051, Figure 4.46) that was very similar to Accidents 094 and 096. In those two crashes (see Figures 4.27, 4.28, 4.31) the drivers were restrained by static 3-point belts. They both received a fracture of the right clavicle and facial injuries from striking the steering wheel. The driver in Accident 096 also fractured his left wrist on the steering-column-mounted gear level. The 32 year old female driver in Accident 051 was not wearing the available seat belt. She was thrown forward in the crash and struck the steering wheel (Figure 4.47) with her chest and the lower part of the instrument panel with her knees. She sustained fractures of the ankle and upper arm, multiple rib fractures that resulted in a flail chest, fractures of the facial bones and a fracture of the odontoid process in the cervical spine (a broken neck). The spinal fracture was without neurological involvement, largely because of highly-skilled emergency care by St. John Ambulance personnel at the scene of the crash. Overall, her injuries were much more severe than were those of the drivers who were restrained by seat belts in the two similar crashes.

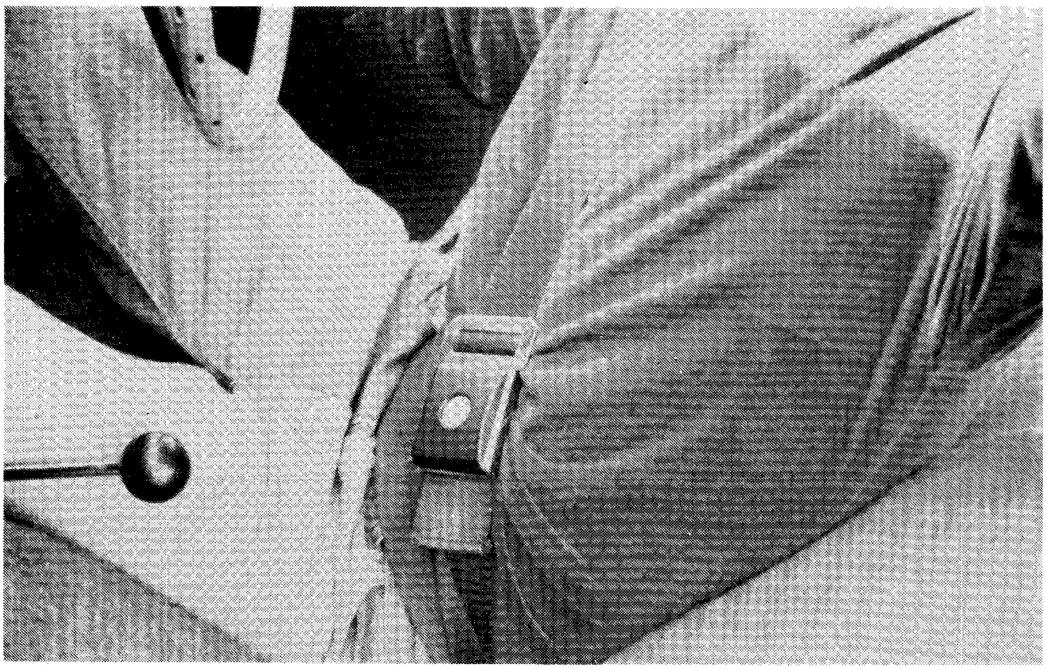


FIGURE 4.26: Incorrectly positioned buckle of seat belt worn by driver in Accident 061 (See Figures 4.25, 4.64)

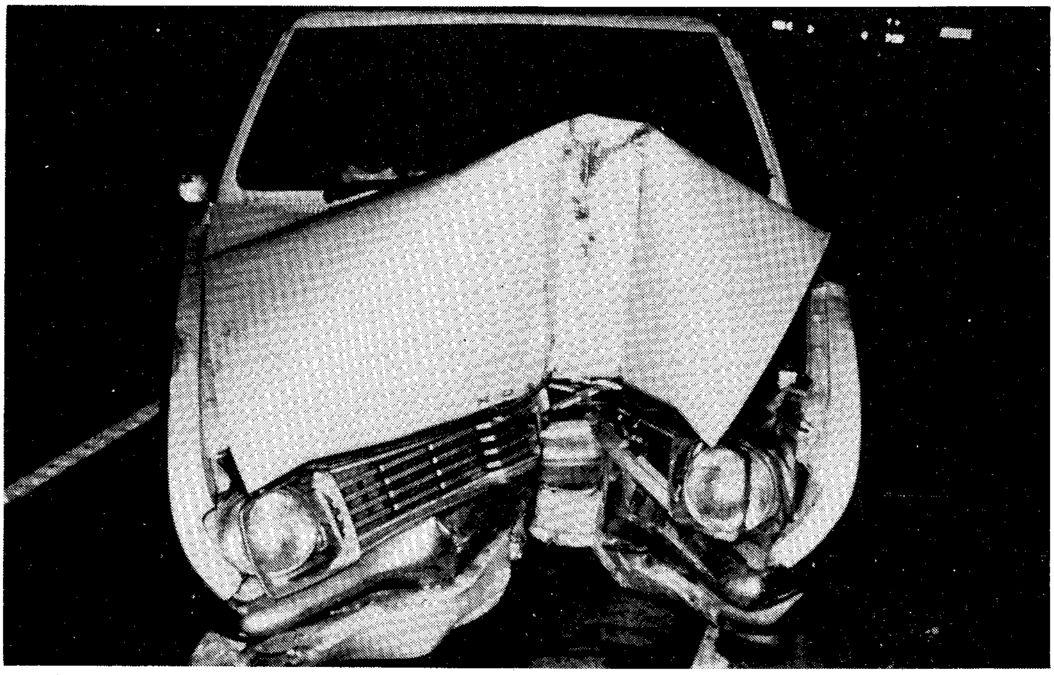


FIGURE 4.27: Damage to car involved in frontal impact with utility pole (Accident 096, See Figures 4.28, 4.29)

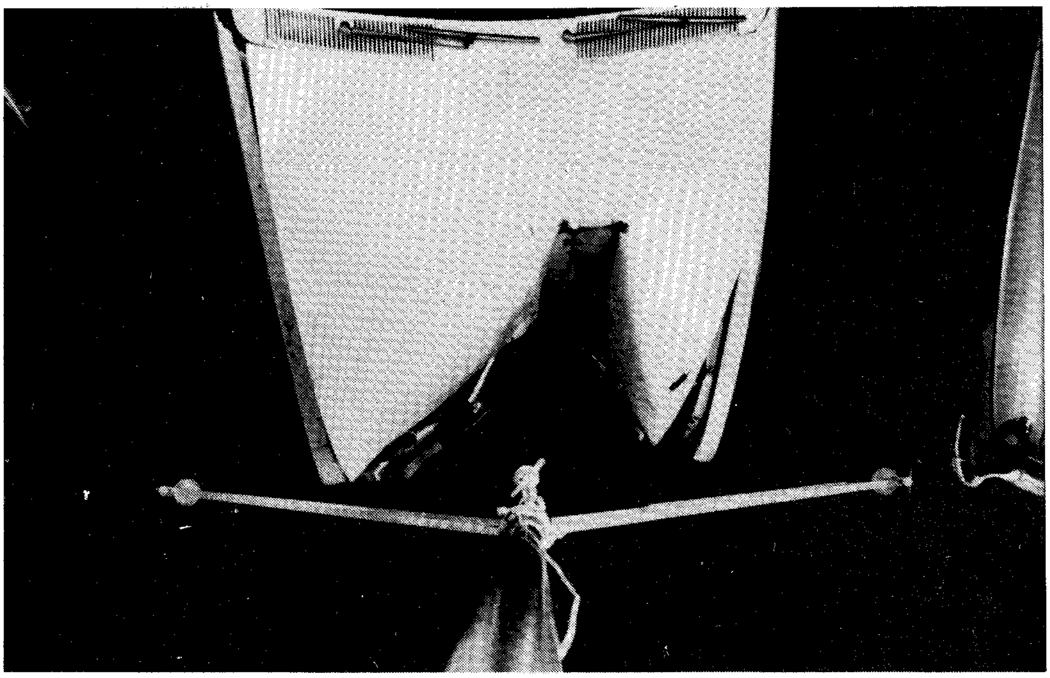


FIGURE 4.28: Overhead view of damage caused by impact with utility pole (Accident 096, See Figure 4.27 etc.)

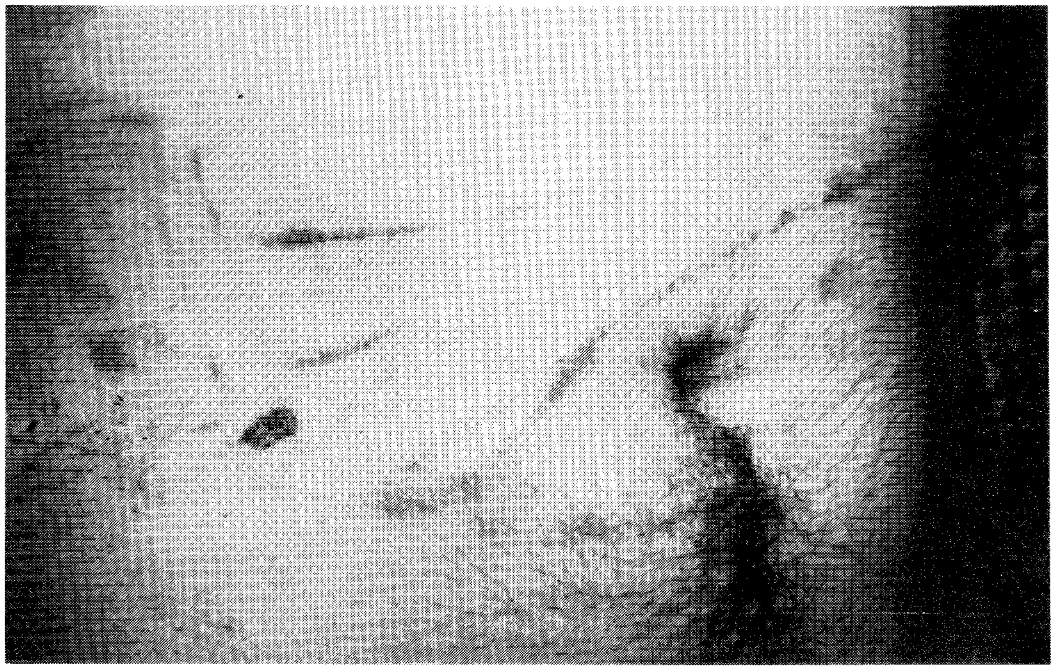


FIGURE 4.29: Seat belt loading marks to abdomen of left front passenger (Accident 096, See Figures 4.27, 4.76)

FIGURE 4.30: Damage to car involved in frontal impact with utility pole (Accident 094, See Figures 4.31, 4.60)

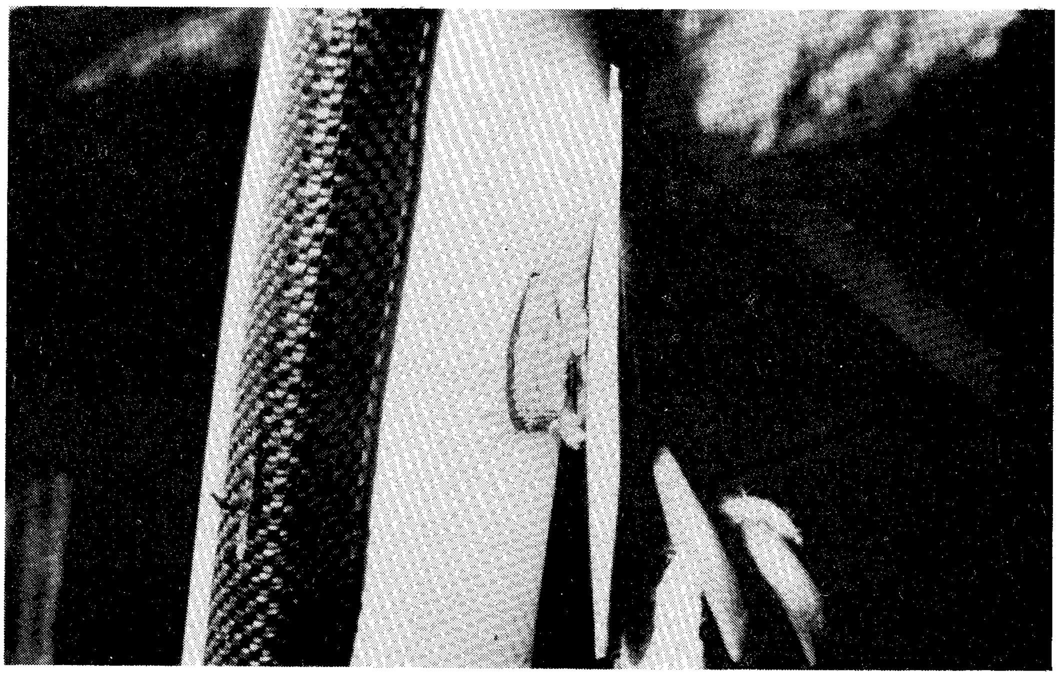


FIGURE 4.31: Yielding of the inner skin of the B-pillar seat belt anchorage (Accident 094, See Figure 4.30)

4.4.5 ADR 5A AND 5B: SEAT BELT ANCHORAGE POINTS AND SEAT BELT ANCHORAGES

The intention of this Australian Design Rule is to define standards for seat belt anchorage points so that seat belt assemblies may be firmly secured to the vehicle. (ADR 5A)

The intention of this Australian Design Rule is to define standards for seat belt anchorage points so that seat belt assemblies may be adequately secured to the vehicle structure and will meet comfort requirements in use. (ADR 5B)

Effective dates:
5A: Front seats, 1 January, 1969
Rear seats, 1 January, 1971
5B: Both seats, 1 January, 1975

The distribution of cars subject to ADR 5A or 5B is shown in Table 4.29. No cases were found in which the anchorage points had been unable to sustain the loading applied through the seat belt system.

There was only one car in which there was obvious deformation of the seat belt anchorage points. This vehicle crashed into a reinforced concrete lamp standard (Accident 094, Figure 4.30). The anchorage for the sash of the belt was of a pre-ADR type and it was partially pulled away from the B-pillar (Figure 4.30). The driver, shown still in the car in Figure 4.31, had his belt adjusted loosely but the inertia loading on the sash was high enough to fracture his clavicle. He also struck his face on the rim of the steering wheel. The left front passenger was virtually uninjured, sustaining contusions across his torso from the webbing of the belt.

Injuries Related to Anchorage Locations

The two cases of severe injuries caused by a belt to the lower torso of a car occupant have been discussed in Section 4.4.4. In neither of these cases could it be inferred that the location of the lower anchorages was a significant factor in the causation of the injury to the lower torso.

There were three cases of direct, if superficial, injury to the neck that may have been caused by the sash of a seat belt. However these cases were all side impacts and there were factors other than the location of the sash of the belt, and hence the location of the upper anchorage, that may have been important.

4.4.6 ADR 6: DIRECTION TURN SIGNAL LAMPS

The intention of this Australian Design Rule is to specify the requirements for direction turn signal lamps which will provide adequate warning to other road users of the intention to perform a turning manoeuvre. (The requirements in respect of the rear lamps are also adequate for lamps used to warn pedestrians and other road users that the vehicle is about to move in the reverse direction.)

Effective date: 1 January, 1973

The number of cars that were subject to ADR 6 is shown in Table 4.30.

There were no cases in which the failure or lack of conspicuity of car turn signals was noted as a causal factor.

The number of cars involved in manoeuvres in which turn signals should have been used is shown in Table 4.31 by ADR 6 compliance. The percentage of ADR 6 cars involved in such manoeuvres (22 per cent) was almost the same as that of pre-ADR 6 cars (18 per cent). This relatively insensitive comparison, therefore, does not indicate any meaningful difference between the performance of the turn signals on ADR 6 and pre-ADR 6 cars.

4.4.7 ADR 7: HYDRAULIC BRAKE HOSES

The intention of this Australian Design Rule is to specify the performance requirements of hydraulic brake hoses in motor vehicles so that the risk of failure in service will be minimised.

Effective date: 1 January, 1970

Table 4.32 shows the number of cars in this study that were subject to the requirements of ADR 7.

No accidents were caused by the failure of brake hoses and the condition of the hoses when examined after the accidents did not indicate any potential sources of brake failure. However the climate and the topography of the study area is unlikely to severely test these components in normal service and the emergency stops that were attempted in these accidents were mostly from relatively low speeds.

4.4.8 ADR 8: SAFETY GLASS

The intention of this Australian Design Rule is to specify the performance requirements of glass used for glazing in motor vehicles which will ensure adequate visibility under normal operating conditions, will minimise obscuration when shattered, and will minimise the likelihood of serious injury if an occupant comes in contact with the broken glass.

Effective date: 1 July, 1971

ADR 8 is based on the Australian Standard for Safety Glass for Land Transport (AS R1-1968, amended 1970). As such, it is likely that many cars manufactured

TABLE 4.29: DISTRIBUTION OF CARS SUBJECT TO ADR 5A OR 5B

No anchorages fitted	30
Subject to ADR 5A	112
Subject to ADR 5B	56
Anchorages fitted but not subject to ADR 5A or 5B	172
Anchorages fitted but not known if subject to ADR 5A or 5B	16
Total	386

TABLE 4.30: NUMBER OF CARS SUBJECT TO ADR 6

Subject to ADR 6	Number of Cars
Yes	96
No	277
Not known	13
Total	386

TABLE 4.31: CARS THAT SHOULD HAVE HAD TURN SIGNALS OPERATING BY ADR 6 COMPLIANCE

Manoeuvre Requiring Turn Signals	Subject to ADR 6		Total
	Yes	No	
Yes	21 (22%)	51 (18%)	72
No	75 (78%)	226 (82%)	301
Total	96 (100%)	277 (100%)	373

TABLE 4.32: NUMBER OF CARS SUBJECT TO ADR 7

Subject to ADR 7	Number of Cars
Yes	165
No	208
Not known	13
Total	386

TABLE 4.33: NUMBER OF CARS SUBJECT TO ADR 8

Subject to ADR 8	Number of Cars
Yes	136
No	235
Not known	14
Total	386

before the effective date noted above did comply with the requirements of ADR 8. The number of cars subject to ADR 8 in the study sample is shown in Table 4.33.

Optical Characteristics of Windscreen Glass

There were no reports or other indications of difficulties with visibility due to the optical characteristics of the windscreen glass, nor was there any case in which a toughened glass windscreen shattered before the crash (both toughened and laminated screens can comply with ADR 8).

Occupant Contact with the Windscreen Glass

As noted in the introduction to Section 4.3, there is a difference between the approach to the identification of objects causing injury (reviewed in Section 4.3) and to the identification of objects struck, on which the following analysis is based. There are, of course, cases in which an object is struck and no injury results. But there are also cases in which an injury is sustained with no clear evidence of contact with any specific object. In these latter cases an attempt has been made, in Section 4.3, to list the most probable cause of the injury. In general there are more injuries with no clear evidence of contact, than contacts with no associated injury and so the number of cases reviewed in this Section is smaller than might otherwise be expected from the data in Section 4.3.

The cases in which occupant contact with the windscreen could be established are listed in Tables 4.34 to 4.37, grouped by ADR 8 compliance and the type of windscreen glass, laminated or toughened. The number of cases is not sufficient for a meaningful comparison to be made of injury rates bearing in mind the many factors that can affect the outcome of such impacts. The following review will therefore concentrate on a discussion of selected cases that relate to the characteristics of the windscreen glass.

Toughened Glass Windscreens

There were three occupants who were severely injured when they struck a toughened glass windscreen.

The left front passenger in a 1966 Holden HD panel van struck his face on the screen when the car hit a utility pole (Accident 051, Table 4.36). The screen shattered and the unrestrained passenger continued forwards and struck his face on the upthrust bonnet of the car (Figure 4.46). Fragments of glass from the shattered windscreen were interposed between his face and the surface of the bonnet. He sustained multiple minor lacerations to his face and severe concussion. The relative contribution to these injuries of each of the two impacts cannot be established from the available information but the fact that the screen shattered and allowed the passenger to continue forwards to the second impact may, in so doing, have exacerbated the severity of the injuries.

The passenger in Accident 051 continued on through the plane of the windscreen when the glass shattered. In four other cases the occupant pivoted forwards and downwards, striking and breaking the windscreen glass with his or her head. The occupant's face then struck the jagged edge of the broken glass that was retained in the frame of the windscreen. Figure 4.32 shows the facial lacerations (one week after the crash) resulting from an impact of this type in which an unrestrained driver moved forwards and to the left when her car was struck from the side at an intersection (Accident 009, Table 4.36, Figure 4.33). In Accident 121 the car hit a tree and the unrestrained front seat passenger struck his face on the base of the windscreen frame as well as on the retained fragments of glass (Table 4.36, Figure 4.34). He sustained severe fractures of the facial bones (zygoma) and extensive and deep facial lacerations. The left front passenger in a Leyland Marina had a similar experience, but with less severe injuries, when the car crashed into the back of another car (Accident 115, Table 4.34) and the driver of a Cortina that struck the left side of another car in a right-angle intersection collision received multiple facial lacerations when his head shattered the toughened glass windscreen (Accident 259, Table 4.34, Figure 4.35).

Although the individual fragments of glass from a shattered toughened glass windscreen are unlikely to be injurious, the cases described above show that the shattered screen can and does inflict extensive facial lacerations. Because a shattered screen cannot prevent the striking occupant from moving further forwards, or from moving downwards, there is the additional risk of sustaining further injury from contact with the jagged edge of broken glass and/or with the edge of the windscreen surround. Accident 051 also shows that there is a risk of partial ejection under such circumstances followed by impacts with objects outside the passenger compartment.

Laminated Glass Windscreens

Although a laminated glass windscreen is less likely to be penetrated when struck than is a toughened screen (there were no cases in which an occupant penetrated a laminated screen) it may serve to redirect the striking occupant to a subsequent impact with another object inside the car. This happened in two of the eight cases listed in Tables 4.35 and 4.37 (Accidents 077 and 124).

In Accident 077 a Toyota Celica crashed into an oncoming car that turned across its path. The driver, who probably was unrestrained, struck his head on the

TABLE 4.34: OCCUPANT CONTACT WITH ADR 8 TOUGHENED WINDSCREEN

Acc. No.	Car			Occupant		
	Make, Model	Year	Damage to Glass	Seated Position	Belted	Injury from Glass Contact
115	Marina	1972	Shattered	L.F. Passenger[1]	No	Concussion, facial lacerations.
122	Renault 16TL	1972	Shattered	L.F. Passenger	No	Facial lacerations.
163	Torana LJ	1972	None	Driver	Yes	Head contact - uninjured.
193	Galant	1973	None[2]	L.F. Passenger	No	Concussion.
232	Valiant VH	1972	None	L.F. Passenger	No	Neck sprain
259	Cortina TC	1973	Shattered	Driver	No	Facial laceration around left eye.
301	Holden HJ	1975	None	L.F. Passenger	No	Bruised forehead.

Note: [1] Left Front Passenger.
[2] Replacement windscreen.

TABLE 4.35: OCCUPANT CONTACT WITH ADR 8 LAMINATED WINDSCREEN

Acc. No.	Car			Occupant		
	Make, Model	Year	Damage to Glass	Seated Position	Belted	Injury from Glass Contact
012	Mazda 808	1973	Cracked inner layer of glass.	L.F. Passenger	No	Bruised forehead.
077	Toyota Celica	1975	Cracked	Driver	Unknown	Concussion.
124	Mazda 929	1974	Cracked	Driver	No	Concussion (severe)[1]
124	BMW 3.0 Si[2]	1972	None	Driver	Unknown	Head contact - uninjured.
258	Datsun 120Y	1974	None	L.F. Passenger	No	Hand contact - uninjured.

Note: [1] Subsequent head contact with A-pillar was main cause of injury.
[2] No compliance plate (privately-imported vehicle); compliance with ADR 8 assumed here.

TABLE 4.36: OCCUPANT CONTACT WITH PRE-ADR 8 TOUGHENED WINDSCREEN

Acc. No.	Car			Occupant		
	Make, Model	Year	Damage to Glass	Seated Position	Belted	Injury from Glass Contact
006	Holden HK	1968	None	L.F. Passenger	No	Bruised forehead and strained neck.
009	Torana HB	1967	Shattered	Driver	No	Severe facial lacerations.
016	VW 1200	1961	None	Driver	Yes	Concussion
051	Holden HD	1966	Shattered	L.F. Passenger	No	Severe facial abrasions.[1]
055	Morris Oxford	1956	None	Driver	No	Head contact - uninjured.
059	Valiant VF	1969	Shattered	L.F. Passenger	No	Facial laceration.
121	Holden EJ	1963	Shattered	L.F. Passenger	No	Fractures of facial bones and severe facial lacerations.
130	VW 1200	1958	Shattered	Driver	No	Multiple minor facial lacerations.
168	VW 1200	1963	Shattered	L.F. Passenger	No	Minor facial laceration.
179	Holden FB	1960	None	Driver	No	Head contact - uninjured.
186	Holden HD	1965	None	L.F. Passenger	No	Bruised forehead.
194	Valiant AP5	1964	None	Centre front Passenger	No	Abrasion - forehead.
206	Holden HR	1967	None	Driver	Yes Loose	Concussion.
229	Karmann Ghia	1964	None[2]	Driver	No	Concussion.
239	VW 1200	1959	None	L.F. Passenger	Yes	Head contact - uninjured.
241	Holden HR	1966	None	Driver	Yes Loose	Abrasion above right eye (sunglasses worn)
245	Holden EH	1964	None	Driver	No	Facial bruising.
266	Holden EJ	1963	None	L.F. Passenger	No	Bruised forehead.
290	Vauxhall Velox	1957	None	Driver	No	Concussion.
303	VW 1300	1967	None	Driver	No	Head contact - uninjured.

Note: [1] Subsequent contact between face and bonnet of car.
[2] Windscreen dislodged from frame.

TABLE 4.37: OCCUPANT CONTACT WITH PRE-ADR 8 LAMINATED WINDSCREEN

Acc. No.	Car			Occupant		
	Make, Model	Year	Damage to Glass	Seated Position	Belted	Injury from Glass Contact
094	Rambler American	1968	None[1]	L.F. Passenger	Yes	Hand contact - uninjured.
119	Falcon XR	1968	Cracked	Driver	Yes	Abrasion to right forearm.
165	VW 1200	1960	Cracked	Driver	No	Concussion

Note: [1] Classification of screen as laminated not confirmed.

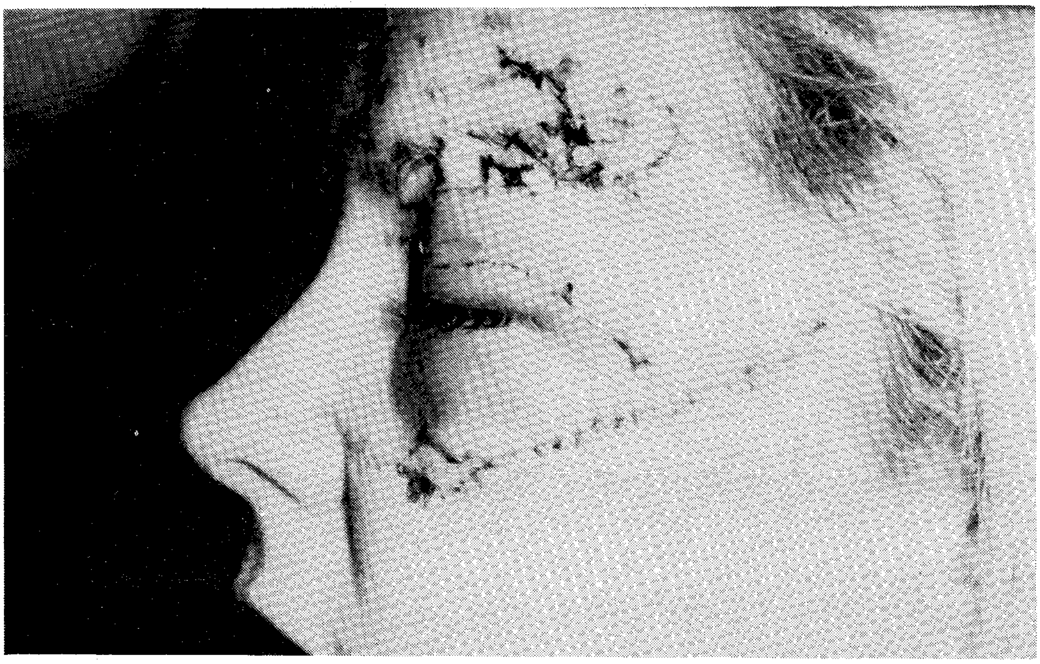


FIGURE 4.32: Facial lacerations from striking edge of broken glass in shattered toughened glass windscreen (one week after the crash) (Accident 009, see Figure 4.33)

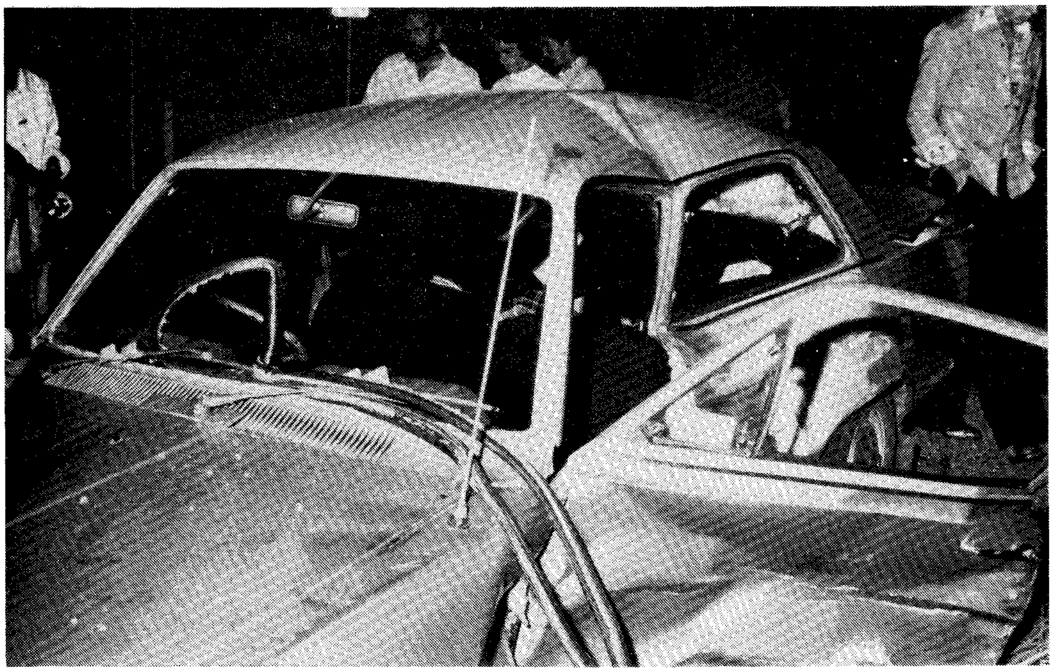


FIGURE 4.33: Damage to car referred to in Figure 4.32.

FIGURE 4.34: Lower edge of windscreen frame and retained fragments of shattered toughened glass struck by face of unrestrained front seat passenger (glove box lid is open and grill is missing from plenum chamber in front of the windscreen) (Accident 121)

FIGURE 4.35: Lacerations sustained on penetrating toughened glass windscreen (Accident 259, see Figures 4.36, 4.52, 4.80)

windscreen and slid across to the left side of the car where he then struck his head on the sill of the left front window. He was concussed by these impacts.

The driver of a Mazda 929 coupe turned right, across the path of an oncoming car. The cars collided and the resulting damage to the left side of the Mazda was extensive (Figure 4.37). The unrestrained driver struck his head on the laminated windscreen, fracturing the glass (Figure 4.38). His head then slid across to the left until it struck the A-pillar, which inflicted severe lacerations (Figures 4.39 and 4.40).

Seat Belt Wearing and Head Contact with the Windscreen

Almost all of the cases of head contact with the windscreen involved occupants who were not wearing a seat belt. In the instances in which a belted occupant was concussed by such an impact either the static belt was worn loosely or the windscreen was unusually close to the driver (eg: VW 1200).

Windscreen Struck by Pedestrian or Pedal Cyclist

There were two cases in which a windscreen was struck by a person outside the vehicle. A pedestrian who was standing in the middle of the road was hit by a Datsun 1200 coupe that was travelling at a speed of about 60 km/h. The resulting damage to the front of the car is shown in Figure 4.41. The pedestrian's head struck the laminated glass windscreen, breaking the glass and penetrating the laminate (Figure 4.42). The pedestrian then pivoted about this head-impact area and 'cart-wheeled' over the top of the car, falling to the road surface behind it. He was concussed, with a period of unconsciousness of less than five minutes, and received multiple minor facial abrasions and lacerations. It is likely that the yielding laminated glass windscreen was a relatively safe object for the pedestrian's head to have struck, whereas a toughened screen may have, on shattering, exposed the pedestrian to the risk of further head injury from contact with objects inside the car.

A pedal cyclist who was hit from the rear by a Ford Falcon XA sedan struck his head on the grill of the plenum chamber in front of the base of the toughened glass windscreen and on the base of the screen. One hand struck the top of the screen and the leading edge of the roof. The glass shattered, and the cyclist sustained concussion and lacerations of moderate severity to his scalp and to the back of his hand.

If the incidence of seat belt-wearing increases among car occupants who are involved in accidents it may be that the injury potential of the windscreen will become more important to the pedestrian or cyclist than to the occupant of the car. In this respect the restraining properties of the laminated screen may be found to be an important injury countermeasure.

Occupant Contact with Window Glass

Tables 4.38 and 4.39 list those cases in which there was evidence that an occupant had been thrown against the glass of a side window during the crash (there were no cases in which occupant contact with the rear window glass could be substantiated).

Six of the nine glass-contact cases listed in Tables 4.38 and 4.39 were thought to have received one or more injuries that were directly attributable to hitting the glass (the three remaining occupants were not injured by their impact with the window glass). None of these six occupants was known to have hit his or her head on any object other than the glass but most of them were thrown heavily up against the door (eg: Figure 4.44). Consequently in the one case of neck sprain (Accident 206, Table 4.39) the injury may have resulted from a combination of shoulder impact with the window sill and head impact with the glass. The lacerations resulting from contact with shattered side window glass were minor (eg: Figure 4.45).

The Performance of ADR 8 in Injury Reduction

As noted in the introduction to this Section, ADR 8 is based on an Australian Standard that was published in 1968. This Standard, in turn, was based on the British Standard BS 857, 'Safety Glass for Land Transport'. As ADR 8 became effective in mid-1971 there is unlikely to have been any marked difference in the injury potential of car windscreens and side window glass in the five years before and after that date (most of the cars in this study were manufactured during that ten-year period). The cases of known occupant contact with windscreen or side window glass that have been presented in this Section do not show any obvious change in injury patterns due to the introduction of ADR 8. That may be due to the small number of such cases but comparison with data from the first Adelaide in-depth study (Robertson, McLean and Ryan, 1966) shows that the mechanisms of injuries inflicted by toughened glass windscreens changed little, if at all, from the early-1960s to the mid-1970s (McLean, 1969). The most significant source of severe facial injury in these two periods was a jagged edge of broken glass fragments retained by the windscreen frame after the screen has been shattered by the head of an unrestrained occupant.

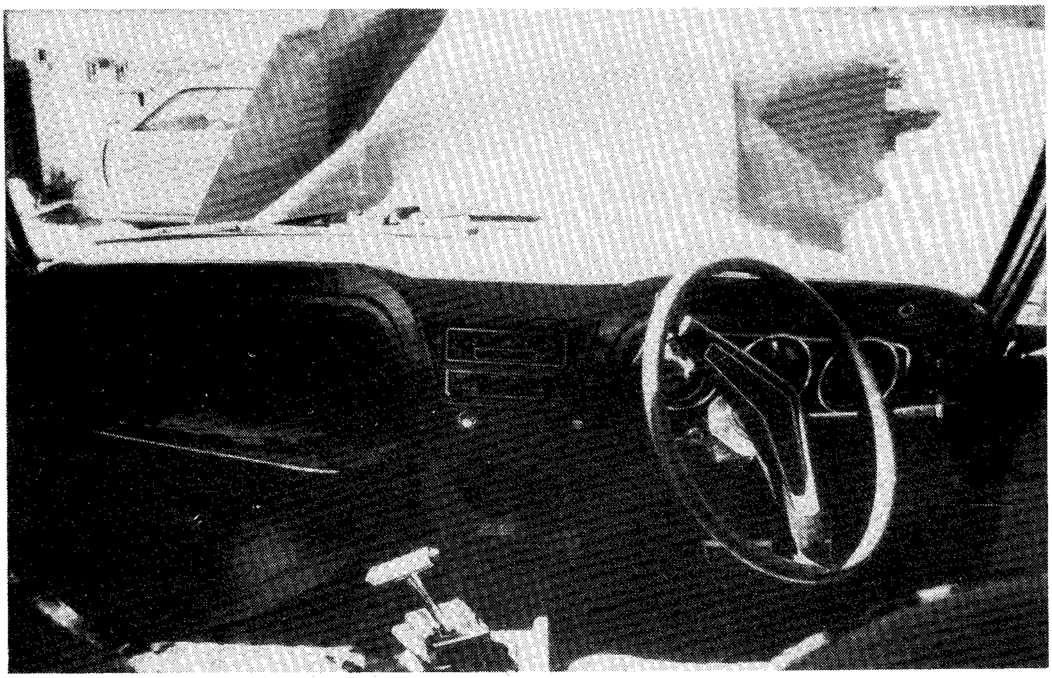


FIGURE 4.36: Damage to toughened glass windscreen caused by impact by head of driver (See Figure 4.35)

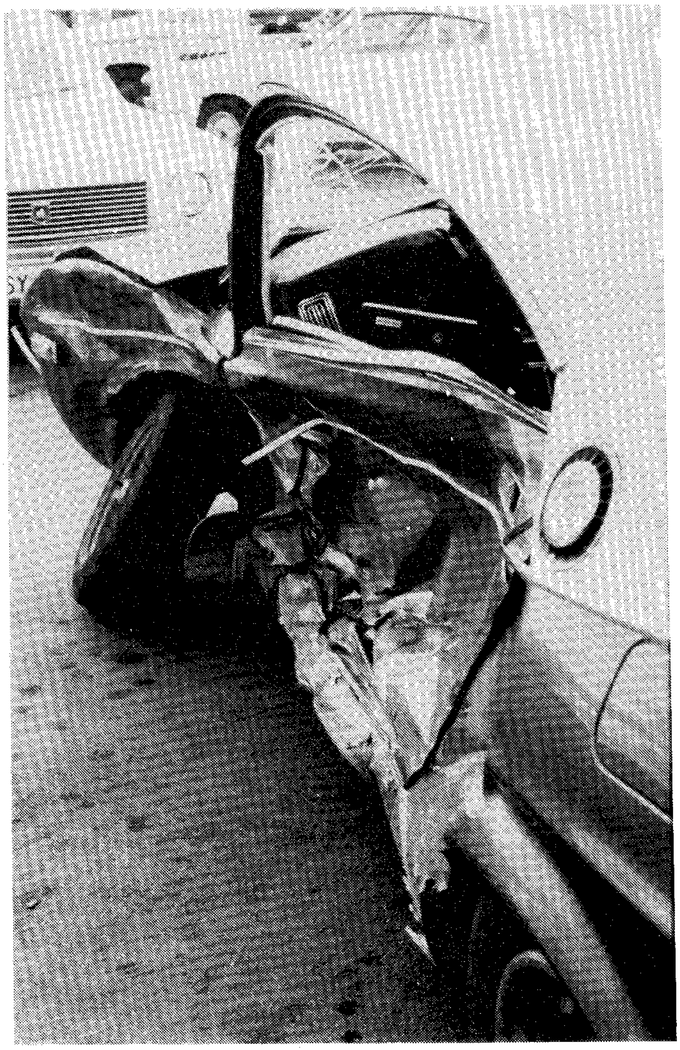


FIGURE 4.37:

Deformation of left side of Mazda 929 coupe in Accident 124 (See Figures 4.38, 4.39 and 4.78)

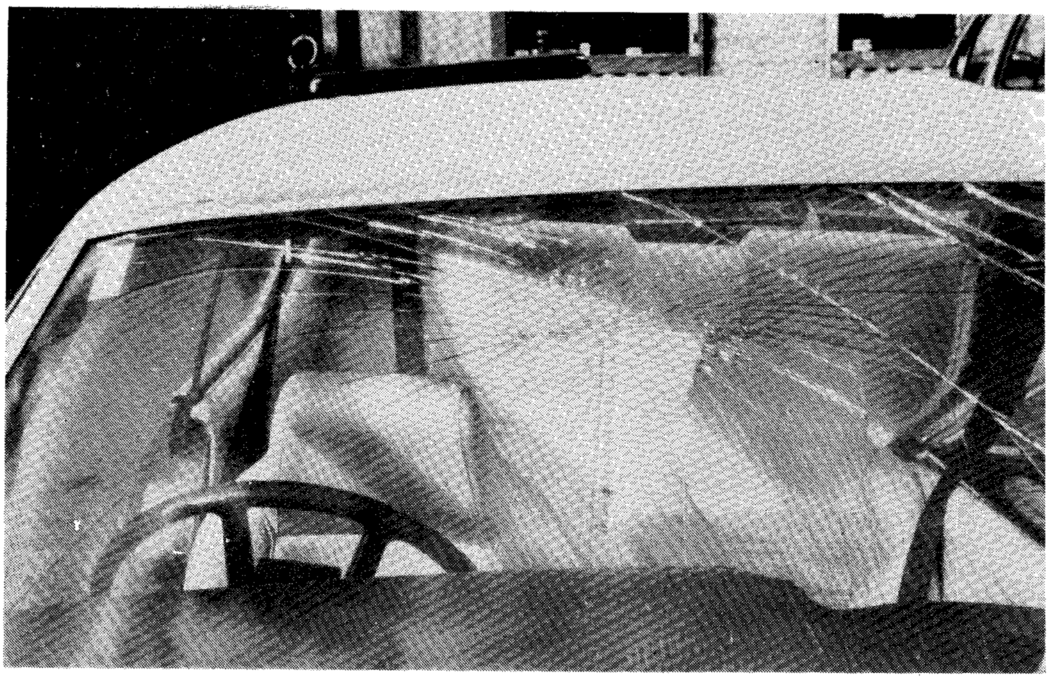


FIGURE 4.38: Point of impact of driver's head on laminated windscreen. (Accident 124, See Figures 4.37, 4.39)

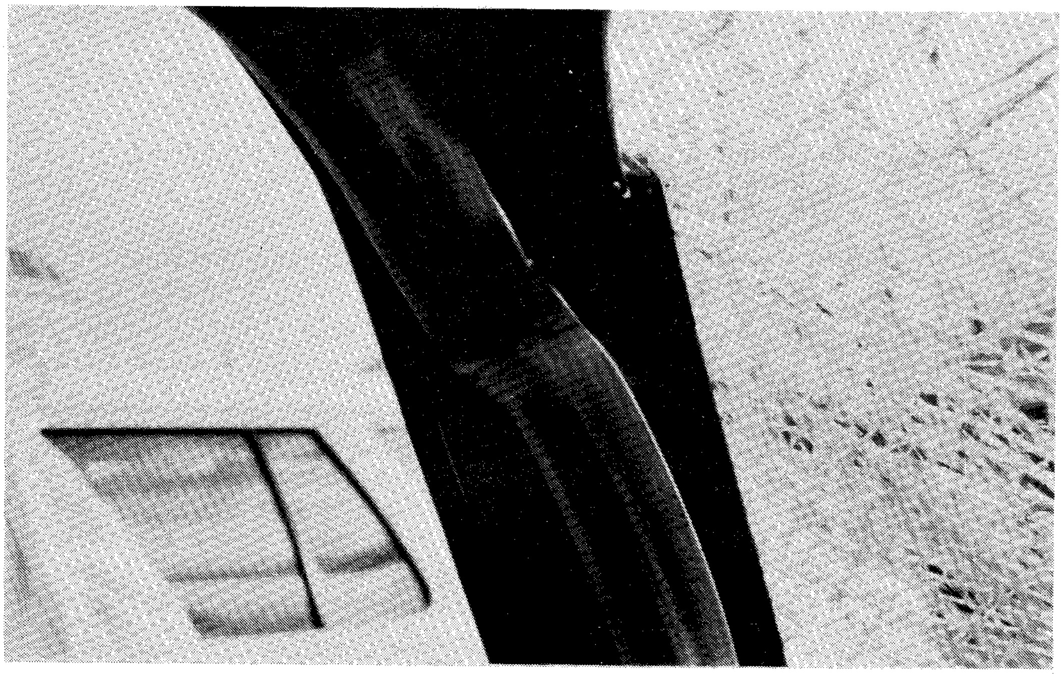


FIGURE 4.39: Point of impact of driver's head on left hand A pillar. (Accident 124, See Figures 4.37, 4.38, 4.40).

FIGURE 4.40: Lacerations caused by impact with A-pillar shown in Figure 4.39.

FIGURE 4.41: Datsun 1200 following impact with pedestrian (Accident 144, See Figures 4.42, 4.43)

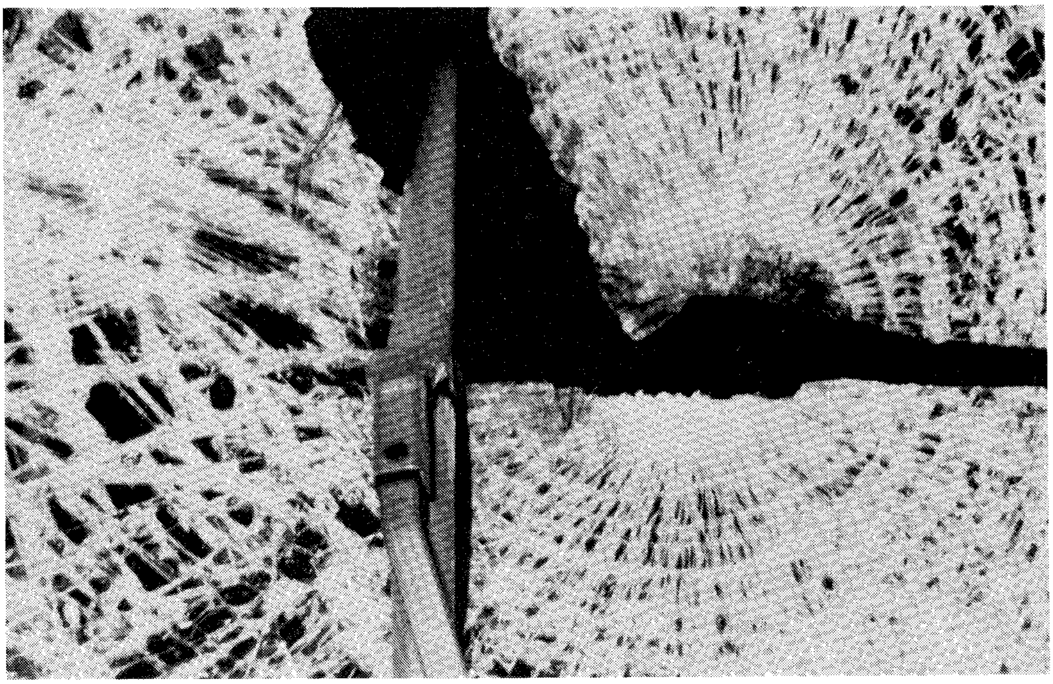


FIGURE 4.42: Detail of fracture of laminated glass caused by impact with head of pedestrian (Accident 144, See Figures 4.41, 4.43)

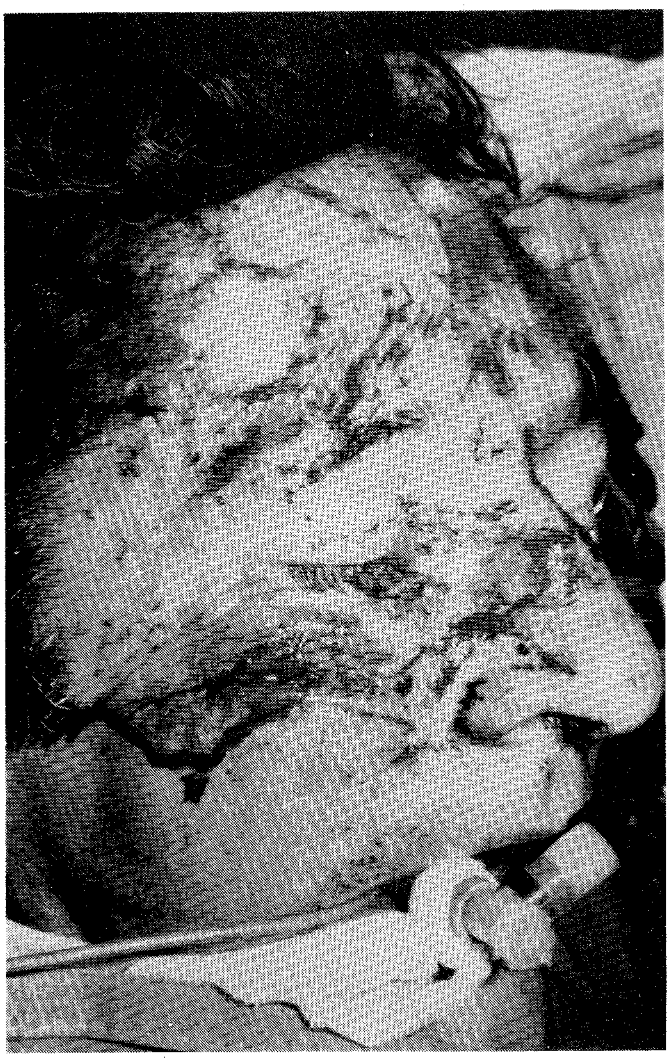


FIGURE 4.43:

Lacerations caused by impact with windscreen shown in Figures 4.41 and 4.42.

TABLE 4.38: OCCUPANT CONTACT WITH ADR 8 SIDE WINDOW GLASS

Acc. No.	Car			Occupant		
	Make, Model, Body Style	Year	Damage to Glass[1]	Seated Position	Belted	Injury from Glass Contact
104	Toyota Corolla 4 door sedan	1975	None	Driver	Yes	Concussion
128	Holden HJ 4 door sedan	1975	None	Left Front passenger	Yes	Uninjured
164	Toyota Corolla 2 door sedan	1971	Shattered	Driver	Yes	Minor facial lacerations

Note: [1] All toughened glass; all contacts with window of front door.

TABLE 4.39: OCCUPANT CONTACT WITH PRE-ADR 8 SIDE WINDOW GLASS

Acc. No.	Car			Occupant		
	Make, Model, Body Style	Year	Damage to Glass[1]	Seated Position	Belted	Injury from Glass Contact
020	Holden EH 4 door sedan	1964	Shattered	Left Front passenger	No	Concussion, minor lacerations.
114	Vauxhall Victor 4 door sedan	1964	None	Driver	No	Concussion.
148	Morris 1100 4 door sedan	1965	None	Driver	No	Neck sprain.
149	Holden HT 4 door wagon	1969	None	Left Front passenger	No	Uninjured.
172	Valiant AP5 4 door sedan	1964	None	Driver	No	Uninjured.
206	Valiant VF 4 door sedan	1969	None	Left Front passenger	No	Bruised nose.

Note: [1] All toughened glass; all contacts with window of front door (Acc.206 contact was with vent window).

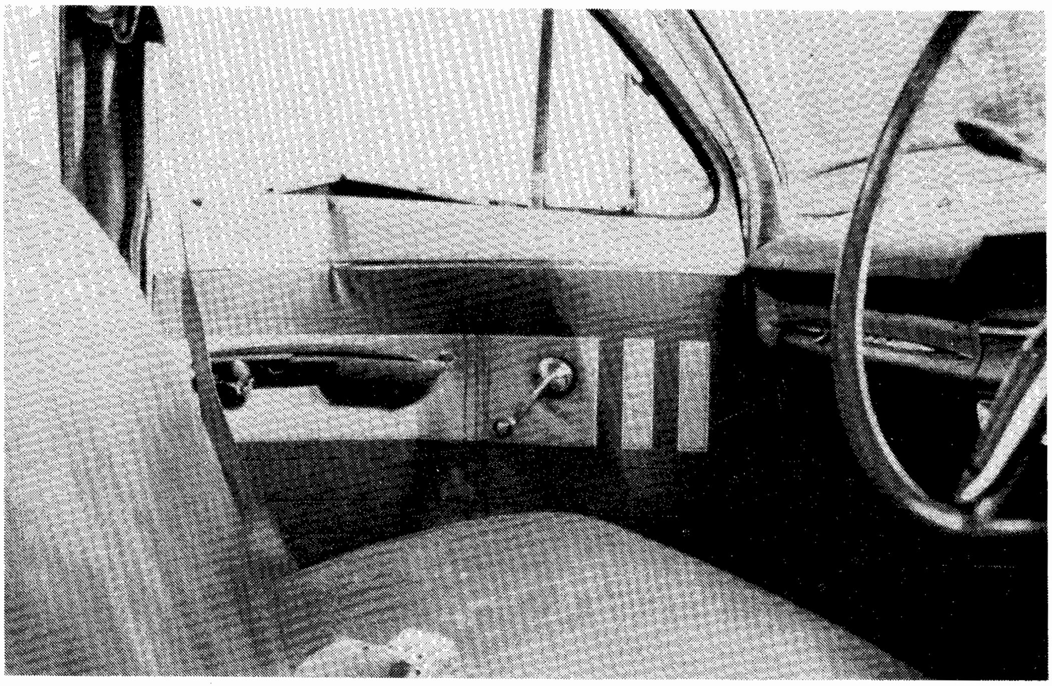


FIGURE 4.44: Damage to door caused by left front passenger being thrown against it (Accident 020, see Figure 4.45)

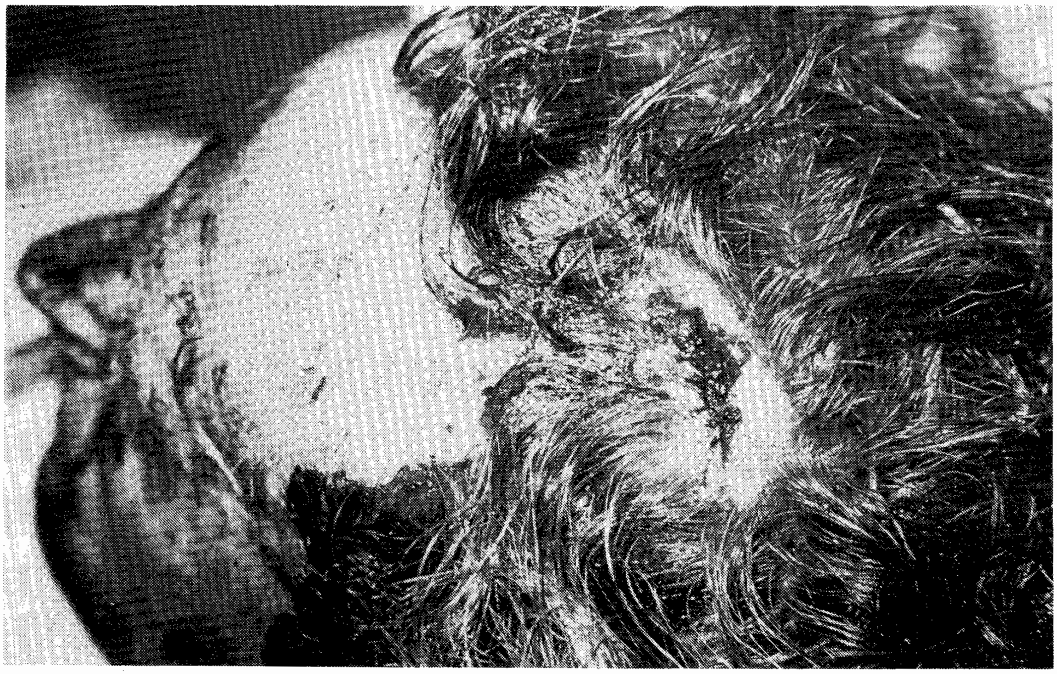


FIGURE 4.45: Minor scalp laceration from head impact with toughened glass side window (See Figure 4.44)

4.4.9 ADR 9: STANDARD CONTROLS FOR AUTOMATIC TRANSMISSIONS

The intention of this Australian Design Rule is to standardise the control movements required to select forward and reverse motion of vehicles fitted with automatic transmissions, to minimise the accidental engagement of the wrong gear, to provide safeguards against inadvertent movement of the vehicle when starting the engine, and to provide some engine braking at speeds below 25 miles per hour.

Effective date: 1 January, 1972
Ceased to apply: 1 January, 1976

There were no instances in which the characteristics of an automatic transmission were relevant to the causation of an accident.

4.4.10 ADR 10A AND 10B: STEERING COLUMNS

The intention of this Australian Design Rule is to minimise crushing or penetrating injuries to drivers due to the steering column as a result of frontal impact.

Effective date:
10A: 1 January, 1971
10B: 1 January, 1973

ADR 10A provides performance specifications for the collapse of the steering column under a loading intended to simulate contact by the driver's chest; ADR 10B includes the requirements of ADR 10A and also provides a limit on the allowable rearward displacement of the steering column in a barrier impact test. The number of cars subject to these rules is shown in Table 4.40.

Occupant Contact with the Steering Assembly

There were 96 cases in which a driver was thought to have contacted the steering wheel or column during the crash (other than the normal contact with the wheel when driving). These cases were identified by either damage to the steering assembly or by the nature of the injuries sustained by the driver. They include some cases in which more than one object inside the car was struck by the driver. In one accident a front seat passenger may also have struck the rim of the steering wheel but this event is not included in the following tables and discussion. Table 4.41 lists the numbers of drivers involved by belt usage and compliance of the car with the relevant ADRs.

A crude estimate of the relative frequency of driver contact with the steering assembly is shown in Table 4.42. Cars that struck a pedestrian, pedal cycle or motorcycle are not included, nor is one collision with a train but no attempt has been made to control for possible differences in impact type or severity. The total percentage involvements in the last column appear to indicate a steady reduction from pre-ADR through 10A to 10B cars. However this apparent change is more likely to have been due to the confounding effects of differences in belt-wearing rates and, possibly, in the efficacy of the restraint afforded by improved types of seat belt (see Table 4.28). Overall, the proportion of steering assembly contacts among restrained drivers was less than that among drivers who were not wearing a seat belt (26.6 versus 40.9 per cent, Chi square = 6.18, $p < 0.05$).

Considering only those contacts that injured a driver the relative frequencies are as shown in Table 4.43. Once again the superior protection afforded by the later model belts is indicated but there is no meaningful difference in the injury potential of these crashes by compliance, or otherwise, with ADR 10A or 10B.

Most of the drivers listed in Table 4.43 sustained only minor injuries. Those who sustained a more severe injury from contact with the steering assembly were more likely to have been in pre-ADR 10A, 10B cars but, once again, this is largely a reflection of differential belt wearing rates and, possibly, differences in type of belt.

It should be remembered that few of the frontal impacts to the cars in the accidents studied were severe. Consequently there was little opportunity to assess the value of ADR 10A and 10B in terms of preventing penetration of the column into the passenger compartment, or the value of the peak loading requirements when the wheel is struck by the driver. Even so, the steering assembly is an important factor in the causation of injuries to drivers in crashes in an urban area.

Injuries to the Upper Torso

The relative frequency of injury to the driver's upper torso from striking the steering assembly is shown in Table 4.45 by belt usage and by compliance of the car with ADR 10A or 10B. These injuries were mostly contusions but there were some fractures, including one case that resulted in a flail chest (Accident 051). The belt induced injuries are discussed later in this Section. Interpretation of the data in Table 4.45 in terms of the effectiveness of this ADR or of belt wearing in preventing injury is not warranted because of the variations in both impact and injury severity between cases.

The most severe thoracic injuries due to contact with the steering assembly were sustained by the 32 year-old female driver of a 1966 Holden panel van that crashed into a utility pole (Accident 051, Figures 4.46 and 4.47). In this crash the steering column was displaced only slightly but the collapse of the spokes

TABLE 4.40: NUMBER OF CARS SUBJECT TO ADRs 10A OR 10B

ADR 10A or 10B Requirement	Number of Cars
Subject to ADR 10A	41
Subject to ADR 10B	112
Not subject to ADR 10A or 10B	221
Not known if subject to ADR 10A or 10B	12
Total	386

TABLE 4.41: DRIVER CONTACT WITH THE STEERING ASSEMBLY BY ADR 10A AND 10B COMPLIANCE AND BELT USAGE

ADR 10A, 10B Compliance	Belt Usage			
	Yes	No	Unknown	Total
No[1]	27	38[2]	4	69
10A	8	3	-	11
10B	7	8	-	15
Unknown	-	-	1[3]	1
Total	42	49	5	96

Note: [1] Includes some cars that probably would have complied with ADR 10A or 10B but which were not required to carry a compliance plate (pre-January 1, 1971).

[2] Injuries, if any, not known for two drivers (one left the scene; in the other case a "passenger" was suspected of being the driver).

[3] Privately imported car, probable compliance with ADR 10B

TABLE 4.42: RELATIVE FREQUENCY OF DRIVER CONTACT WITH THE STEERING ASSEMBLY BY ADR 10A AND 10B COMPLIANCE AND BELT USAGE

ADR 10A, 10B Compliance[1]	Belt Usage[1] Yes	No	Total
No[2]	42.2% (64)[3]	38.3% (96)	39.9% (160)
10A	26.7% (30)	75.0% (4)	32.4% (34)
10B	10.9% (64)	47.1% (17)	18.5% (81)
Total	26.6% (158)	40.9% (117)	32.6% (275)

Note: [1] Unknown compliance and/or usage cases excluded.

[2] See note[1] to Table 4.38.

[3] Number in parentheses is denominator for the above percentage.

TABLE 4.43: RELATIVE FREQUENCY OF DRIVER INJURY FROM CONTACT WITH THE STEERING ASSEMBLY BY ADR 10A AND 10B AND BELT USAGE

ADR 10A, 10B Compliance[1]	Belt Usage[1]		Total
	Yes	No	
No	25.0% (64)[2]	23.4% (94)[3]	24.1% (158)
10A	20.0% (30)	75.0% (4)	26.5% (34)
10B	4.7% (64)	23.5% (17)	8.6% (81)
Total	15.8% (158)	25.2% (115)	19.8% (273)

Note: [1] Unknown compliance and/or usage cases excluded.

[2] Number in parentheses is denominator for the above percentage.

[3] Two cases in which injuries, if any, were not known are excluded.

TABLE 4.44: RELATIVE FREQUENCY OF DRIVER INJURY (AIS >1) FROM CONTACT WITH THE STEERING ASSEMBLY BY ADR 10A, 10B AND BELT USAGE

ADR 10A, 10B Compliance[1]	Belt Usage[1]		Total
	Yes	No	
No	12.5% (64)[2]	6.4% (94)[3]	8.9% (158)
10A or 10B	1.1% (94)	4.8% (21)	1.7% (115)
Total	5.7% (158)	6.1% (115)	5.9% (273)

Note: [1] Unknown compliance and/or usage cases excluded.

[2] Number in parentheses is denominator for the above percentage.

[3] Two cases in which injuries, if any, were not known are excluded.

TABLE 4.45: RELATIVE FREQUENCY OF UPPER TORSO INJURY TO THE DRIVER FROM THE STEERING ASSEMBLY BY ADR 10A OR 10B COMPLIANCE AND BELT USAGE

ADR 10A, 10B Compliance	Belt Usage Yes	Belt Usage No	Total
No	4.7% [1] (64)	7.4% (94)	6.3% (158)
Yes	2.1% (94)	19.0% (21)	5.2% (115)
Total	3.2% (158)	9.6% (115)	5.9% (273)

Note: [1] If belt-induced injuries are included this becomes 10.9%.

See notes to Table 4.44.

TABLE 4.46: RELATIVE FREQUENCY OF HEAD OR FACIAL INJURY TO THE DRIVER FROM THE STEERING WHEEL BY ADR 10A OR 10B COMPLIANCE AND BELT USAGE

ADR 10A, 10B Compliance	Belt Yes	Belt No	Total
No	14.1% (64)	14.9% (94)	14.6% (158)
Yes	6.4% (94)	9.5% (21)	7.0% (115)
Total	9.5% (158)	13.9% (115)	11.4% (273)

See notes to Table 4.44

FIGURE 4.46: Damage to Holden panel van following collision with utility pole (Accident 051, See Figure 4.47)

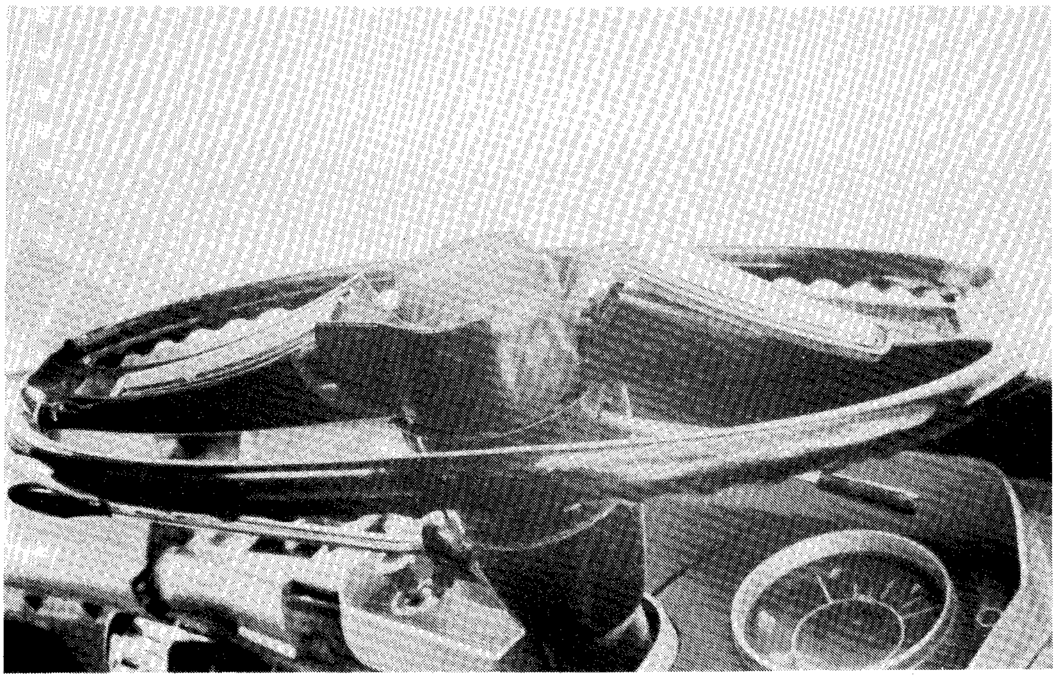


FIGURE 4.47: Damage to steering wheel caused by unrestrained driver being thrown against it (Accident 051, see Figures 4.46 and 4.89)

of the wheel exposed the driver to a direct impact with the hub. This fractured three ribs and dislocated the sterno-clavicular joint, leaving the driver with a flail chest and a left pneumothorax. She also struck her face on the rim of the wheel, sustaining concussion and fractures of the facial bones (the maxilla) and a broken neck (fractured odontoid process).

In Accident 245 a 1964 Holden sedan crashed head-on into a Jaguar 420G sedan (Figure 4.48). The unrestrained 52 year old male driver of the Holden was thrown against the steering wheel, the rim of which yielded (Figure 4.49) and allowed his chest to contact the two spokes and the hub, fracturing one rib and causing extensive bruising. The steering column was pushed back 40mm into the passenger compartment but this was unlikely to have affected the severity of the driver's injuries. The driver of the Jaguar was wearing a loosely-adjusted seat belt. He sustained minor bruising to his chest from both the belt webbing and the steering wheel.

Considerable deformation of the steering wheel and penetration of the column into the passenger compartment can occur without the driver necessarily receiving more than minor injuries. Figure 4.50 shows the extent of the damage to the front of a 1963 Volkswagen 1200 sedan that ran into a concrete wall. The steering column was forced back 120mm into the passenger compartment but the unrestrained driver, a 16 year-old male, received only abrasions to his arms even though the steering wheel was severely deformed (Figure 4.51). This wheel had the hub recessed well below the plane of the rim and so some energy of the driver/wheel impact could be absorbed by yielding of the spokes without exposing the relatively rigid hub. This characteristic of so-called 'dished' wheels, in which the hub is recessed, was observed in the first Adelaide in-depth study (Robertson et al, 1966, paras. 9.34 et seq.), as was the undesirability of the column being forced back in a collision.

Similar deformation of a 'dished' wheel was observed in Accident 259 (Figures 4.52 and 4.53). A 1973 Ford Cortina TC four-door sedan struck the side of another car at an intersection. The unrestrained driver of the Ford was not injured by being thrown against the steering wheel, even though the wheel itself was severely damaged.

There were two other cases in which 'dished' steering wheels were severely deformed without the driver sustaining upper torso injuries. Figure 4.16 shows the damage to the wheel of a 1968 Ford Falcon XY sedan. The unrestrained driver was concussed and his face was lacerated and bruised from striking the rim of the wheel. He had no other injuries. In Accident 138 a 1963 Ford Falcon XM sedan crashed into the back of a parked car. The deformation of the front of the Ford was severe (Figure 4.54), as was the damage to the steering wheel (Figure 4.55) but the unrestrained driver was uninjured apart from a bruised left wrist.

The apparent success of the steering wheels shown in Figures 4.16 and 4.55 in preventing injury to the driver's upper torso may be, in part, a function of the severity of the collision. In an even more severe crash the hub of the wheel may be exposed.

The deformation to the front of the car shown in Figure 4.54 was not adjacent to the steering column. In Accident 057, a collision with a tree, there was severe localised deformation of the structure of the car in line with the steering column of a 1975 Chrysler Valiant VJ sedan (Figure 4.56). The column was pushed back 70mm and up 160mm (Figure 4.57). The 15 year-old driver, who was wearing a seat belt, sustained a bruised chest from striking the hub of the wheel and concussion and facial lacerations from the rim. As can be seen in Figure 4.57 the two spokes of this steering wheel were twisted through an angle of about 25 degrees, allowing the rim of the wheel to be displaced without bending. The energy-absorbing element below the hub of the wheel had begun to collapse at one side of the bottom convolution, as intended (Adams and Cassle, 1970) allowing the hub of the wheel to tilt five degrees from its original alignment (Figure 4.58). The total angular displacement of the rim of the wheel about an horizontal axis across the car was therefore about 30 degrees.

The same make and model of car was involved in a similar collision, this time with a pole and with the impact in line with the motor (Accident 294, Figure 4.59). The extent of the deformation was consequently much less than in the case of the off-centre impact in Accident 057 and so there was no displacement of the steering column (Figure 4.60). The impact speed may have been slightly less in Accident 294 but the deformation of the energy-absorbing element below the steering wheel was slightly greater (Figure 4.60). The driver in this case was not wearing a seat belt. His upper torso was not injured but his face was bruised by the impact with the rim of the wheel.

There were two cases in which a non-standard steering wheel was struck in a car that struck the side of another car at an intersection (Accidents 017 and 033). The driver in the former case was wearing a seat belt and was not injured but the spokes of the wheel were bent, exposing the hub (Figure 4.61). The driver in Accident 033 was unrestrained but the non-standard steering wheel was deeply 'dished' and was not associated with any injury.

While belt-wearing was seen to be associated with lower rates of both contact with the steering assembly and with the resulting frequency of injury there were cases in which significant injuries were caused by the belt itself. Three drivers sustained fractures of the ribs and/or sternum from striking the steering assembly (Accidents 051, 245 and 290) whereas two other drivers sustained

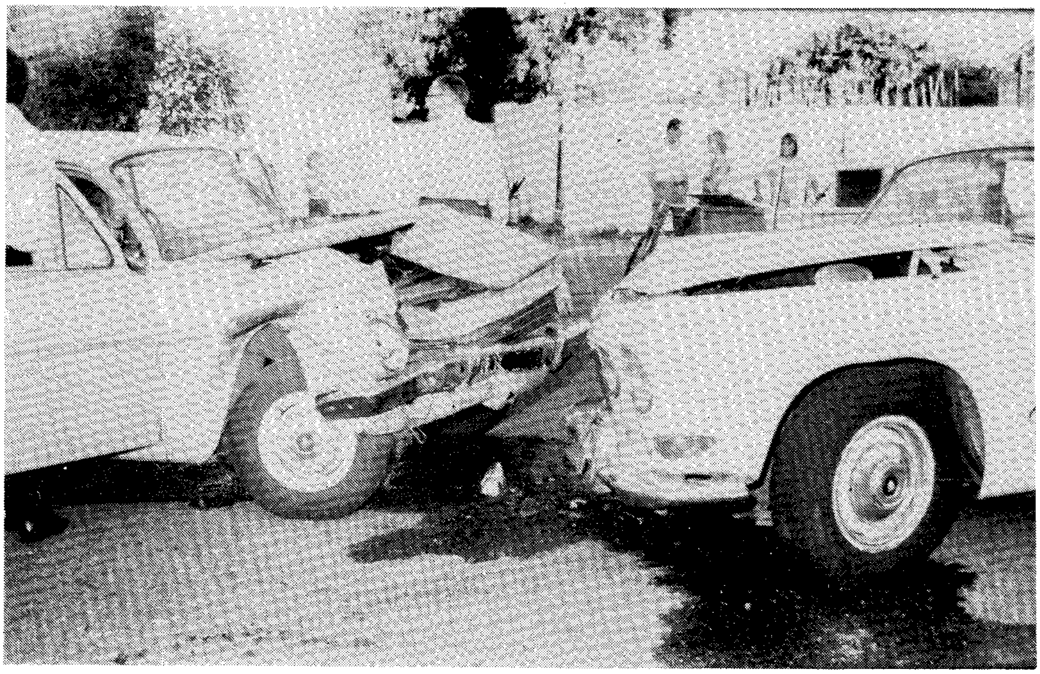


FIGURE 4.48: Head-on collision between a 1966 Holden sedan and a 1967 Jaguar 420G (Accident 245, See Figures 4.49, 4.81)

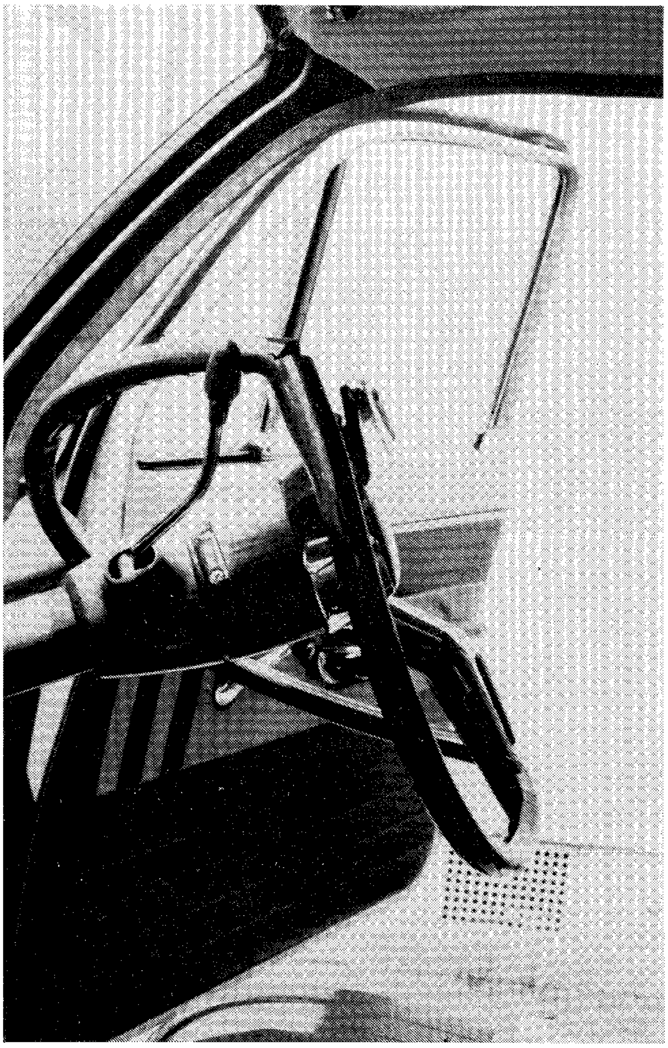
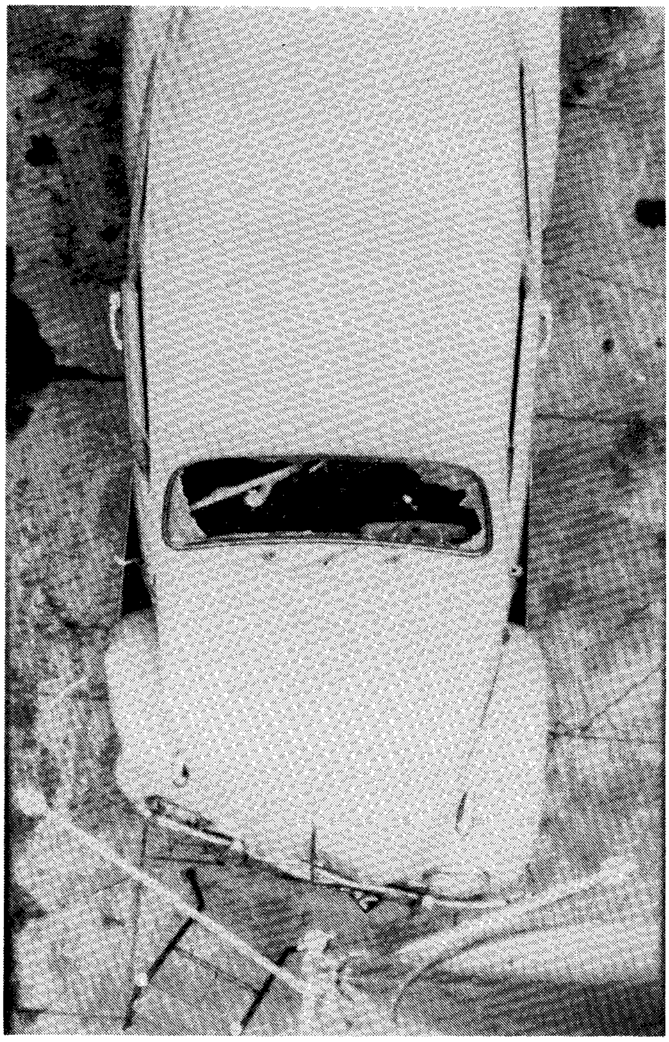


FIGURE 4.49:

Damage to steering wheel of Holden in Accident 245 (see Figure 4.48)

FIGURE 4.50:

Damage to 1963 VW 1200 following collision with concrete wall (Accident 168, See Figure 4.51)



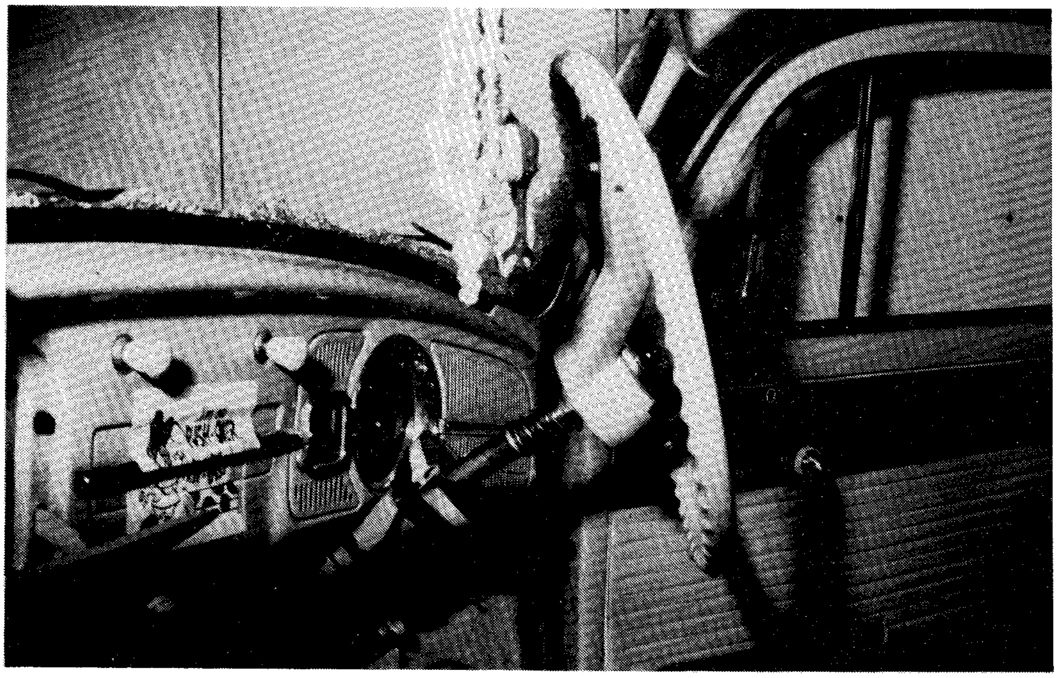


FIGURE 4.51: Unrestrained driver was virtually uninjured despite damage to steering wheel and penetration of steering column (See Figure 4.50)

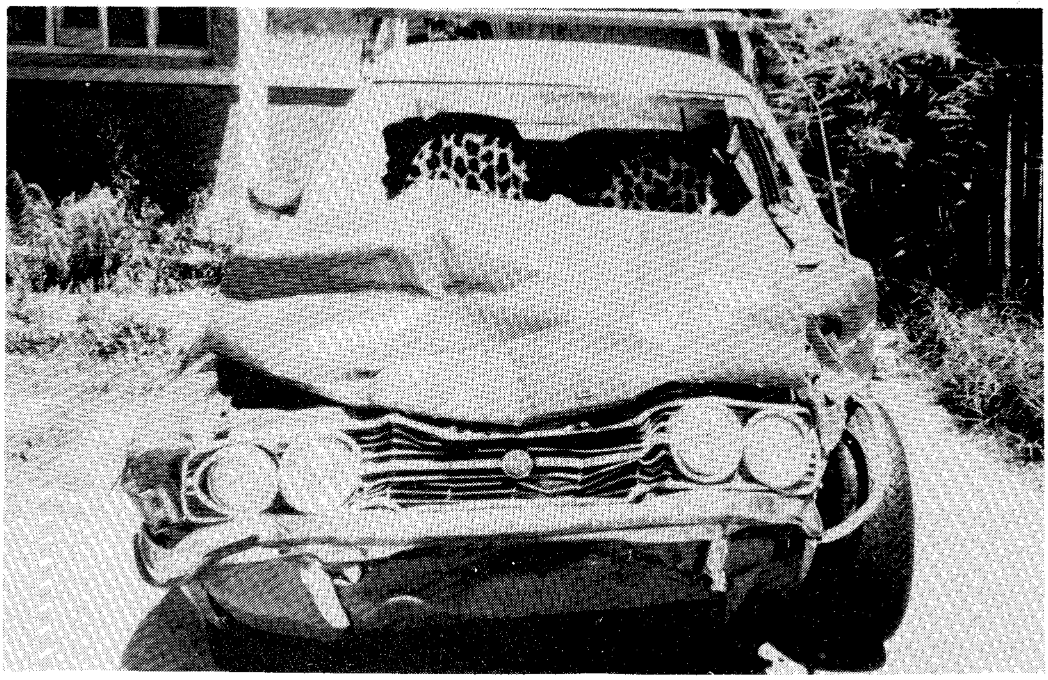


FIGURE 4.52: Damage to a 1973 Ford Cortina TC following an intersection collision (Accident 259, See Figure 4.53, 4.80)

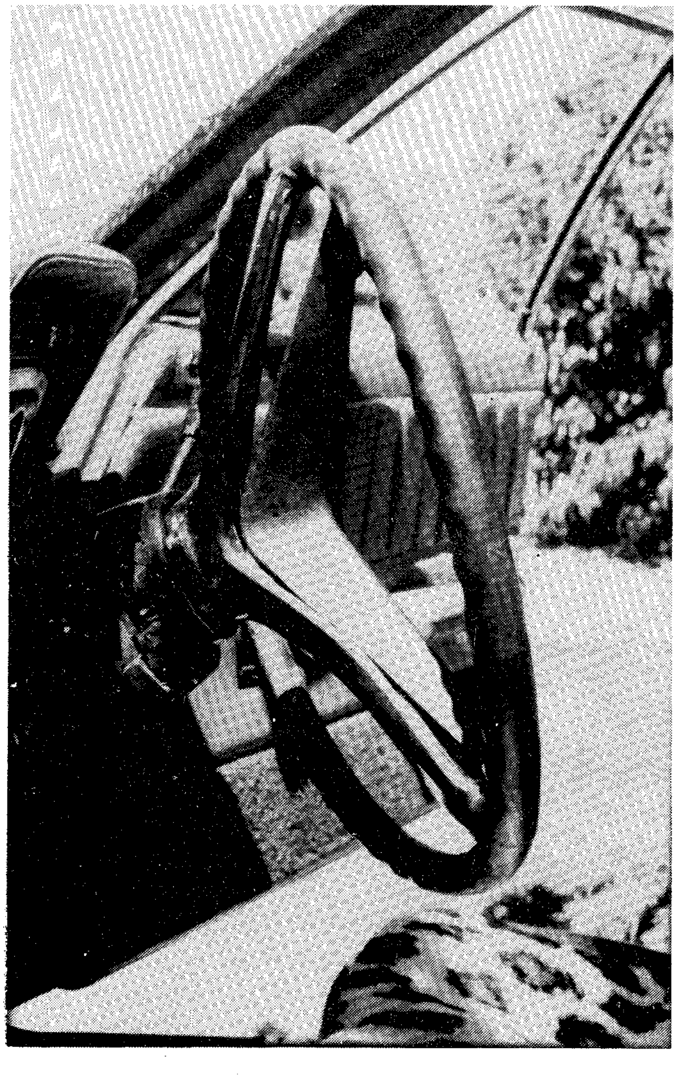


FIGURE 4.53:

Damage to steering wheel of car shown in Figure 4.52.

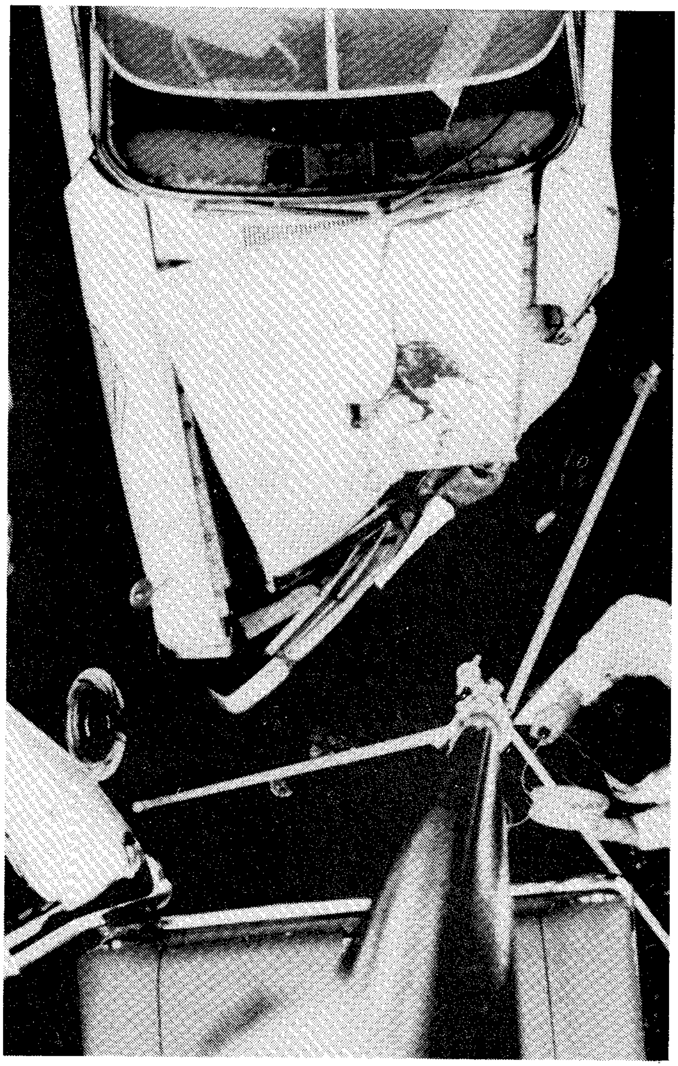


FIGURE 4.54:

Damage to Ford Falcon due to collision with parked car. (Accident 138, See Figure 4.55)

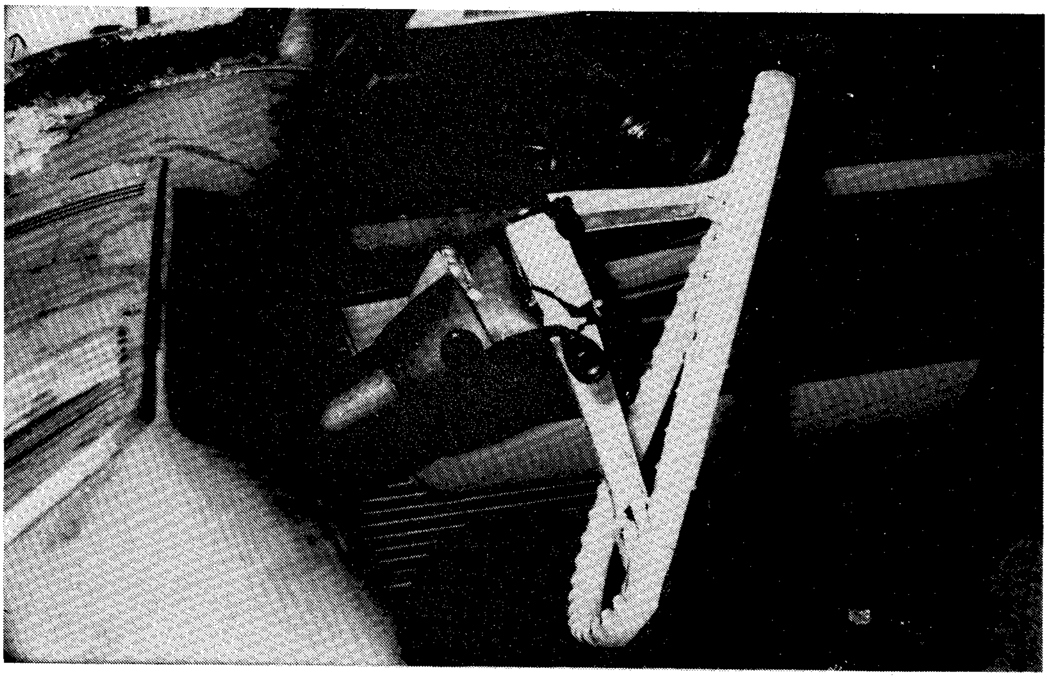


FIGURE 4.55: Damage to steering wheel of car shown in Figure 4.54. Unrestrained driver received a bruised wrist.

FIGURE 4.56:

Severe localised damage to car following collision with a tree. (Accident 057, See Figures 4.57, 4.58, 4.79)

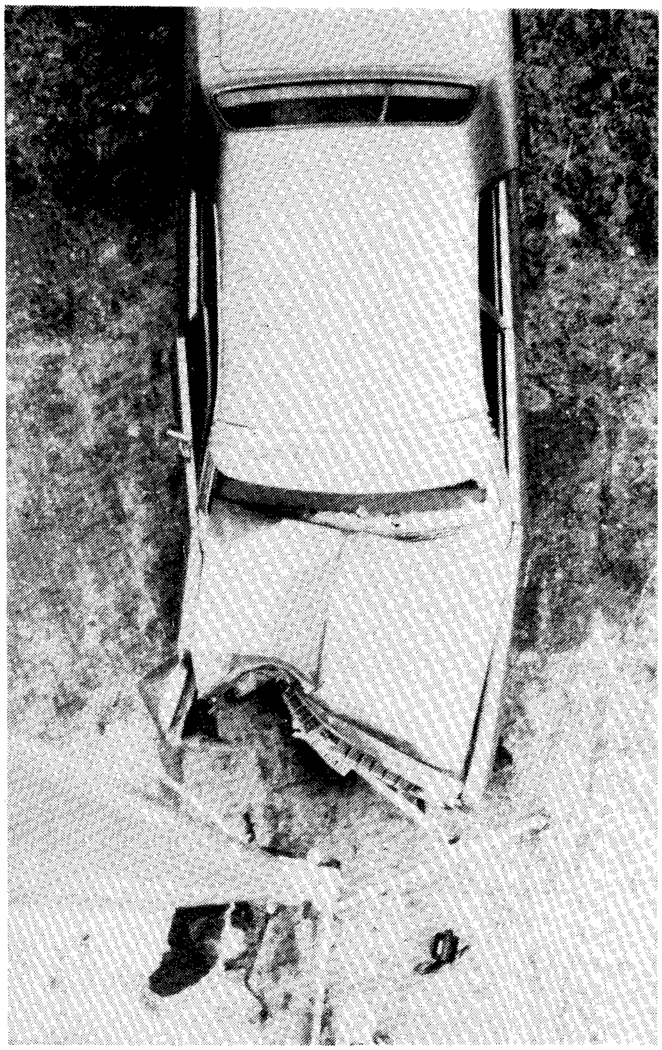


FIGURE 4.57:

Deformation of steering wheel and penetration of column into passenger compartment. (Accident 057, See also Figures 4.56, 4.58, 4.79)

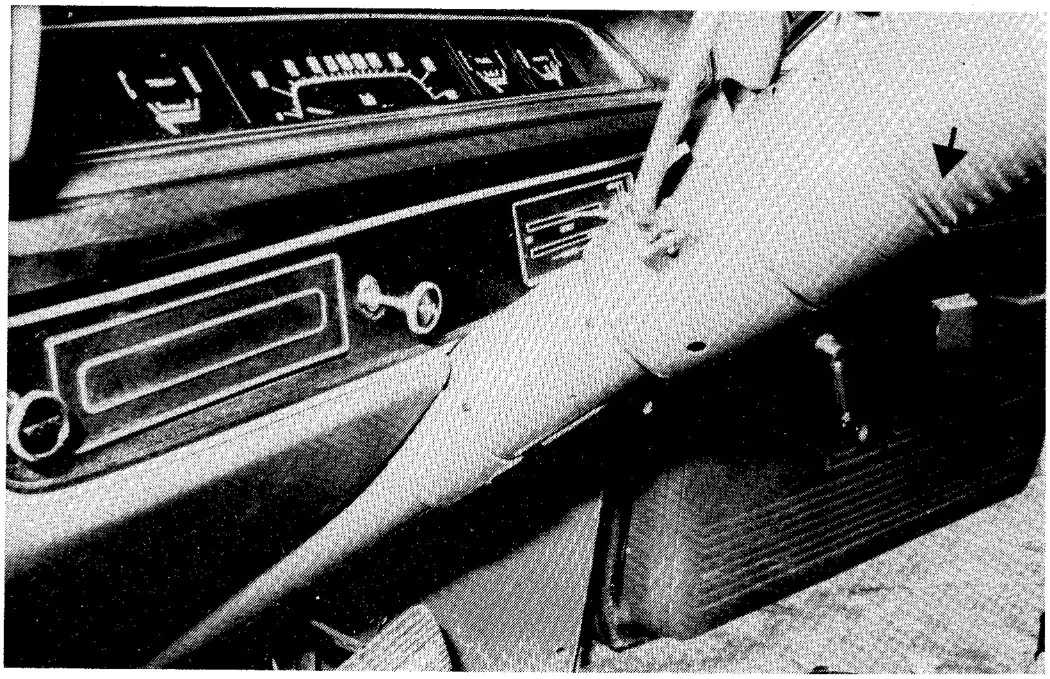


FIGURE 4.58: Collapse of energy-absorbing element at top of steering column (arrowed) and penetration of column into passenger compartment. (Accident 057, See Figures 4.56, 4.57)

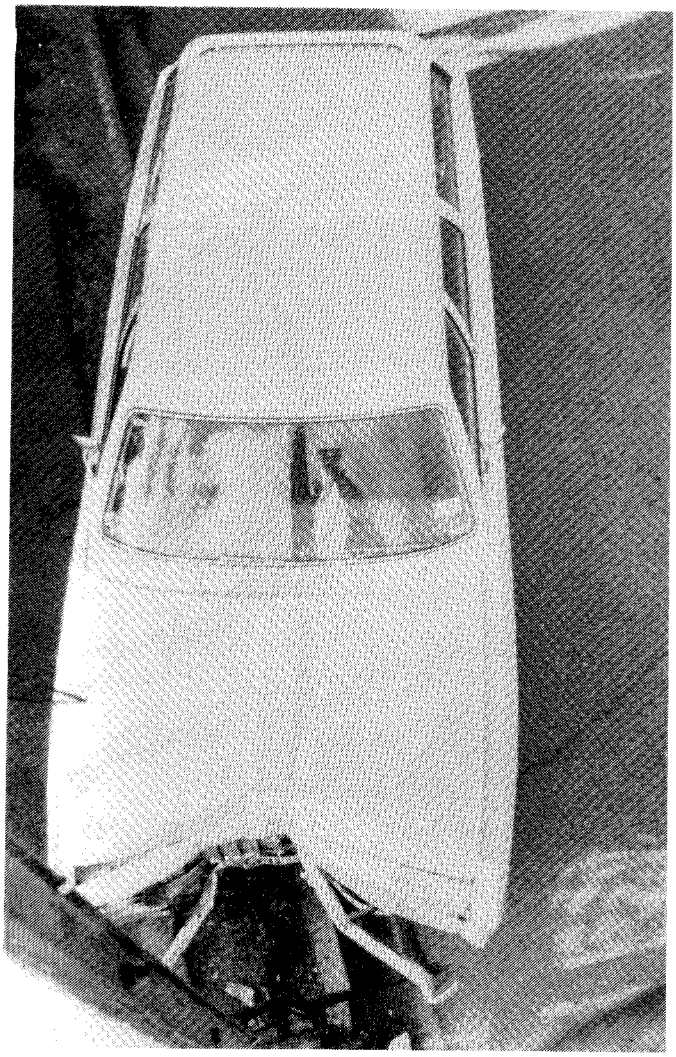


FIGURE 4.59:

Damage to front of car following collision with utility pole. (Accident 294, See Figure 4.60)

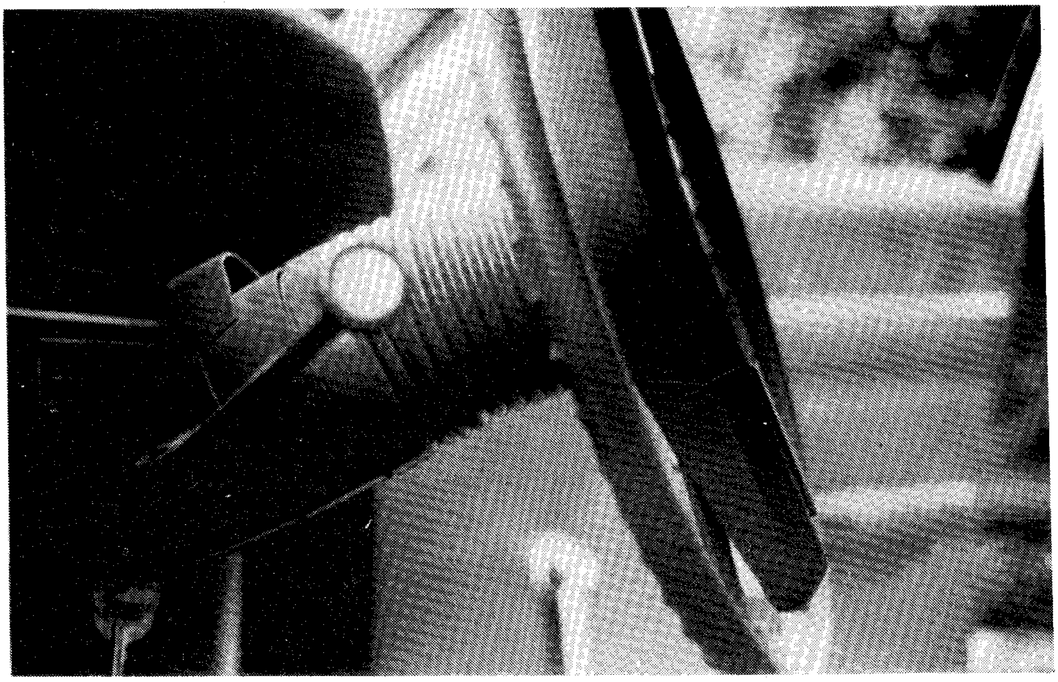


FIGURE 4.60: Deformation of steering wheel and energy-absorbing element following collision with utility pole. (Accident 294, See Figure 4.59)

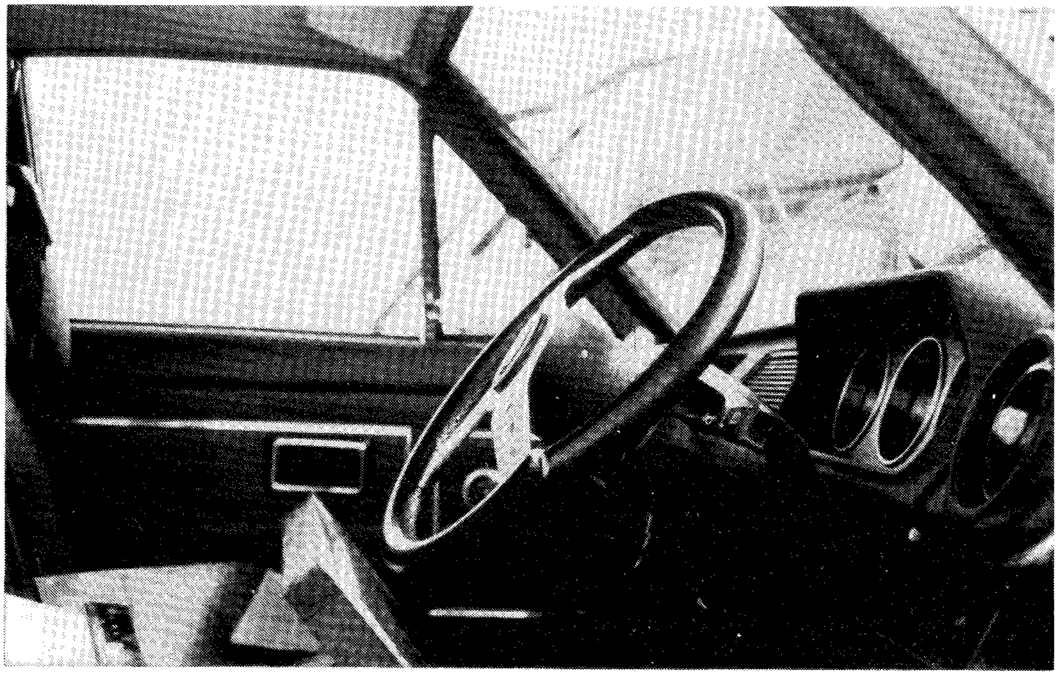


FIGURE 4.61: Steering column hub exposed by bending of spokes of non-standard steering wheel. (Accident 017.)

fractures of the sternum (Accidents 016 and 241), one driver received rib fractures (Accident 019) and two others fractured clavicles (094 and 096) from the webbing of the seat belt. This does not mean that these last five drivers would have not been as severely injured had they not been wearing a seat belt. Rather it is probable that the injury experience of some of them would have been similar to that of the driver of the car shown in Figure 4.46 had they not been restrained.

Facial Injuries

Almost half (47.8 per cent) of the facial injuries sustained by car drivers were caused by hitting the rim of the steering wheel. The next most common cause was the windscreen, with 13.4 per cent of the total of 67 injuries. With the windscreen, the steering wheel rim was the most common cause of head injuries (other than to the face) for car drivers, each accounting for 17.1 per cent of the total.

The association between the frequency of injury to the head or face of the driver and belt wearing and compliance of the car with ADR 10A or 10B is shown in Table 4.46. As noted in the discussion of Table 4.45, variations in impact and injury severity may account for some of the differences in relative frequency of injury. Nevertheless it seems likely that belt wearing may reduce the risk of sustaining an injury to the head or face from striking the steering wheel. (A similar conclusion that belt wearing may reduce the frequency of upper torso injury, is not reasonable because of the injuries caused by the belt. It is probable, however, that belt wearing does reduce the severity of injury to the upper torso, as noted above.) The apparent reduction in the incidence of head or facial injury in ADR 10A or 10B cars compared to the pre-ADR vehicles may, once again, largely be associated with changes in belt characteristics.

Figures 4.62 and 4.64 show two of the cases of facial injuries that were observed among those drivers who struck the rim of the wheel (the steering wheels are shown in Figures 4.63 and 4.65 respectively). The driver of the car in Accident 096 sustained a fracture of the frontal sinus as well as the laceration shown in Figure 4.63.

The rim of the steering wheel should be recognized as a head and face impact area and designed to minimise the severity of the impact and the associated injuries. Consideration might also be given to possible changes in the location or alignment of the wheel to reduce the frequency of such impacts.

Other Injuries

The other injuries caused by contact with the steering assembly in the crash were mostly to the arms and thighs. Knee injuries, from striking the lower part of the steering column, are discussed in Section 4.4.17.

4.4.11 ADR 11: INTERNAL SUN VISORS

The intention of this Australian Design Rule is to define standards for internal sun visors to reduce the injury potential of internal sun visors and the adjacent vehicle structure.

Effective date: 1 January, 1972.

The number of passenger cars and passenger car derivatives in the study that were subject to ADR 11 is listed in Table 4.47. There were nine cases, in eight cars, in which there was clear evidence that an occupant had struck an internal sunvisor and/or the header area during the crash and that this was more than a trivial impact. In two other cars the sunvisor was damaged but this could have occurred when the occupant was climbing out of the overturned car.

None of the nine persons involved in these contacts with a sunvisor or header area was wearing a seat belt. Consequently they often hit more than one object; the windscreen, rear vision mirror and A-pillar being the most common additional objects. This meant that it was often difficult to isolate the role played by the sunvisor in the prevention, or production, of injury. Furthermore, only one of the eight cars complied with ADR 11 (and in that car the driver's head hit the A-pillar after glancing off the sunvisor) and so in some of the other seven cars the sunvisor incorporated no energy-absorbing material at all.

TABLE 4.47: DISTRIBUTION OF VEHICLES SUBJECT TO ADR 11

Subject to ADR 11	128
Not subject to ADR 11	245
Unknown if subject to ADR 11	13
Total	386

FIGURE 4.62: Facial injuries from contact with the rim of the steering wheel shown in Figure 4.63. (Accident 096, See Figure 4.27)

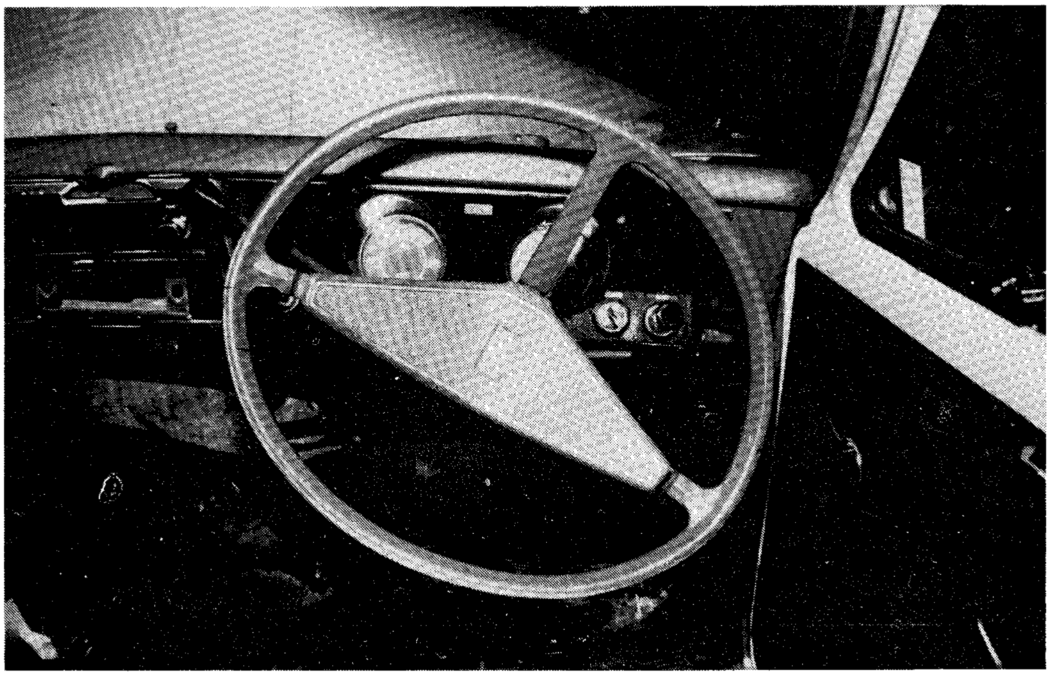


FIGURE 4.63: Steering wheel contacted by driver shown in Figure 4.62.

FIGURE 4.64:

Facial lacerations caused by striking the rim of the steering wheel shown in Figure 4.65.
(Accident 094, See Figure 4.30)

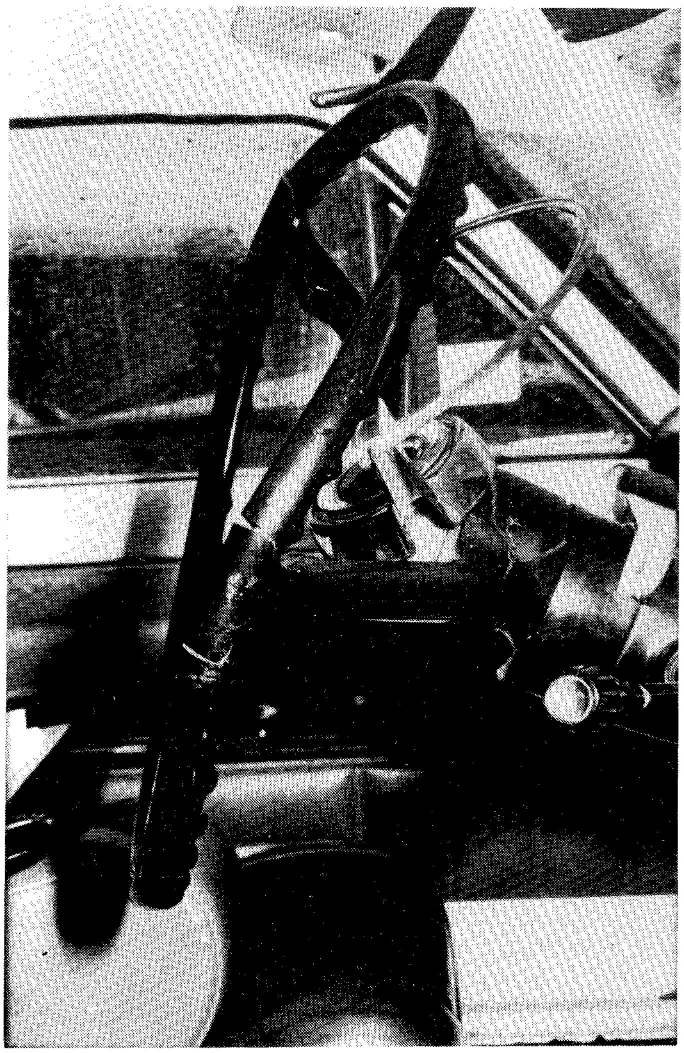


FIGURE 4.65:

Deformation of steering wheel following impact by driver's head and face (See Figure 4.64)

In Accident 192 the driver and front passenger of a 1957 Volkswagen Beetle both struck the header area. The driver's head contact was on the sunvisor, a plastic strip, and he sustained scalp lacerations. There was no visor fitted to the passenger's side. The passenger dented the pressed-steel header rail which has a shallow convex cross-section but he sustained only abrasions to the forehead, in marked contrast to the experience of a rear seat passenger in a 1967 HR Holden sedan in Accident 206. This person was thrown forwards over the bench-type front seat. She struck the driver's side sunvisor, which was in the up position (Figure 4.66) and received a laceration across the full width of her forehead as well as concussion (Figure 4.67). The severity of the injury may have been increased by the sharp edge of the sheet metal section of the header area immediately behind the point of contact with the sunvisor (Figure 4.68) but the direct cause of the laceration appears to have been the scalp "dragging" on the rod that forms the lateral pivot for the sun-visor. The windscreen of this car was not damaged. A similar mechanism of injury was observed in a 1964 EH Holden sedan (Accident 254) in which the driver struck the sunvisor (Figure 4.69).

While there is some doubt about the role played by the sharp edge of the header area section in the production of the injury shown in Figure 4.67, the evidence in Accident 076 was quite clear. Figure 4.70 shows two lacerations to the forehead of the driver of a 1970 Chrysler Valiant VF sedan. These lacerations match the end of the rear vision mirror and the sharp edge of the header section (the point of head contact is indicated by the tear in the head lining) as shown in Figure 4.71.

If a seat belt is worn it appears that contact with the front header area is unlikely in crashes in a metropolitan area. However, as shown in Table 4.22, it is not realistic to assume that all occupants will be wearing belts, even when the belts are available.

4.4.12 ADR 12: GLARE REDUCTION IN THE FIELD OF VIEW

The intention of this Australian Design Rule is to minimise the glare from certain unpainted metal surfaces in the view of the driver.

Effective date: 1 January, 1973.

The number of cars subject to ADR 12 is shown in Table 4.48. There was no case in which there was any indication that glare from unpainted metal surfaces had played a role in the causation of the accident.

TABLE 4.48: NUMBER OF CARS SUBJECT TO ADR 12

Subject to ADR 12	112
Not subject to ADR 12	262
Unknown if subject to ADR 12	12
Total	386

TABLE 4.49: NUMBER OF CARS SUBJECT TO ADR 14

Subject to ADR 14	127
Not subject to ADR 14	245
Not known if subject to ADR 14	14
Total	386

FIGURE 4.66:

Sunvisor (arrowed) struck by unrestrained rear seat occupant shown in Figure 4.67. Note deformation of back of front seat. (Accident 206.)

FIGURE 4.67: Sutured laceration across the upper forehead resulting from impact with sunvisor and header area. (Accident 206, See also Figures 4.66 and 4.68)

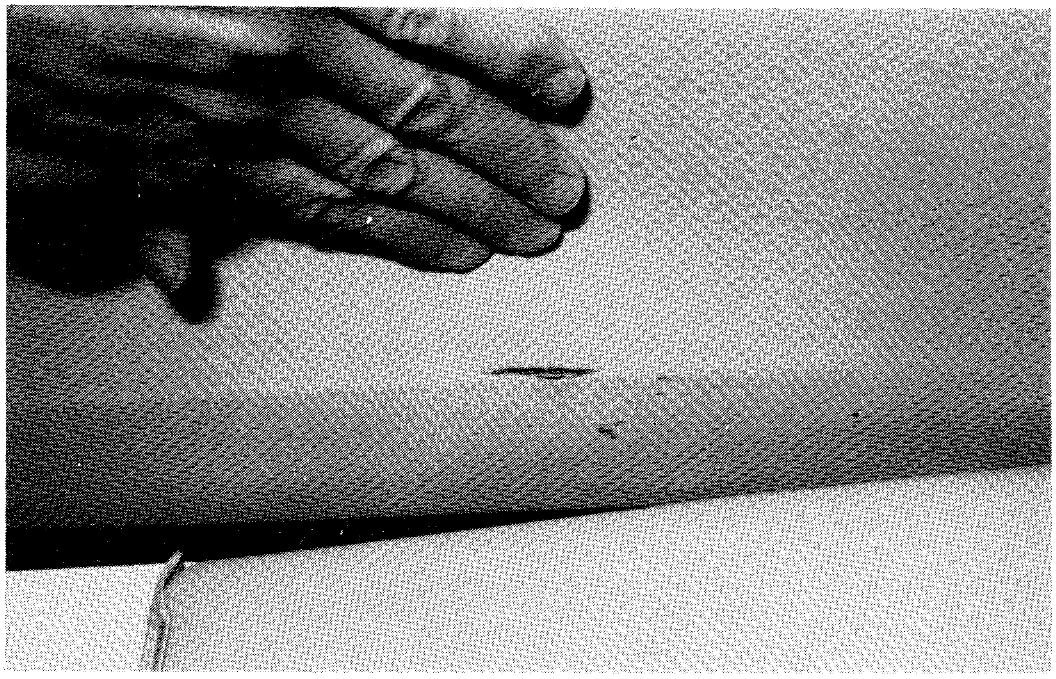


FIGURE 4.68: Tear in head-lining along edge of sheet metal section of header area that was struck by the rear seat passenger shown in Figure 4.67.

FIGURE 4.69:

Hair adhering to the leading edge of a sunvisor following impact by driver's head. (Accident 245, See also Figure 4.48)

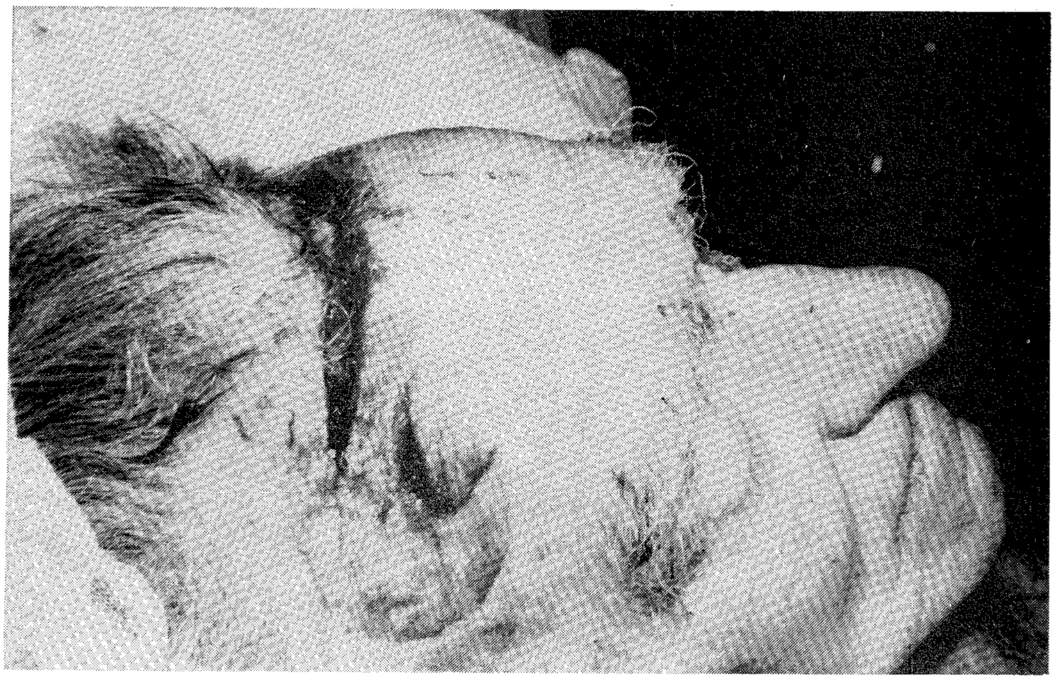


FIGURE 4.70: Lacerations to the forehead caused by the rear vision mirror and the edge of the sheet metal section forming the header area. (Accident 076, See also Figure 4.71)

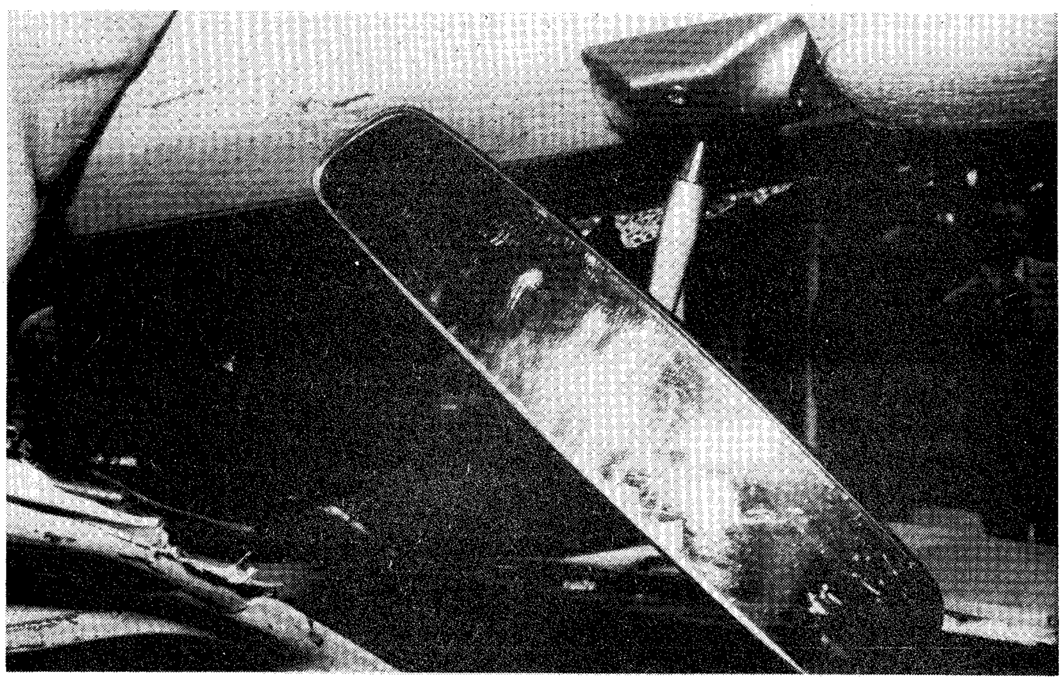


FIGURE 4.71: See Figure 4.70.

4.4.13: ADR 14: REAR VISION MIRRORS

The intention of this Australian Design Rule is to specify requirements for rear vision mirrors to provide the driver with a clear and reasonably unobstructed view to the rear.

Effective date: 1 January, 1972.

ADR 14 also specifies that internal rear vision mirrors must break away, deflect or collapse when loaded with a simulated occupant head contact.

The number of cars subject to ADR 14 is shown in Table 4.49.

Rearward Field of View

There were 12 accidents in which a car driver's rearward field of view was potentially a causal factor. In seven of these accidents a driver was attempting a U turn when the car was struck by an overtaking vehicle (016, 032, 044, 134, 192, 195 and 281). Two cars turned right, one to enter an off street parking area (255) and the other to start a three-point turn (212). Another car turned left from the second lane out from the kerb to enter a shopping centre parking area (Accident 248) and a car in Accident 105 turned right into the stem of a T-junction. These last four cars all collided with an overtaking vehicle. The final accident in this group of 12 involved a pedal cyclist who rode into a car door that was opened as he was about to pass the parked car (157).

From the information obtained by interviewing the drivers and from other sources it seems probable that the rearward field of view provided by the mirrors may have been a major factor in only two of these twelve accidents. The driver of a 1969 Austin 1800 sedan in Accident 016 said that she looked in the internal rear vision mirror before starting a U-turn. She did not see a 1961 Volkswagen sedan that subsequently crashed into the right side of her car. Her car was not fitted with an external rear vision mirror and the roadway was 17 metres wide, with no lane or centre line markings.

In accident 281 the driver of a taxi pulled away from the kerb having taken on a fare. He intended to make a U-turn through a gap in a raised median after crossing three lanes on a 13 metre wide one-way road. He said that he turned and looked back over his right shoulder and saw that the traffic behind him was stationary at a red traffic signal. He then moved off and checked his internal rear vision mirror before entering the lane adjacent to the median where he struck the side of an overtaking motorcycle that had oved off when the signal changed to green. The car, a 1974 XB Falcon four-door sedan, was fitted with an external rear vision mirror.

Accidents 016 and 281 both occurred in daylight, as did another six of the 12 accidents listed above. One other was at dusk and two at night, one of which involved a pedal cyclist who was riding without lights (Accident 157).

Five of the overtaking vehicles were motorcycles, which would have been harder to detect than a larger vehicle. In Accident 134 the driver of a 1962 EJ Holden sedan looked in the internal rear vision mirror and saw a truck approaching but far enough away to enable her to execute a U turn. She failed to see a motorcyclist who was travelling ahead of the truck.

Tests of static visual acuity were conducted on eight of the 12 drivers. Only one of the eight did not have 6:6 vision; he was the driver of the taxi in Accident 281 but his rating of 6:9 was not considered to have been a significant factor in his failure to detect the overtaking motorcycle.

With so few relevant cases it is not practicable to assess the value of ADR 14 in this respect. However it should be noted that the performance requirements for rear vision mirrors in ADR 14 are very nearly identical to those in the Society of Automotive Engineers Recommended Practice J834a of 1962 (revised 1967) and so it is unlikely that the introduction of ADR 14 changed existing practice with the exception that the provision of an external rear vision mirror became mandatory.

Occupant Contact with the Internal Rear Vision Mirror.

There was evidence of probable occupant contact with the internal rear vision mirror in 45 cars. In nine of these 45 cars the glass of the mirror was broken and in 13 cars the mirror was broken away from its mounting, the mounting arm itself broke or the mirror and mounting broke away. There were four cases, included in the above, in which the glass was broken and the mirror was also broken away from its mounting.

The determination of the injuries that resulted from these contacts with the rear vision mirror was made difficult by the fact that the occupant nearly always continued on to strike the windscreen or the header area. There were seven cases, however, in which it was reasonable to conclude that the rear vision mirror was the main cause of a specific injury. All of these injuries were minor lacerations, such as the smaller of the two lacerations shown in Figure 4.70, or contusions to the face. There were two additional cases in which an occupant who struck the rear vision mirror was concussed. Although there was no evidence of contact with another object it is possible that the concussion was caused by a secondary impact rather than by striking the rear vision mirror.

TABLE 4.50: BREAKAWAY OF INTERNAL REAR VISION MIRROR ASSEMBLY WHEN STRUCK BY AN OCCUPANT BY COMPLIANCE WITH ADR 14

Compliance with ADR 14	Breakaway of Mirror Assembly Yes	No	Total
No	4	25	29
Yes	10	5	15
Not known	-	1	1
Total	14	31	45

In five of the nine cases in which a rear vision mirror was, or may have been, associated with an injury to an occupant the mirror was broken away from the mounting. The mirror glass was broken in five of these nine cases (in two of which the mirror remained in place).

The mirror assembly was much more likely to break away when struck in an ADR 14 car than in an earlier vehicle (Table 4.50). Even so there were three cases in which an ADR 14 mirror assembly appeared not to perform as intended by the requirements of the Design Rule. Figure 4.72 shows the mounting arm of the internal rear vision mirror of a 1975 Toyota Corolla from which the mirror has separated leaving the arm exposed. This car struck a parked vehicle and then overturned (Accident 074). The driver, who was wearing a seat belt, sustained a minor facial laceration from striking the mirror and breaking the glass (Figure 4.73).

The other two cases both involved 1973 XA Ford falcons, one in collision with another car (Accident 104) and the other with a utility pole (Accident 108). The mirror assemblies are shown in Figures 4.74 and 4.75, where it can be seen that the glass was broken but the assembly was not dislodged from its mounting on the windscreen. Neither of the occupants who struck these mirrors was wearing a seat belt. One sustained minor facial lacerations (Accident 104) and the other a sprained neck (possibly from also striking the windscreen).

A more general assessment of the efficacy of ADR 14 in reducing the frequency of injury from contact with the internal rear vision mirror was not practicable with the number of cases available and the need to control for the confounding effects of other factors, such as differences in belt wearing rates between ADR 14 and earlier cars. As would be expected, belt use appeared to reduce the risk of striking the mirror.

Contact with the External Rear Vision Mirror

All of the 127 cars that complied with ADR 14 were fitted with an external rear vision mirror on the driver's side compared to only two-thirds (162 out of 245) of the pre-ADR 14 cars.

One exterior mirror, on a 1974 XB Falcon, struck a pedestrian (Accident 026). There was a fabric deposit on the mirror housing that was the same colour as the pedestrian's dress and bruising of her upper right thigh.

Two motorcyclists struck cars in the region of the external rear vision mirror and in both cases the mirror assembly was torn away from the bodywork (Accidents 219 and 255). It is probable that the motorcycle, rather than the rider, struck the mirror in each case.

No other accidents occurred in which a pedestrian, pedal cyclist or motorcyclist came into contact with an external rear vision mirror of a car.

4.4.14 ADR 15: DEMISTING OF WINDSCREEN

The intention of this Australian Design Rule is to define standards for equipment to maintain windscreens clear of mist so that drivers' forward vision is not obscured.

Effective date: 1 January, 1971.

The number of cars in the study that complied with ADR 15 is shown in Table 4.51. The transient nature of windscreen misting makes it difficult to obtain the evidence necessary to make a reliable evaluation of the need for or performance of windscreen demisting systems. Doors are usually opened, and often left open, soon after the accident and the passenger compartment may

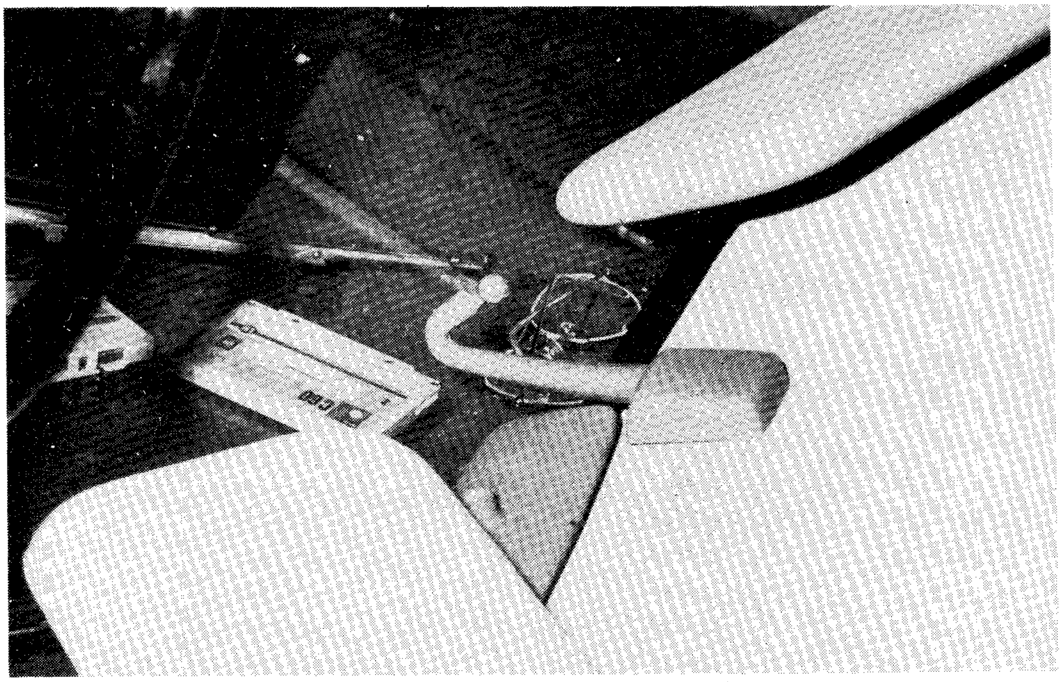


FIGURE 4.72: Mirror support arm still in position after mirror housing separated at the swivel joint (car is upside-down). (Accident 074, See Figure 4.73)

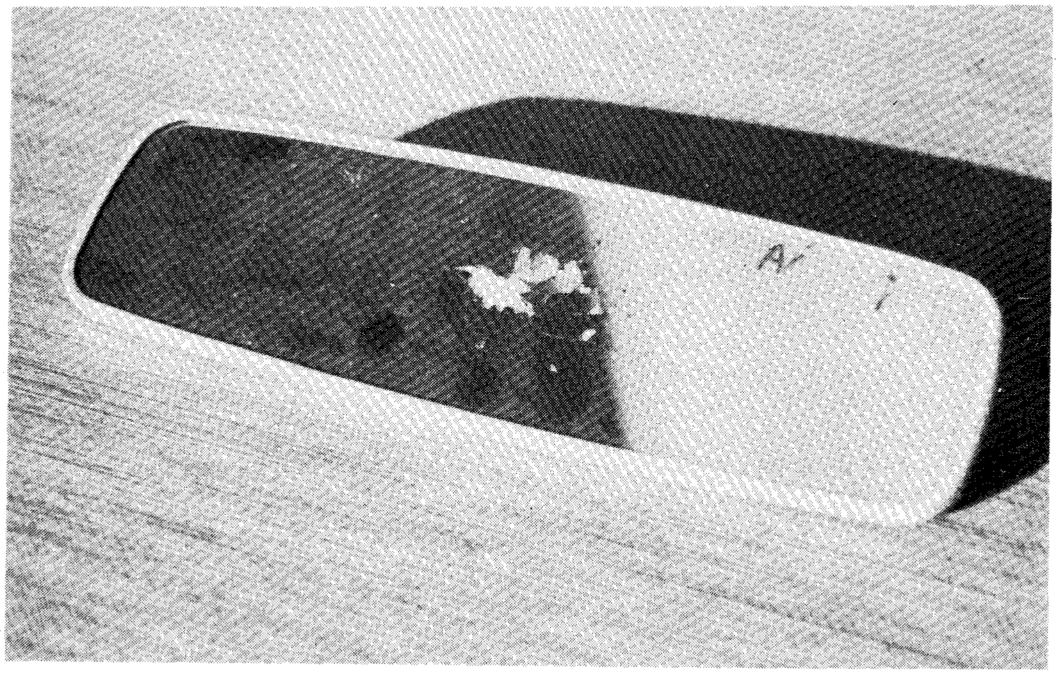


FIGURE 4.73: Damage to rear vision mirror glass (See Figure 4.72)

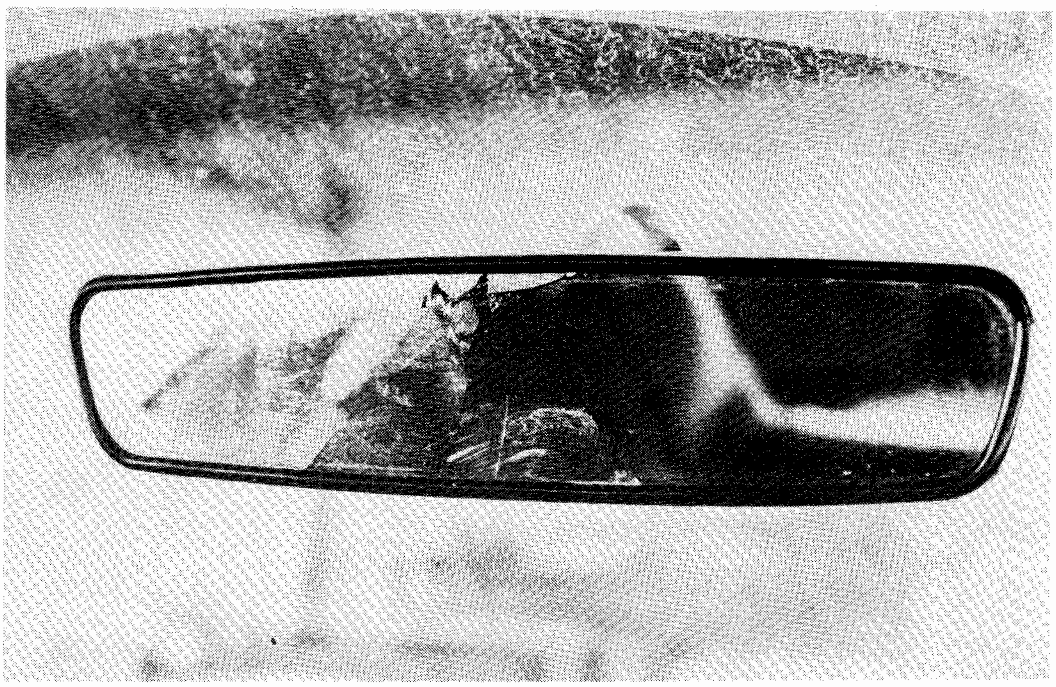


FIGURE 4.74: Damage to mirror due to head contact with rear vision mirror which did not break away (Accident 104)

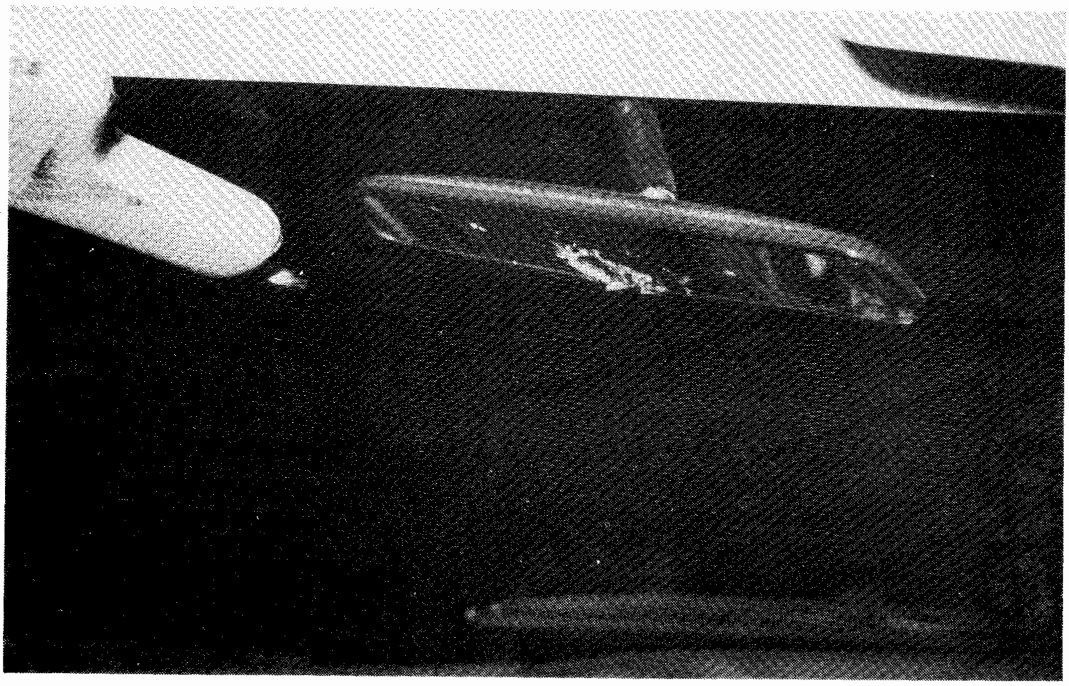


FIGURE 4.75: Damage to rear vision mirror following impact by occupant (Accident 108)

TABLE 4.51: NUMBER OF CARS COMPLYING WITH ADR 15

ADR 15 Compliance	Number of Cars
Yes	141
No	230
Not known	15
Total	386

also be ventilated by other means, such as broken side windows or even the windscreen itself. Furthermore the climatic conditions during the year in which the study was conducted were rarely conducive to misting of the windscreen. However the windscreens of three cars were found to be partially obscured by misting when the research team arrived at the scenes of the accidents. The driver of another car said that the windscreen was misted up at the time of the accident, the condensation clearing before the arrival of the research team. Poor visibility was thought to have contributed to two of these four accidents.

In Accident 069 the driver of a 1974 Triumph 2.5 sedan failed to see an oncoming pedal cyclist in heavy rain at night. The windscreen demister was not turned on and the screen was misted up. Although the misting made the driver's task more difficult the heavy rain was likely to have been a more important causal factor.

The driver who reported that the windscreen of his car, a 1967 VC Chrysler Valiant, was misted up said that he wiped that part of the screen immediately ahead of him as he approached a signalised intersection (Accident 110). He saw the amber signal appear and then the red but chose not to stop. He claimed not to have seen another car entering the intersection on his right, possibly because it would have to be viewed through the misted part of the windscreen. However even if he had seen this other car he may not have been able to have avoided the collision. His own car was not fitted with a demister.

4.4.15 ADR 16: WINDSCREEN WIPERS AND WASHERS

The intention of this Australian Design Rule is to define requirements for windscreen wipers and washers to ensure reasonable visibility through the windscreen in inclement weather.

Effective date: 1 January, 1973.

Table 4.52 shows the number of cars that complied with ADR 16. Only 13 of the 304 accidents studied occurred when it was raining and in six of these 13 the rain was not heavy. A further 13 accidents took place on wet roads.

There were three accidents, all at night, in which heavy rain may have made it difficult to see through the windscreen and in which this may have been relevant to the causation of the collision. One of these accidents has been mentioned previously in Section 4.4.14; it was a collision between a car and a pedal cycle (Accident 069). In Accident 144 a 1973 Datsun 1200 coupe struck a pedestrian who was standing in the centre of the road in a poorly lit area about 150 metres beyond a brightly-illuminated major intersection.

TABLE 4.52: NUMBER OF CARS COMPLYING WITH ADR 16

ADR 16 Compliance	Number of Cars
Yes	97
No	277
Not known	12
Total	386

Not only did the driver not see the pedestrian but he was unwittingly on a collision course because he could not see the lane markings on the wet road surface. In the third accident (179) the driver of a 1960 FB Holden sedan was keeping to the left in the kerb lane to allow room for other cars travelling in the same direction in the lane on her right. She did not see a row of parked cars and crashed into the back of the one closest to her. She did mention not being able to see the lane marking because of the heavy rain but also recalled being distracted by something off the road on her right immediately before the impact.

These cases provide an obviously inadequate basis for any evaluation of the effectiveness of ADR 16 with respect to the performance of windscreen wipers.

There were no cases in which it was thought that a driver had difficulty in seeing through the windscreen because of road grime on the outer surface and so no comment can be made on the requirement in this ADR for cars to be equipped with windscreen washers.

4.4.16 ADR 18: LOCATION AND VISIBILITY OF INSTRUMENTS

The intention of this Australian Design Rule is to specify the general area for the location of essential visual indicators to facilitate observation by the driver.

Effective date: 1 January, 1973.

The number of cars that complied with ADR 18 is shown in Table 4.53. There was one case in which a driver said that he had been reading an instrument (the speedometer) immediately before the accident (256). He was travelling in the kerb lane with another car alongside him in the adjacent lane on his right. When he looked up from reading the speedometer he saw that a pedestrian, who would have been partically hidden from his view by the other car, had walked into his path and he was unable to avoid the collision.

The driver was short-sighted but this was corrected by spectacles that he was wearing at the time. The accident occurred in daylight.

Although no such case could be identified in the study, the possible interaction between reading the speedometer and alcohol intoxication, as discussed in general in relation to secondary activities in Section 3.2.1, may merit review of ADR 18 with emphasis on the performance of the intoxicated driver.

4.4.17 ADR 20: SAFETY RIMS

The intention of this Australian Design Rule is to specify wheel rims that will retain a deflated tyre in the event of a rapid loss of inflation pressure.

Effective date: 1 July, 1970

The number of cars that complied with ADR 20 is shown in Table 4.54. There were no cases in which a tyre deflated rapidly before the accident. The deflations that did occur were all a consequence of damage sustained in a collision and in no case did this appear to affect the severity of the crash.

4.4.18 ADR 21: INSTRUMENT PANELS

The intention of this Australian Design Rule is to define standards for instrument panels to reduce their injury potential to occupants on impact.

Effective date: 1 January, 1973

The distribution of cars by compliance with ADR 21 is shown in Table 4.55. The instrument panel was the leading cause of injury to car occupants (Table 4.9). It was also the leading cause of injuries that were rated as being severe or worse (Table 4.10). ADR 21 contains a performance specification for simulated head impacts with the upper surface of the instrument panel and for the latching

TABLE 4.53: NUMBER OF CARS COMPLYING WITH ADR 18

ADR 18 Compliance	Number of Cars
Yes	97
No	277
Not known	12
Total	386

TABLE 4.54: NUMBER OF CARS COMPLYING WITH ADR 20

ADR 20 Compliance	Number of Cars
Yes	157
No	216
Not known	13
Total	386

TABLE 4.55: COMPLIANCE WITH ADR 21

ADR 21 Compliance	Number of Cars
Yes	110
No	263
Not known	13
Total	386

TABLE 4.56: FREQUENCY AND SEVERITY OF INJURY BY SECTION OF INSTRUMENT PANEL STRUCK BY THE OCCUPANT[1]

Section of Instrument Panel	Frequency of Injury	
	All Injuries	Severe or worse injuries
Upper	14%	56%
Middle	24%	-
Lower	62%	44%
Total (%)	100%	100%
(No. of cases)	118	9

Note: [1] In some cases the instrument panel was not the only object involved in the causation of the injury.

system on doors on interior compartments such as the glovebox. There are no requirements for the lower part of the instrument panel if it is not the rearmost surface of the panel (and therefore unlikely to be struck by the head of an occupant).

The frequency of injury associated with striking the instrument panel is listed for various sections of the panel and for associated components in Table 4.8 and, for severe or worse injuries only, in Table 4.9. The information contained in those Tables is summarised in Table 4.56. Although the upper surface of the instrument panel is associated with fewer injuries than the other sections the injuries that are caused in this way are more severe, largely because they often involve the head and face.

Upper Surface of the Instrument Panel

There was no case in which there was evidence that a restrained occupant struck the upper surface of the instrument panel in a car that complied with ADR 21 (but there was no centre front passenger wearing a lap belt in these cars). In earlier model cars two persons who were wearing lap-sash belts struck the upper surface of the panel but in both cases (Accidents 029 and 096) the belt failed to provide adequate restraint, as described in Section 4.4.4. The left front passenger in Accident 096 sustained severe facial injuries on striking the padded instrument panel shown in Figure 4.76. In Accident 029 the driver's head struck the sill of the window on the left side of the car as well as the instrument panel. Apart from these two cases no person who was wearing a lap-sash seat belt came into contact with the upper surface of the instrument panel.

There was only one accident (120) in which the centre front seating position was occupied by an occupant who was wearing a lap belt. The belt did not prevent a facial impact with the padded upper surface of the instrument panel (of the type shown in Figure 4.76) that resulted in concussion and a lacerated chin. There was no corresponding mark on the padding of the instrument panel of the car (a 1969 HT Holden sedan) when it was examined two days after the accident (having been rapidly removed from the scene of the crash).

ADR 21 is based on the United States Federal Motor Vehicle Safety Standard No. 201 that assumes that only laminated glass is used for windscreens and that the area of the upper surface of the instrument panel at the base of the screen is therefore unlikely to be struck by the head or face of an occupant of the vehicle. Toughened glass windscreens, which are more common in Australia, do not prevent the head from striking that part of the panel because the glass shatters into small fragments when struck and provides no further resistance to the forward movement of the occupant. This can result in severe head and facial impacts with that part of the upper instrument panel at the base of the windscreen, as discussed in Section 4.4.8 (see also Figure 4.34). Consequently it is recommended that this aspect of the requirements for ADR 21 be reviewed.

There were some cases in which an unrestrained occupant shattered the windscreen and continued to move forwards, striking the upper instrument panel with the chest. This happened to the left front passenger of a 1966 HD Holden panel van when it hit a utility pole (Accident 051, Figure 4.46). He sustained severe rib fractures resulting in a flail chest. By comparison, the left front passenger in a 1972 Chrysler VH Valiant Charger received no chest injury in an impact that severely deformed the upper surface of the instrument panel (Figure 4.77). This car predated the introduction of ADR 21 by six months but no changes appear to have been made to the instrument panel in later models for which ADR 21 compliance was claimed.

Middle Section of the Instrument Panel

No severe injuries were caused by contact with the middle section of the instrument panel. Those injuries that did occur were mainly to the knees and hands.

There were relatively few (16) cases in which a glovebox door came open in the crash. Possibly because of this small number of cases no association could be detected between ADR 21 compliance and the frequency of latch release. In five of the 16 cases we could not be certain that the door of the glovebox had not been opened by someone after the accident had occurred but this was thought to have been unlikely. There was one other case in which a home-made plywood door, covering an otherwise open glovebox, came open. It is not considered further in this Section.

Two of the glovebox doors came open because the instrument panel area was severely deformed in the collision (see, for example, Figure 4.78). In two other cases the area adjacent to the glovebox was damaged by an occupant being thrown against it (Figures 4.77, 4.79).

Eight of the glovebox doors that opened were not struck by an occupant at any stage, six others may have been hit and in the remaining two cases there was clear evidence that an occupant had struck the door before it came open. Only one of these contacts resulted in injury, an abraded knee (Figure 4.80). The fact that the glovebox door came open did not aggravate the severity of the injury in this instance.

Lower Section of the Instrument Panel

There were 84 occupants who struck the

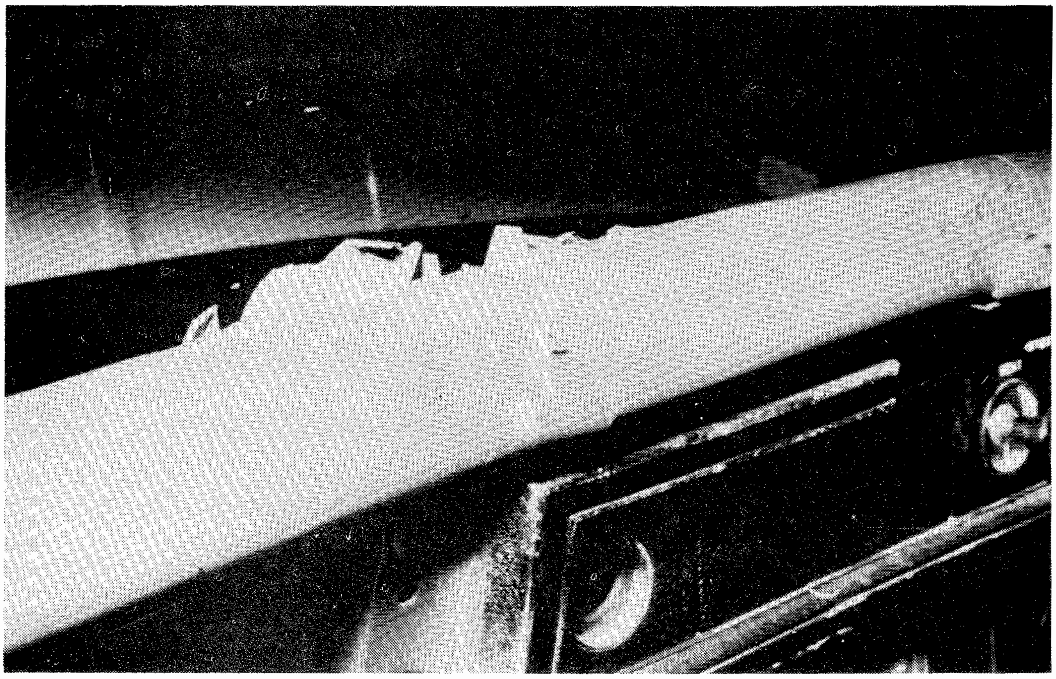


FIGURE 4.76: Damage to padding of instrument panel of a 1969 HT Holden station wagon caused by face of left front passenger (Accident 096, see also Figures 4.27 et seq.)

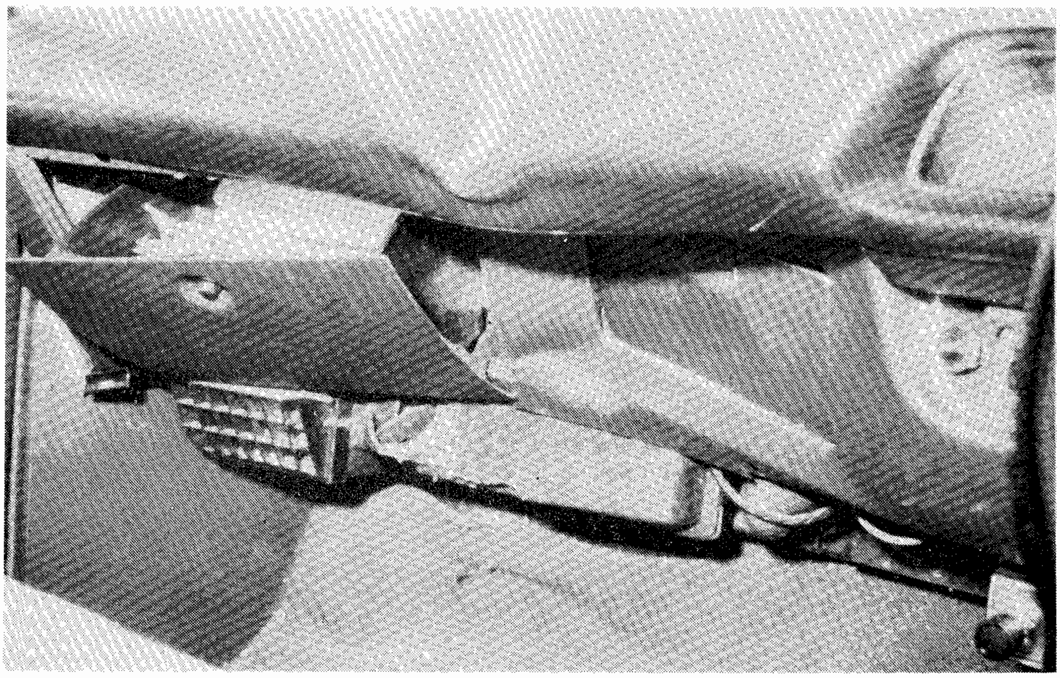


FIGURE 4.77: Damage to instrument panel caused by unrestrained occupant being thrown against it. Door of glove-box has come open. (Accident 232, 1972 Chrysler VH Valiant Charger)

FIGURE 4.78: Door of glovebox hanging open after severe deformation of the instrument panel when car was struck on the left side (Accident 124, 1974 Mazda 929 coupe. See also Figures 4.37 et seq.)

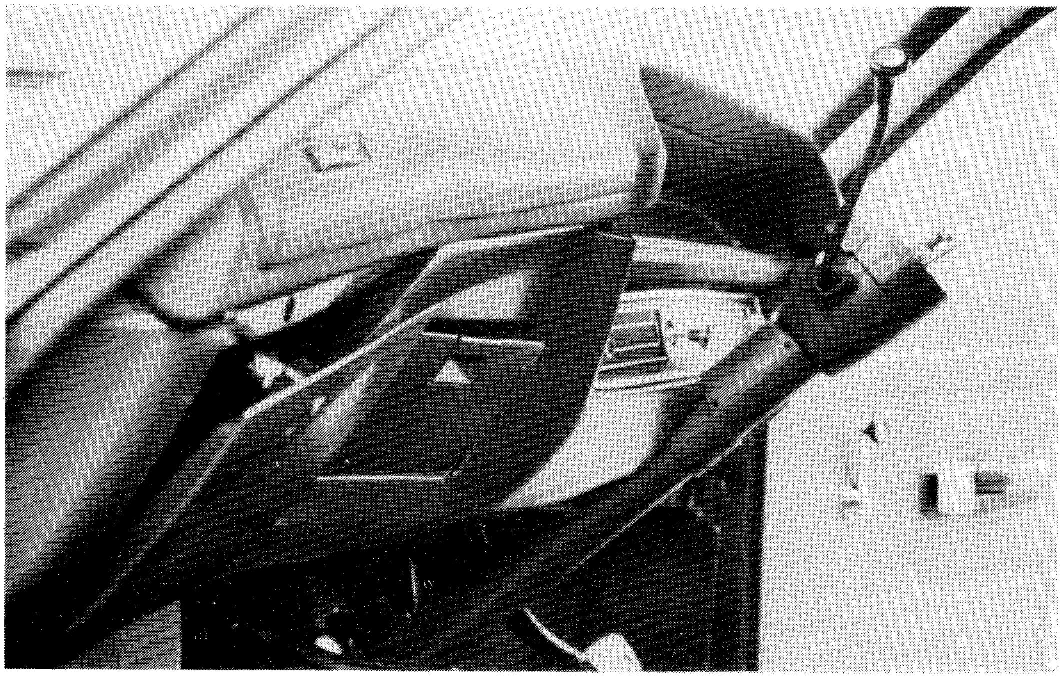


FIGURE 4.79: Damage to instrument panel of a 1975 Chrysler VJ sedan caused by unrestrained occupant, who was not injured. Note opened door of glovebox. (Accident 057, see also Figures 4.56 et seq. and 4.90)

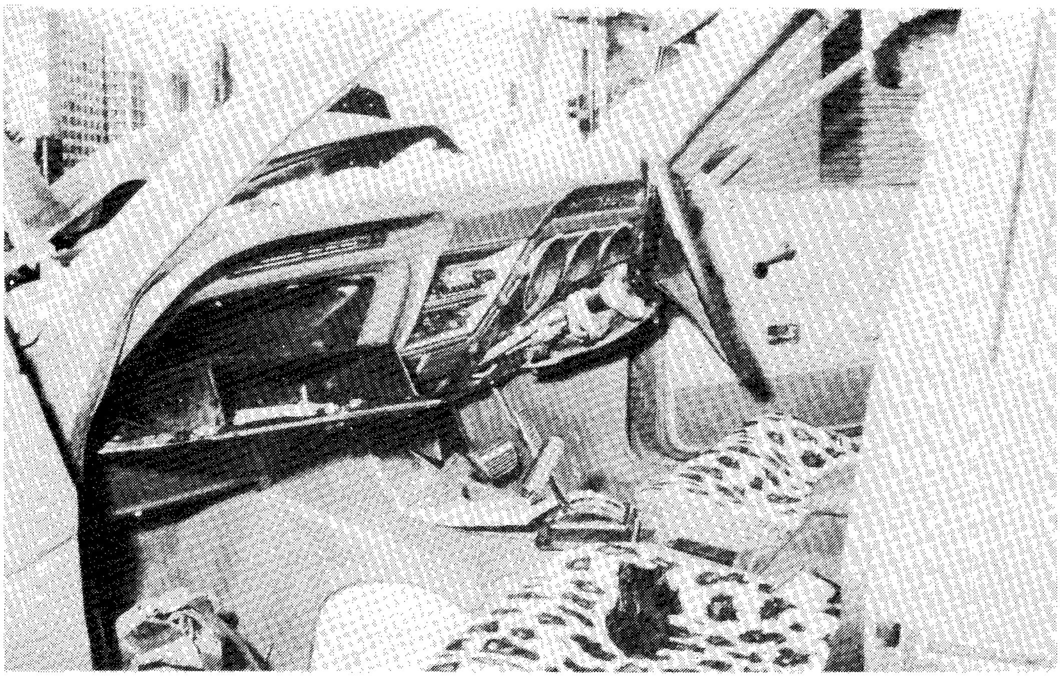


FIGURE 4.80: Glovebox door open following impact by knee of unrestrained front passenger. (Accident 259, 1973 TC Ford Cortina, see Figures 4.83 and 4.52)

FIGURE 4.81: Damage resulting from a head-on collision (Accident 245, see Figures 4.82 and 4.48 et seq.)

lower section of the instrument panel and 56 of them had one or both knees injured. Tables 4.57 and 4.58 show the incidence and severity of these knee injuries by ADR 21 compliance (even though, as noted above, the Rule does not relate directly to the lower section of the instrument panel) and belt use by the affected occupant. The information contained in these two Tables should not be taken as an indication that knee contacts with the lower part of the instrument panel are either less common or more severe in ADR 21 cars than in pre-ADR 21 cars because in many cases it was more difficult to detect a non-injurious knee contact in the later model cars.

The data on belt usage in Tables 4.57 and 4.58 do not permit conclusions to be drawn about the value of seat belts in preventing such contacts but they do show that belt-wearing cannot be relied upon to prevent the knees from being injured in this way. However the fracture case listed in the "belt worn" row of Table 4.58 occurred in a 1964 EH Holden sedan (Figures 4.81 and 4.82) in which the driver was wearing a very loosely adjusted static belt. His right patella was fractured. An almost identical case involving the same make and model of car was recorded in the report on the first Adelaide in-depth study (Robertson, McLean and Ryan, 1966, Figures 11.13 and 11.14). The other two cases listed under "Fracture" in Table 4.58 were also fractures of the patella sustained by drivers in early-model cars (a 1958 FC Holden in Accident 084 and a 1957 Vauxhall Velox in Accident 290).

Components Below the Instrument Panel

Twenty drivers injured their knees by striking them on the steering column or on associated hardware. These injuries were mostly minor contusions and abrasions but some of them would not have occurred had not the plastic housing around the column shattered on impact by the knee (eg: Figures 4.83 and 4.84). The retaining bolt for the upper mounting bracket on the column also caused knee injuries. For example, those shown in Figure 4.85 were sustained by an otherwise uninjured driver who was wearing a seat belt in the car shown in Figure 4.87.

There were 26 cases in which an occupant struck an accessory radio or tape-player that was mounted below the instrument panel. These contacts again were with the knees and typically resulted in minor lacerations, abrasions and contusions. As would be expected, the exposed location of the units that were mounted under the instrument panel rendered them much more likely to be struck than were the units mounted in the panel (see Table 4.59), the latter units more often being hit by the occupant's hands. Because most of these injuries were relatively minor not all of them are listed in Table 4.8. That Table is based on the Crash Injury data code in which priority was assigned to the more severe injuries in cases of multiple injuries.

Twenty-six cars had been fitted with auxiliary instruments or warning lights below the instrument panel. Six occupants struck their knees on these accessories, two of them sustained minor abrasions and one a severe laceration (Figures 4.88 and 4.89).

Even original equipment items mounted on the firewall under the instrument panel can be struck by an occupant. Figure 4.90 shows the result of such an impact on a heater duct of a 1975 VJ Valiant sedan (shown also in Figure 4.79). The housing of the duct has broken away exposing sharp-edged steel vanes.

Summary

The requirements for ADR 21 should be reviewed to allow for the non-retentive properties of toughened glass windscreens. Although most of the knee injuries caused by striking the lower section of the instrument panel and objects beneath the panel were relatively minor it may be possible to extend ADR 21 to ensure that the frequency of such injuries is greatly reduced.

4.4.19 ADR 22 AND 22A: HEAD RESTRAINTS

The intention of this Australian Design Rule is to define standards for the construction of head restraints so as to limit the severity of injury in the event of rear-end impacts (ADR 22) and to ensure that the head restraints cannot be adjusted too low (ADR 22A).

Effective date:
ADR 22: 1 January, 1972
ADR 22A: 1 January, 1975

The distribution of cars by compliance with ADR 22 and 22A is shown in Table 4.60.

Head Restraints in Rear Impacts

There were 17 accidents in which one or more cars were struck from the rear. In three of these accidents two cars sustained rear impacts and there was a front seat passenger as well as the driver in five of the cars. Thus there were 20 cars, containing a total of 25 front seat occupants, that were involved in impacts in which the requirements of ADR 22 and ADR 22A could have been relevant.

Table 4.61 presents a simple comparison of the incidence of neck injury by the presence or absence of a head restraint. One driver is omitted from this comparison because he sustained a severe head injury when his car, after being hit from the rear,

TABLE 4.57: INCIDENCE AND SEVERITY OF KNEE INJURIES FROM STRIKING THE LOWER SECTION OF THE INSTRUMENT PANEL BY BELT USAGE: ADR 21 CARS

Belt Usage	Knee Injuries[1] from Lower Instrument Panel Contact			
	No Injury	Minor/Moderate Injury	Fracture	Total
Belt worn	1	4	-	5
Belt not worn	-	3	-	3
Belt usage not known	-	3	-	3
Total	1	10	-	11

Note: [1] Numbers relate to occupants with one or both knees injured in this way. The more severe injury is listed if severity differs for two injuries to the one occupant.

TABLE 4.58: INCIDENCE AND SEVERITY OF KNEE INJURIES FROM STRIKING THE LOWER SECTION OF THE INSTRUMENT PANEL BY BELT USAGE: PRE-ADR 21 CARS

Belt Usage	Knee Injuries[1] from Lower Instrument Panel Contact			
	No Injury	Minor/Moderate Injury	Fracture	Total
Belt worn	5	15	1	21
Belt not worn	12	22	2	36
Belt usage not known	10	6	-	16
Total	27	43	3	73

Note: [1] See note to Table 4.57.

TABLE 4.59: RADIOS AND TAPE PLAYERS: FREQUENCY OF OCCUPANT CONTACT AND INJURY

Location of Radio or Tape Player	Number Fitted	Occupant Contact	Injury due to Contact
In instrument panel	235	5	3
Below panel	85	26	10
Total	320	31	13

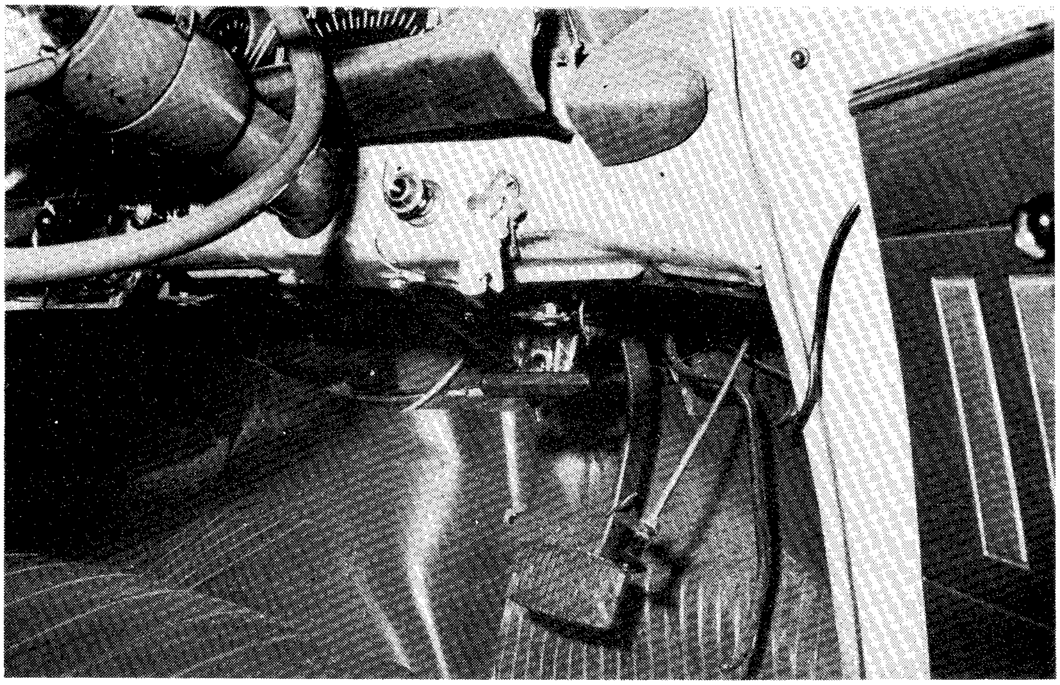


FIGURE 4.82: Dent in instrument panel below ignition key was caused by driver's right knee (Accident 245, see also Figure 4.81)

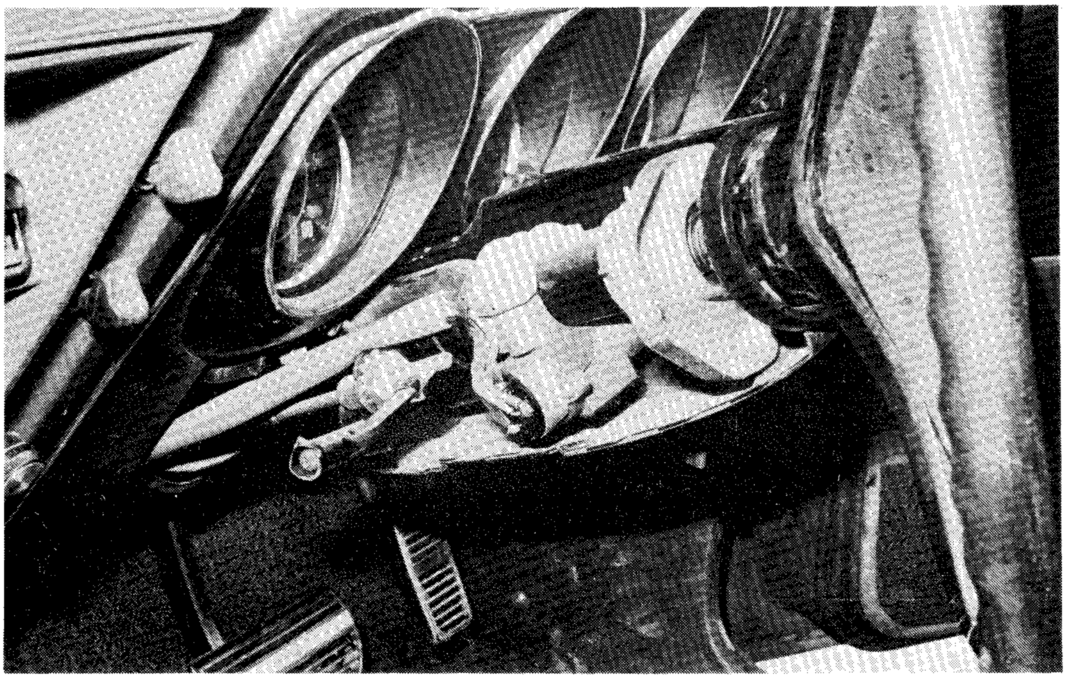


FIGURE 4.83: Plastic housing around steering column shattered by impact by driver's knee. (Accident 259, see also Figure 4.80)

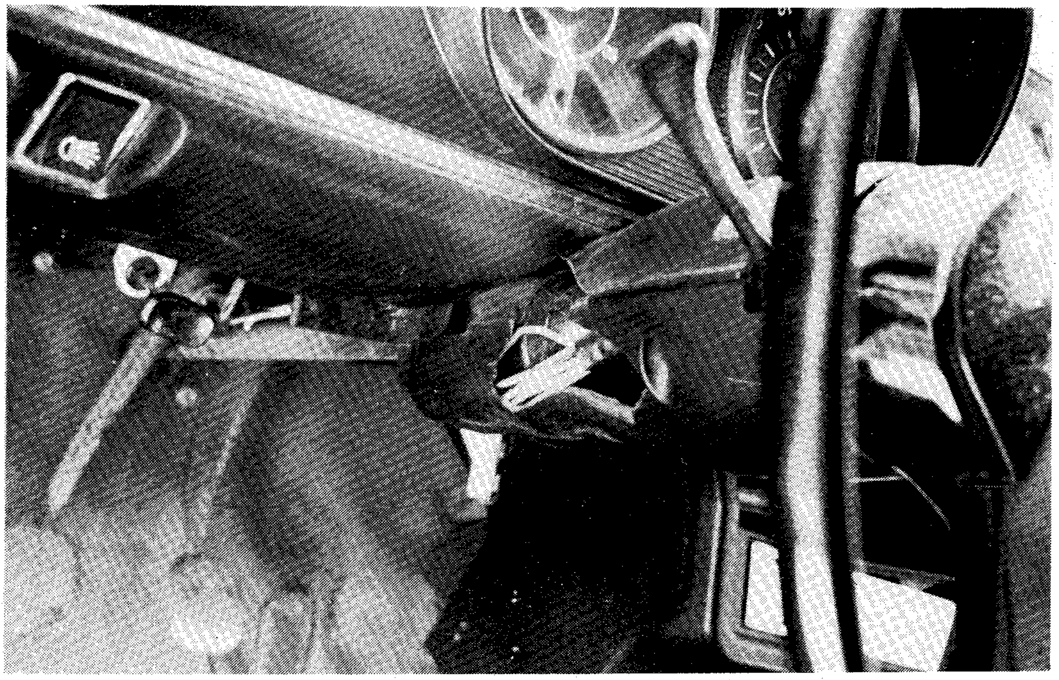


FIGURE 4.84: Damage to plastic housing around steering column from impact by driver's knee. (1970 Fiat 125S sedan, Accident 008)

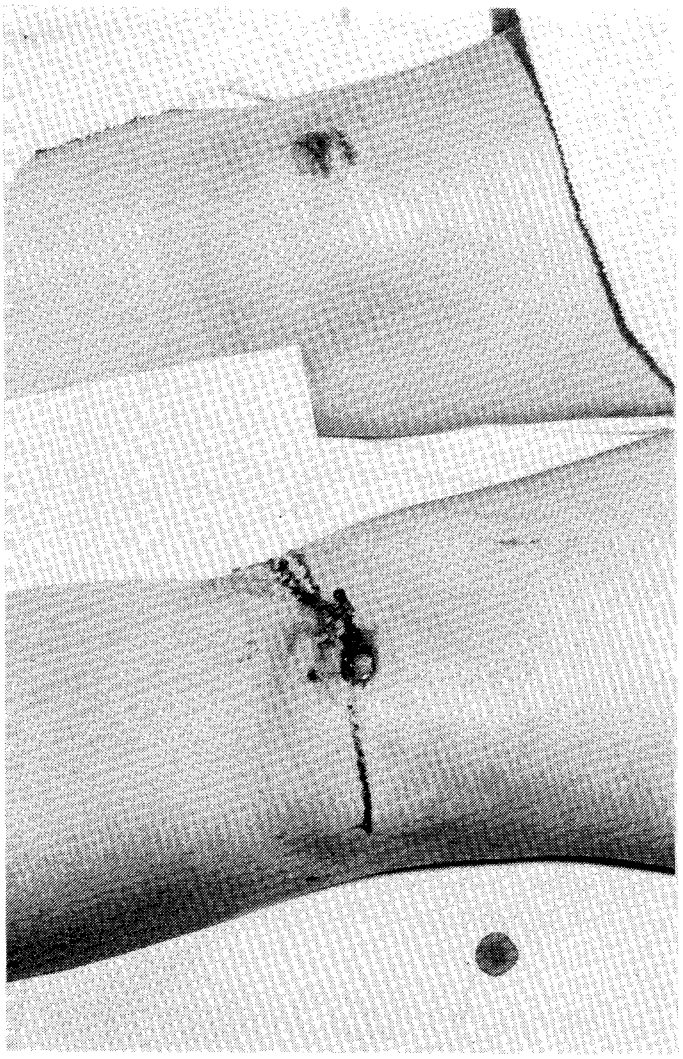


FIGURE 4.85:

Injury to left (lower) knee was caused by contact with the head of the bolt retaining the steering column bracket shown in Figure 4.86. (See also Figure 4.87)

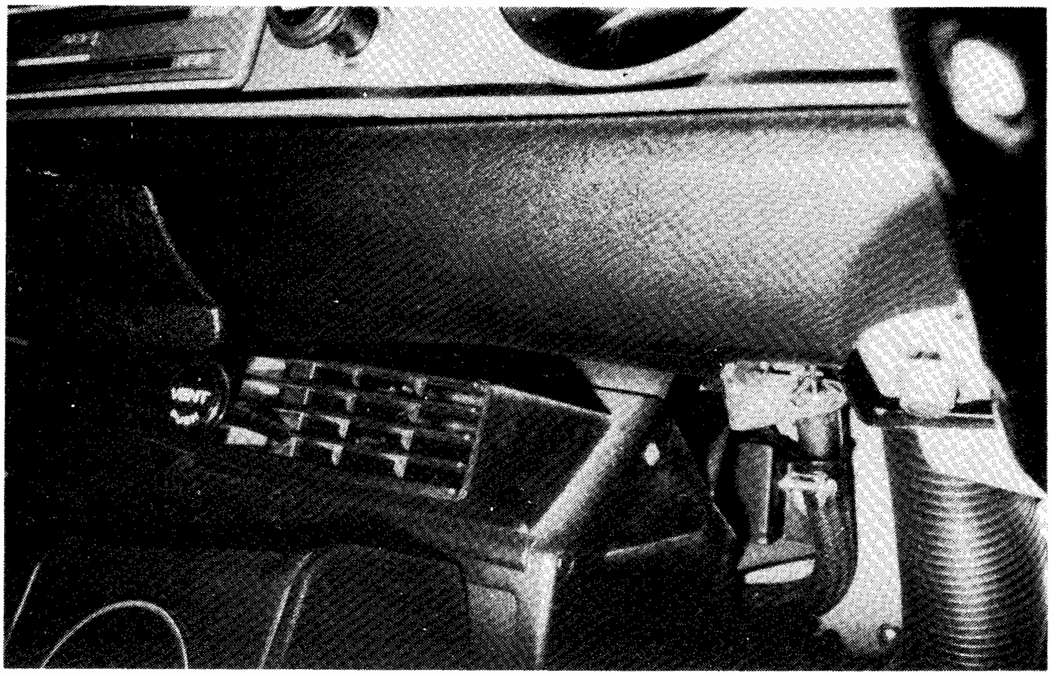


FIGURE 4.86: Steering column bracket retaining bolt (far right) referred to in caption to Figure 4.85. (See also Figure 4.87)

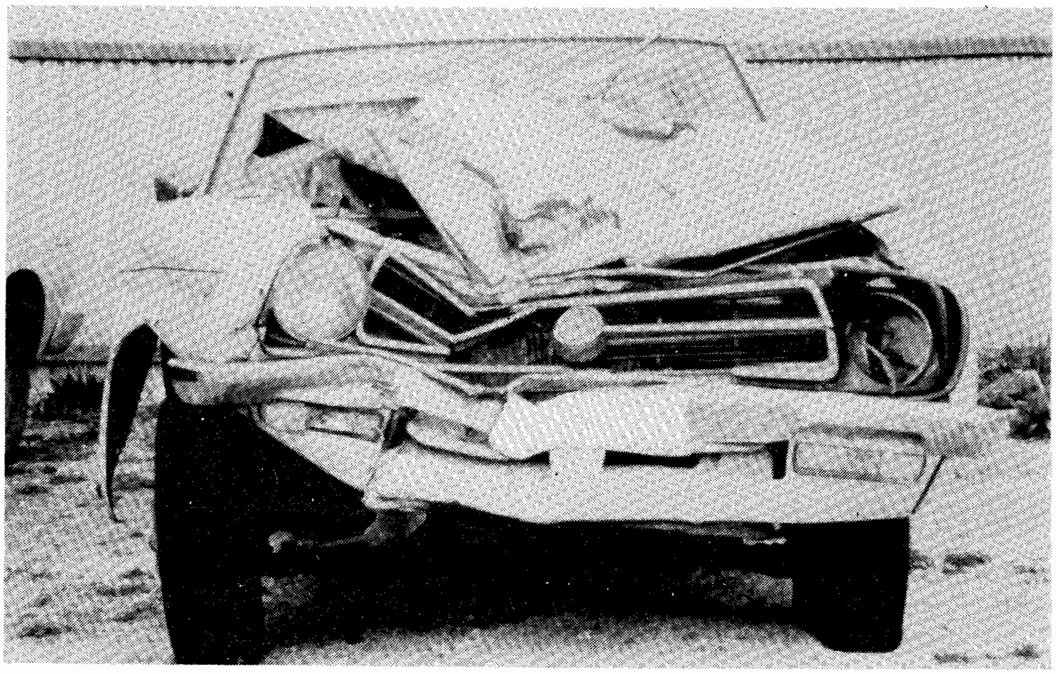


FIGURE 4.87: 1972 Datsun 1200 coupe following a two-car collision. (Accident 150, see Figures 4.85 and 4.86).

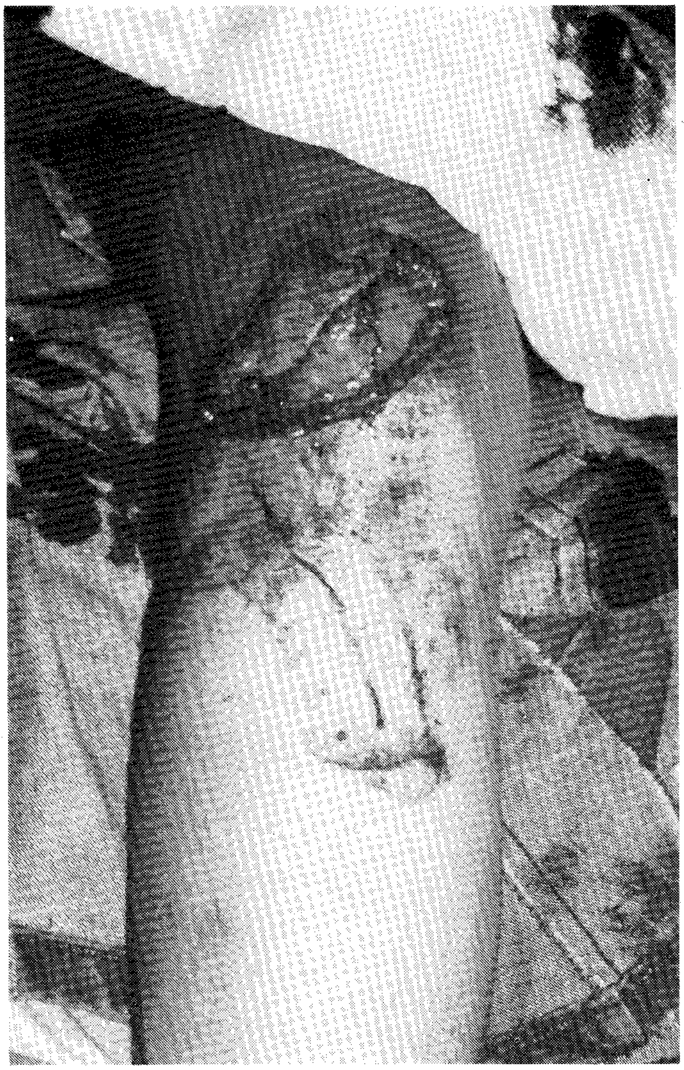


FIGURE 4.88:

Knee laceration caused by contact with the accessory bracket shown in Figure 4.89.

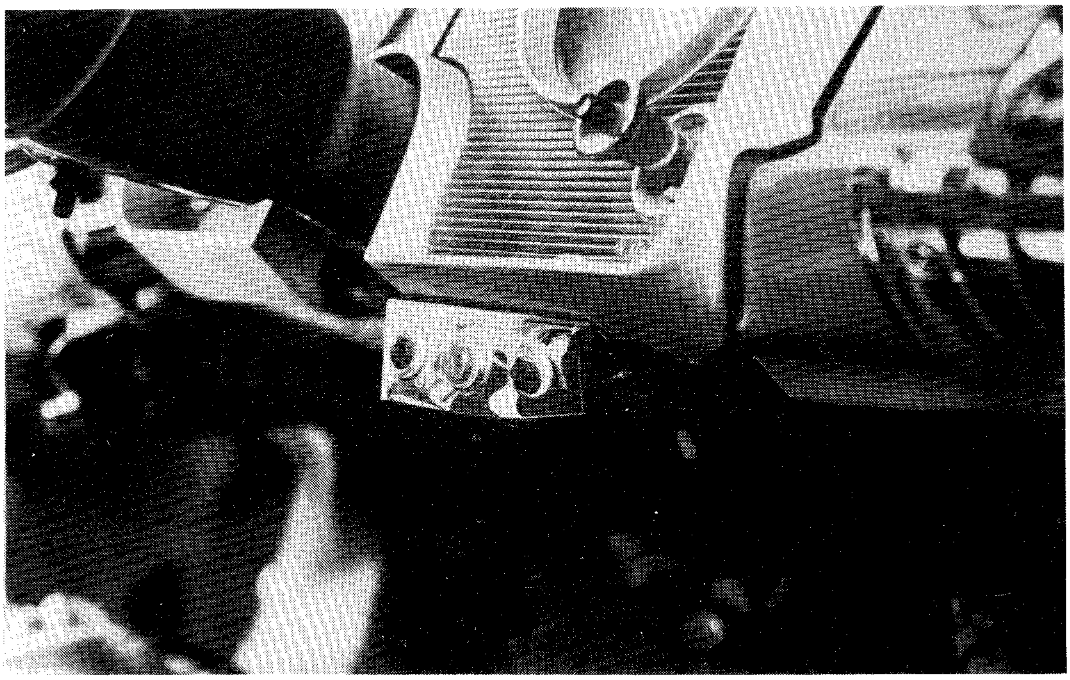


FIGURE 4.89: Accessory bracket fitted below the instrument panel. (Accident 051, See Figures 4.88 and 4.46, 4.47)

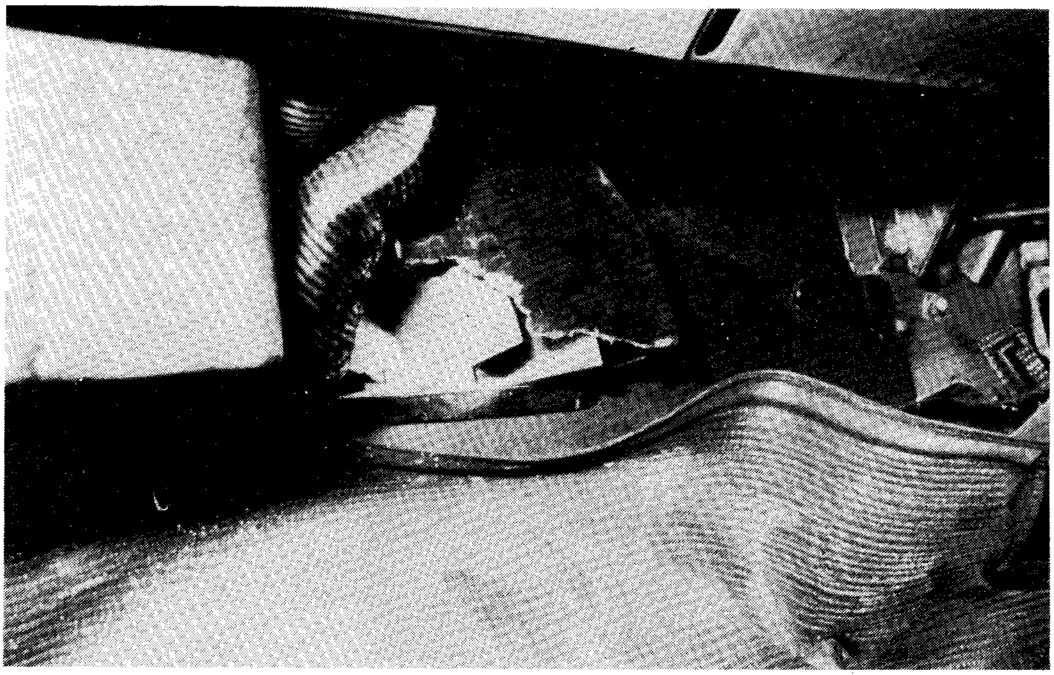


FIGURE 4.90: Failure of housing of heater duct due to occupant contact, exposing sheet metal vanes. (Accident 057, see Figure 4.79)

TABLE 4.60: COMPLIANCE WITH ADR 22 AND 22A

ADR 22, 22A Compliance	Number of Cars
ADR 22	79
ADR 22A	49
Pre-ADR 22	245
Compliance not known	13
Total	386

TABLE 4.61: NECK INJURY BY THE PRESENCE OF HEAD RESTRAINTS: FRONT SEAT OCCUPANTS IN REAR IMPACTS

Neck Injury	Head Restraint Fitted Yes	No	Total
Yes	4	6	10
No	9	5	14
Total	13	11	24

crashed into the car in front (Fiat 124 coupe, Accident 029). The data in this Table suggests that the risk of sustaining a neck injury in a rear impact is reduced by the provision of a head restraint. However this result may have arisen by chance (Chi square = 1.38, $p < 0.25$) or it may simply reflect the influence of other factors such as differences in impact severity, seat back failure or even in susceptibility to an injury of this type. The last of these factors, susceptibility to whiplash injury, was found to vary by as much as 60 per cent between males and females of similar stature in a study conducted in North Carolina whereas there was only a slight and inconsistent positive association between the presence of a head restraint and a reduction in the risk of neck injury (McLean, 1973).

For reasons such as these the 24 cases of front seat occupants in cars that were struck from the rear are far too few for a meaningful evaluation of the effectiveness of ADR 22 and 22A. However the data were consistent with seat back failure reducing the risk of neck injury and, as noted in the North Carolina study referred to above, with the driver having a higher risk of such injury than the front passenger in a given rear impact. For example, in Accident 115, in which a 1969 XW Ford Falcon sedan fitted with a bench front seat was struck from the rear, the female driver sustained a whiplash injury whereas the female left front passenger did not.

Head Restraints in Front Impacts

There were four cases in which there was evidence that a front seat head restraint had been struck by an unrestrained rear seat occupant in a frontal collision. In three of these cases the head restraint was an integral part of the seat (the high seat back type). The injuries sustained by the rear seat occupants were a bruised head (Accident 012) and facial lacerations (Accidents 067 and 301).

The fourth case (Accident 067) involved a 1975 Datsun 180B four door sedan that struck a utility pole. The driver and front passenger were wearing lap-sash seat belts. They sustained only minor injuries. The two rear seat occupants were not restrained and both struck the back of the seat in front and the adjustable head restraint. The left rear passenger sustained fractures of the facial bones from striking the head restraint which separated from the seat and was found in the left front footwell immediately after the impact.

4.4.20 ADR 23: NEW PNEUMATIC PASSENGER CAR TYRES

The intention of this Australian Design Rule is to specify standards of strength, construction and standard pressure/load relationships for tyres of particular size designations to facilitate the choice of tyres for passenger cars and derivatives thereof.

Effective date: 1 January, 1974

The number of cars that complied with ADR 23 is shown in Table 4.62. No cases were found in which the accident could be attributed to tyre failure. This applied to tyres which were required to meet ADR 23 and to all other tyres, including retreads. Some cases were recorded in which the tyre bead left the bead seat as a consequence of a collision but, as noted in Section 4.4.17, this had no apparent effect on the outcome of the accident.

4.4.21 ADR 24: TYRE SELECTION

The intention of this Australian Design Rule is to specify requirements for tyre selection appropriate to vehicle load capacity rim size and speed characteristics.

Effective date: 1 January, 1973

The distribution of cars in the sample by compliance with ADR 24 is shown in Table 4.63. Cases in which tyre characteristics were causal factors in the crash are noted in Section 4.2.3 and described in Appendix A2. Two of these cases have particular relevance to the provisions of ADR 24.

In Accident 108 the rear wheels and tyres of an ADR 24 car, a 1973 XA Ford Falcon sedan, had been replaced with equipment that was not shown on the tyre placard; 185 SR 14 tyres on five inch rims at the front and FR 5014 tyres on seven inch rims on the rear. Although it might be shown that the FR 5014 tyres would have an adequate load bearing and speed capability, their use in combination with 185 SR 14 tyres provided an imbalance in cornering power between the front and rear tyres such that the driver was unable to satisfactorily control the path of his vehicle.

Tyre mismatch was also judged to have been a significant causal factor in Accident 237 in which the intoxicated driver of a 1974 Chrysler Galant lost control in a relatively high speed (possibly 100 km/h) lane-change manoeuvre. The car was fitted with almost new 6.15 L 13 tyres to all wheels except the right rear which was fitted with a worn-out 5.20 13 tyre. The immediately obvious difference in the two rear tyres was the tread depth. However, the difference in the design of the two tyres (5.20 13: Aspect Ratio 98%, Design Rim

TABLE 4.62: NUMBER OF CARS COMPLYING WITH ADR 23

ADR 23 Compliance	Number of Cars
Yes	67
No	305
Not known	14
Total	386

TABLE 4.63: COMPLIANCE WITH ADR 24

ADR 24 Compliance	Number of Cars
Yes	92
No	280
Not known	14
Total	386

Width 3½" and the 6.15 L 13: Aspect Ratio 80%, Design Rim Width 4½") and the consequently different response to the forces generated in the rapid lane-change manoeuvre may have been the dominant factor. The point of interest in the present context is that since both tyre sizes were displayed on the tyre placard and both tyres were of the same carcass construction, the car was equipped in accordance with ADR 24. It is of course correct to say that the ADRs are intended to apply to a vehicle at the time of first registration and that vehicle manufacturers do not build their vehicles with one odd tyre (until the advent of space-saver spare wheels). However the ADRs have been used as a guide for in-service operation, as shown by the requirements to provide information relating to ADRs 4A, B and C (Seat Belts) and ADR 31 (Hydraulic Braking Systems). With this precedent it is recommended that the information displayed on the placard required by ADR 24 should include Clause 24.2.2 of the Rule. This Clause calls for all tyres fitted to the car to be of the same type of carcass construction. Furthermore, a warning note should be included about the possible incompatibility of a mixture of the tyre sizes that may be listed on the placard.

4.4.22 ADR 25: ANTI-THEFT LOCK

The intention of this Australian Design Rule is to specify the requirements for a lock to limit unauthorised use of the vehicle.

Effective date: 1 January, 1972
(ADR 25A effective: 1 January, 1978 - after the data collection period for this study.)

The number of cars that complied with ADR 25 is shown in Table 4.64. One car that claimed compliance with ADR 25 on a compliance plate dated 3/74, did not have an anti-theft lock fitted. This was a 1974 Leyland Marina sedan (Accident 079).

There was one case of illegal use of a motor vehicle. A 15 year old youth took a 1975 VJ Valiant sedan from a garage parking area. The cars in this area were parked with the keys in the ignition lock and were unattended. The resulting accident, a single-car crash into a tree (057), could be directly attributable to this practice of leaving the keys in unattended cars, thereby vitiating the purpose of ADR 25.

TABLE 4.64: COMPLIANCE WITH ADR 25

ADR 25 Compliance	Number of Cars
Yes	161[1]
No	212
Not known	13
Total	386

Note: [1] See text.

5. CONSEQUENCES OF THE ACCIDENTS

5.1 INJURY SEVERITY

Although nearly half of the occupants of these vehicles were injured to some degree the percentage of severe to critical injuries (3.9 per cent, Table 5.1) was much lower than those sustained by pedestrians (45.4 per cent), pedal cyclists (34.7 per cent) or motorcyclists (23.7 per cent). Details on the injuries to these other road users are presented in the relevant companion Reports Nos. 2, 3 and 4. The single fatality to a car occupant was the result of a car being struck by a train.

A similar indication of relative injury severity is given by the Injury Severity Scores (ISS) presented in Table 5.2. The ISS is the sum of the squares of the numerical ratings assigned to the three most severely injured body regions, using the Abbreviated Injury Scale (AIS) to rate the severity of each injury. Table 5.2 shows the percentage of occupants with ISS scores greater than or equal to 10 (3.9 per cent) corresponding to the percentage with severe to critical injuries as shown in Table 5.1. The relatively high number of occupants with an ISS score between four and 10 largely represents those who received more than one injury, with no individual injury being severe.

A practical index of injury severity is obtained by tabulating the treatment required by those occupants involved. Table 5.3 shows that although 47.2 per cent of car occupants were injured only 33.8 per cent required treatment by a doctor and of them less than half (44 per cent) were admitted to hospital. Additional information is provided by the length of the stay of those hospitalised (Table 5.4). Just over 60 per cent were discharged within three days of being admitted although nine persons (8 per cent) were still in hospital one month after the accident.

5.2 BODY REGION INJURED

The frequency and severity of injury by body region is presented in Table 5.5. The most frequent injuries were to the head (17.3 per cent), knees (17.0 per cent), face (15.5 per cent) and chest (9.2 per cent). Although knee injuries appear more frequently than facial injuries the number of persons affected was slightly less.

The number of severe injuries (AIS ⩾ 3) is also shown in Table 5.5. The body regions most frequently severely injured were the head and face, neck, chest, abdomen and back. The 30 injuries associated with these classifications were sustained by 17 people involved in 15 accidents. The nature and probable cause of these injuries are discussed below.

5.2.1 HEAD INJURIES

There were two cases of an occupant suffering severe concussion which resulted only in extended retrograde amnesia. The 22 year old driver of a car which struck the side of another vehicle at a four-way uncontrolled intersection in Accident 083 was completely ejected from her vehicle. She sustained concussion and this was associated with a laceration to the right of the head. Accident 096 was a single vehicle accident in which a car struck a utility pole. The belted driver struck his forehead on the steering wheel during the collision and sustained concussion and facial lacerations.

The 40 year old driver of the first car to be struck in a chain collision (Accident 029) struck his head on the passenger's side window sill in the region of the quarter-vent. He suffered a contusion to the left frontal area of the brain which resulted in temporary paralysis of the left arm and leg, and a temporary fixed, dilated left pupil.

A 28 year old male who was a passenger in the vehicle that struck a utility pole in Accident 051 also sustained contusion of the left hemisphere from striking his face on the dashboard.

The driver of the car that turned right at a signalised intersection in Accident 124 and was struck on the left side by an oncoming vehicle sustained severe concussion with slight residual brain damage when his head contacted in turn the windscreen, the left A pillar and finally the intruding bonnet of the striking vehicle.

The driver of a car that impacted the side of another vehicle at an uncontrolled intersection (Accident 286) sustained a subdural haematoma. This injury was caused by the driver's head striking either the steering wheel or the windscreen.

The fatally injured driver in the

TABLE 5.1: OVERALL INJURY SEVERITY

Severity	No. of Cases	Percent of Cases
Nil	378	51.3
Minor	239	32.4
Moderate	80	10.9
Severe	15	2.0
Serious	8	1.1
Critical	6	0.8
Fatal	1	0.1
Unknown	10	1.4
Total	737	100.0

TABLE 5.2: INJURY SEVERITY SCORE (I.S.S.)

I.S.S.	No. of Cases	Percent of Cases
0	376	51.0
1	181	24.6
2 $<$ 5	76	10.3
5 $<$ 10	61	8.3
$\geqslant$ 10	29	3.9
Fatal	1	0.1
Unknown	13	1.8
Total	737	100.0

TABLE 5.3: STATUS OF TRAUMATIC INJURIES

Treatment required	No. of Cases	Percent of Cases
None	378	51.3
First aid at scene	98	13.3
Treated by doctor but not admitted to hospital	140	19.0
Hospitalised	109	14.8
Fatal	1	0.1
Unknown	11	1.5
Total	737	100.0

TABLE 5.4: PERIOD OF STAY IN HOSPITAL

Period of Stay	No. of Cases	Percent of Cases
Not admitted	619	84.0
Less than 24 hours	22	3.0
One day to less than two days	26	3.5
Two days to less than three days	18	2.4
Three days to less than one week	15	2.0
One week to less than one month	19	2.6
One month or more	9	1.2
Unknown	9	1.2
Total	737	100.0

TABLE 5.5: FREQUENCY AND SEVERITY OF INJURY BY BODY REGION

	All Injuries			Severe Injuries[1]		
Body Region	No.	%	No. of persons	No.	%	No. of persons
Head	149	17.3	135	8	16.0	8
Face	133	15.5	113	6	12.0	4
Neck	41	4.8	41	3	6.0	3
Shoulder	43	5.0	43	2	4.0	2
Whole Arm	3	0.3	2	-		
Upper Arm	16	1.9	16	2	4.0	2
Elbow	35	4.1	32	-		
Forearm	19	2.2	17	-		
Wrist/Hand	39	4.5	34	3	6.0	1
Back	17	2.0	16	4	8.0	4
Chest	79	9.2	74	10	20.0	8
Abdomen	23	2.7	22	4	8.0	3
Hip/Pelvis	31	3.6	31	2	4.0	2
Thigh	16	1.9	16	2	4.0	2
Knee	146	17.0	110	2	4.0	2
Lower Leg	34	4.0	29	2	4.0	2
Ankle/Foot	33	3.8	28	-		
Unknown	2	0.2	2			
Total	859	100.0	-[2]	50	100.0	-[2]

Notes: [1] AIS $\geqslant$ 3.
[2] Column not additive.

car that was struck on the right side by a train in Accident 264 sustained contusions to the frontal region of the brain which were associated with comminuted fractures of the skull.

5.2.2 CHEST INJURIES

There were eight vehicle occupants who sustained severe chest injuries in these accidents. Both the driver and passenger involved in Accident 051 each received two injuries to this region. As a result of striking the steering wheel the driver sustained a flail chest which resulted in a left pneumothorax. The passenger struck the dashboard which flailed a segment of the sternum which in turn produced a myocardial contusion.

Similarly the driver of the car which impacted the side of a vehicle, the driver of which was executing a U-turn (Accident 016), sustained a fractured sternum when he struck the steering wheel.

The driver of the car in Accident 076 turned right across the path of an oncoming truck. As a result of this impact from the left he sustained fractures to both the left shoulder and ribs.

In addition to her head injury the female driver of the car in Accident 083 received flailing to the right side of the chest when, on ejection, she was crushed between the sides of the two involved vehicles during the collision.

Accidents 126 and 286 also occurred at four-way uncontrolled intersections. The driver who was ejected after being struck from the right in the former accident sustained fractures to the 9th, 10th and 11th ribs. The driver in the other accident was struck from the left and sustained a haemo-pneumothorax resulting from fractures of the fourth, fifth and sixth ribs.

The driver in the fatal level crossing accident (Accident 264) was found to have bruised lungs and a bruised heart associated with fractures to third and fourth ribs on the right side.

5.2.3 FACIAL INJURIES

Three of the four persons in this category sustained fractures to the facial bones. The remaining individual was the left front passenger in a car which was involved in a collision at a four-way uncontrolled intersection (Accident 009). She sustained multiple lacerations to the face when her head struck and broke the windscreen of the vehicle in which she was travelling.

The left front passenger in the vehicle which struck a utility pole in Accident 096 sustained severe facial injuries when the middle third of his face struck the top of the dashboard. The most severe injury was to his right eye which was found to have scleral detachment and a lacerated retina. Only minimal vision was retained in this eye. He also had multiple fractures to the bones comprising this section of his face.

In Accident 111 the driver of a small van was struck on the right jaw by a heavy piece of timber which slid off a half-cab truck when it braked to avoid the van. As a result his mandible was fractured both in the right body and in the left neck.

When the vehicle in which he was travelling struck a large tree (Accident 121) the left front passenger broke the windscreen with his head which then came down onto the sharp lower edge of the glass remaining in the windscreen surround. This resulted in multiple lacerations to the lower part of his face and also produced a bilateral fracture of the zygoma with rotation of the right zygoma.

5.2.4 BACK INJURIES

There were four cases of a car occupant sustaining a fracture to the back. One of the two who were wearing seatbelts was the left front passenger in Accident 096 who was mentioned in the section on facial injuries. This subject had a congenital absence of the left arm which allowed his upper torso to slide more readily from the restraint of the loosely adjusted seat belt sash. This allowed the sash to slide down from the chest to the abdomen which caused a flexion-distraction force to act on the lumbar spine causing a potentially unstable fracture of the second lumbar vertebra. The other occupant wearing a seatbelt was the driver of a car which, after striking a tree, rolled over onto its roof (Accident 231). The mechanism which caused a compression fracture to the second lumbar vertebra is not definitely known although there was evidence of head contact with the roof.

The driver of the car in Accident 126 sustained multiple fractures to the bones on the left side of his body. After being ejected from his vehicle he was found to have fractures to the transverse processes of the second, third and fifth lumbar vertebrae, fractured left clavicle, fractured left ribs four, five and six, and a fracture to the left side of the pelvis.

Another driver whose car was struck from the right was also ejected during the collision (Accident 286). He sustained an anterior chip fracture of the ninth thoracic vertebra. In both the accidents involving ejection the injuries may have occurred when the occupant struck the road surface.

5.2.5 NECK INJURIES

Two of the three persons sustaining severe neck injuries were occupants of the single vehicle involved in Accident 051. The driver sustained a fractured odontoid process of the axis of the second cervical vertebra. This was caused by hyper-extension of the neck which may have occurred when the driver's head was forced back on striking the windscreen. A minor fracture of the body of the axis of the second cervical vertebra was sustained by the passenger in the left front seat of this vehicle. Again the windscreen appears to have been the object contacted.

Accident 124 was described in the previous section on head injuries. In addition the driver sustained a crush fracture of the body of the first thoracic vertebra with fractures of the spinous process of this vertebra and the vertebra above. This injury resulted from compression and flexion forces at the cervical-thoracic junction.

5.2.6 ABDOMINAL INJURIES

The first of three cases of abdominal injury resulted when a vehicle driver turned right across the path of an oncoming vehicle. The driver was wearing a static seat belt which was tightly fastened but as a result of the impact on the left front corner of his vehicle the long buckle component of the belt intruded into his abdomen which resulted in tearing of the mesentery of the small intestine, a ruptured spleen and a haemoperitonium.

The loosely fitting sash section of the seatbelt worn by the passenger in Accident 096 was displaced downward during the collision. In addition to a back injury this produced a torn transverse mesecolon and the ascending colon was torn from attachment to the posterior abdominal wall.

In addition to head and chest injuries the fatally injured driver in Accident 264 sustained a rupture to the right side of the liver, a rupture to the right kidney and a rupture to the outer surface of the spleen.

5.3 PERIOD OF RESTRICTION OF NORMAL ACTIVITIES

The effect that involvement in the accident had on the occupant's ability to continue with his or her normal activities is shown in Table 5.6. The relatively large number of unknown cases compared to previous tables mainly refer to those people with minor injuries who may have thought it necessary to stay at home for a few days.

5.4 EXTENT OF RESIDUAL DISABILITY

The presence and extent of any residual disability is shown in Table 5.7. A major permanent disability was sustained by three people. As a consequence of cerebral injuries suffered in Accident 029 a 70 year old male driver had weakness and poor coordination in his left hand. He also was afflicted by a memory problem which was associated with poor concentration. The 22 year old male passenger in the single vehicle involved in Accident 096 received an eye injury which resulted in him losing the major part of his vision in his right eye. In Accident 124 the driver of the impacted vehicle received multiple blows to the head which resulted in severe concussion and spinal damage. This 68 year old male was subsequently found to have slight brain damage which prompted a slowing of the thought processes and occasional attacks of vertigo.

TABLE 5.6: PERIOD OF RESTRICTION OF NORMAL ACTIVITIES

Period of Restriction		No. of Cases	Percent of Known Cases
Not restricted		499	76.1
Restricted:	Up to one week	85	13.0
	Over one week and up to three months	58	8.8
	Three months or more	13	2.0
Fatally injured		1	0.2
Not known if restricted		81	-
Total		737	100.0

TABLE 5.7: PERMANENT DISABILITY RESULTING FROM THIS ACCIDENT

Disability	No. of Cases	Percent of Known Cases
None	680	96.2
Minor	23	3.3
Major	3	0.4
Fatal	1	0.1
Unknown	30	-
Total	737	100.0

6. CONCLUSIONS AND RECOMMENDATIONS

6.1 THE DRIVER

6.1.1 ALCOHOL INTOXICATION

BAC readings were obtained for 85 per cent of the 403 drivers. Males were much more likely to have had a BAC ⩾ 0.05 than were females (20.5 and 6.0 per cent respectively) and to have had a BAC above the legal limit of 0.08 (15.5 per cent and 3.6 per cent respectively). In view of the demonstrated positive association between BAC and accident involvement in metropolitan Adelaide (McLean, Holubowycz and Sandow, 1980) and the percentage of intoxicated male drivers in these accidents it is recommended that:

> *The continuing search for ways to deter drivers from driving with an elevated BAC should be regarded as an area of prime importance and should be funded accordingly.*

Seventy per cent of the 70 drivers who were found to have a positive BAC said that they occasionally or even regularly drove after consuming ten or more drinks and 40 per cent thought that this quantity of alcohol had little or no effect on their driving performance. These findings suggest that:

> *There is a need for wider dissemination of information on the effect that alcohol intoxication has on the risk of accident involvement.*

Almost half of the drinking drivers had been drinking at an hotel, one-third at a private residence and one-seventh at a restaurant or club. While recognizing that attempts to control excessive drinking at one type of location might well simply change the location at which some drivers drink to excess, these findings suggest that:

> *An attempt should be made to develop measures that can be incorporated into the criteria for the granting or renewal of a liquor licence and that will reduce the frequency with which patrons drink to excess and then drive.*

The proportion of intoxicated drivers in single vehicle accidents was five to six times greater than the corresponding proportion in other types of accident. The intoxicated driver may therefore place himself and his passengers at much greater risk than he does other road users. Therefore it is recommended that:

> *Measures aimed at detecting drivers who have illegal BACs be supported on the grounds that they protect those drivers and their passengers from injury. Such measures might well be considered as being distinct from and complementary to other measures aimed at the general deterrance of the practice of driving when intoxicated.*

There was a close association between involvement in a secondary activity and alcohol intoxication among drivers involved in single vehicle accidents. A similar, but less marked, association was noted in other accidents. It is recommended that:

> *The association between secondary activity involvement and alcohol intoxication among drivers involved in accidents be investigated further in the hope of increasing our understanding of the ways in which alcohol affects a driver's performance.*

Screening breath tests were administered by the police to 16 out of 280 uninjured drivers who remained at the scene of the accident. Forty-one of the 280 drivers had been drinking and the police identified 12 of the 23 who were above 0.08. This result, together with data from blood samples taken in hospitals, suggests that the routinely recorded data on the incidence of a BAC ⩾ 0.08 among drivers involved in casualty accidents may be an underestimate by about 20 per cent. For this reason it is recommended that:

> *Consideration be given to increasing the proportion of uninjured accident-involved drivers who are breath tested by the police, such consideration to include universal testing.*

6.1.2 INTOXICATION BY DRUGS OTHER THAN ALCOHOL

Drugs other than alcohol were known to have been used by about one-eighth (12.2 per cent) of the 403 drivers. Even though we had to rely on self-reporting of drug use there were no cases in which a driver was obviously affected by an unknown intoxicant. Most of the drugs that were reported had been prescribed by a medical practitioner and most of them were thought not to have affected the driver's performance. In 12 cases the drug may have had some effect but this effect was probably beneficial in half of these cases. In five of the remaining six cases alcohol had also been ingested and it alone would have been significant, even in the absence of any additive or synergystic interaction with the drug. One of these five drivers was the only one who was known to have used an illegal drug: marihuana, in combination with a BAC of 0.14. The twelfth case involved an overdose of insulin that resulted in the driver collapsing because of hypoglycaemia. From these results it is concluded that:

> *Drugs other than alcohol are a relatively minor problem but one that may be subject to control by legislation and by more effective advisory action by medical practitioners. In particular, consideration should be given to making any drug which is known to have a synergystic interaction with alcohol available only on prescription.*

6.1.3 DRIVER LICENSING AND EDUCATION

Seventeen drivers had poor vision (static visual acuity worse than 6:12 in at least one eye). This was relevant to the causation of the accident in four cases. Although not a major problem, visual defects are amenable to control at the time of initial application for a driver's licence. The present system in South Australia relies on self-reporting of poor eyesight by the applicant for a licence, or on renewal. That this system is ineffective can be gauged from the fact that only two of the 403 drivers had such an endorsement on their licence. Therefore it is recommended that:

> *The measures taken to identify persons having defective vision among drivers and applicants for a driver's licence be reviewed.*

Newly-licensed drivers (licensed less than two years) were over-represented in the accidents studied on the basis of the number of licensed drivers. Inexperience in driving was an obvious causal factor for nine drivers, three of whom were too young to hold a licence and none had been licensed for more than three months. Turning manoeuvres were characteristic of these nine accidents. It is suggested that:

> *A special study be made of the characteristics of accidents involving inexperienced drivers so as to identify those areas that should be emphasised in tests for a driver's licence and in road safety publicity and educational programs directed at the inexperienced driver.*

6.2 VEHICLE FACTORS

6.2.1 VEHICLE DEFECTS

A vehicle defect in a passenger car definitely contributed to the causation of 0.8 per cent of the accidents in the study and probably contributed to a further 2.8 per cent. Tyre characteristics, both lack of tread depth and mismatch of radial and cross-ply tyres, were the most important single class of defect despite the fact that very few of the accidents occurred on wet roads. There is no system of periodic motor vehicle inspection in South Australia for passenger cars but the police have the authority to examine any vehicle that appears to be defective. It is suggested that:

> *On the basis of the data collected in this study there is no clear case for the introduction of periodic motor vehicle inspection but an expansion of the existing system of spot checks, concentrating on tyre characteristics, may be worthwhile.*

6.2.2 THE AUSTRALIAN DESIGN RULES FOR MOTOR VEHICLE SAFETY

Not all of the safety-related Australian Design Rules (ADRs) could be assessed in this study. This was mainly because there was no case in which the component or performance characteristic covered by an ADR was relevant to the causation or consequences of an accident. This arose from a low probability of failure (such as ADR 7: hydraulic brake hoses), from the characteristics of the accident sample (being generally low severity impacts) or from the, at that time, relatively recent introduction of an ADR resulting in few cars in the accidents studied being in compliance with the Rule (such as ADR 29: side door strength). The following conclusions and recommendations therefore do not cover all of the safety-related ADRs.

ADR 2: Door Latches and Hinges

Door latches and hinges that complied with ADR 2 performed better than did those on earlier-model cars that were not required to comply with the ADR. However one mode of failure of a door latch was observed that is not covered by the ADR and so it is suggested that:

> *The specification for compliance with ADR 2 be reviewed to incorporate a requirement that the integrity of the door latch be maintained when the latch is loaded towards the interior of the car.*

ADR 3: Seat Anchorages

The seat is an essential component of the seat belt restraint system. If the seat fails the occupant may no longer be restrained adequately by the seat belt. Some failures of ADR 3 seats were recorded in the study even though, as noted above, there were few severe impacts. Therefore it is recommended that:

> *The specification for compliance with ADR 3 be reviewed to assess the likely value of higher strength requirements for seats and seat anchorages.*

ADR 4 to 4C: Seat Belts

The injury-protection afforded by the seat belt appears to have improved with the introduction of, and subsequent changes to, ADR 4 based on the accidents in this study. However the wearing rates, overall, were lower than those observed in surveys of the general driving population, to the extent that fewer than half of the left front passengers in these accidents were wearing a seat belt. Therefore it is recommended that:

While the protection against injury provided by seat belts that comply with ADR 4C, and the wearing rates with 4C belts, were both at a high level there were still some front seat occupants in late model cars who were not wearing a seat belt when involved in an accident. Passive restraint devices should therefore be considered for possible introduction in Australian passenger cars.

and,

Because young drivers tend to drive older cars that may not be fitted with seat belts, or with belts that comply with ADR 4C, and because such drivers are at a high risk of being involved in an accident, a case exists for the retrofitting of inertia reel seat belts in older-model cars.

Two cases were observed in which serious injury resulted from the fact that an occupant was displaced from behind the sash of his seat belt and then lacked any effective restraint from the lap belt because the webbing ran through the tongue of the buckle assembly. While recognizing that the following modification would require an additional locking retractor, it is recommended that:

Consideration be given to modifying ADR 4C so that the webbing of a seat belt cannot slip through the tongue of the buckle assembly.

ADR 8: Safety Glass

Disfiguring facial injuries were inflicted by a shattered toughened glass windscreen in one of the accidents in this study in circumstances that were not unusual. Despite the high wearing rate of seat belts in late-model cars, and the consequently low risk of an occupant of such a car contacting the windscreen it is suggested that:

Consideration be given to modifying ADR 8 so as to permit only windscreens that are unlikely to be penetrated when struck by an occupant in a collision.

ADR 10A, 10B: Steering Columns

There were few frontal impacts in this study that were severe enough to provide a test of the adequacy of ADR 10A and 10B. However there were cases in which significant facial injuries were inflicted from contact with the rim of the steering wheel by restrained occupants. Therefore it is recommended that:

Consideration be given to specifying, as an amendment to ADR 10A, 10B, characteristics for the rim of the steering wheel that will minimize the severity of the injuries inflicted in head or facial contact during a frontal collision.

ADR 21: Instrument Panels

Significant injuries were sustained from impacts with the area at the base of the windscreen, by both occupants of the car and by other road users when struck by a car. Therefore it is recommended that:

ADR 21 be reviewed to accommodate the fact that vehicle occupants, in cars fitted with toughened glass windscreens, can and do strike their face or head on the area at the base of the windscreen and that this area is struck by the heads of other road users on being impacted by the front of the car.

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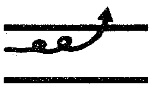
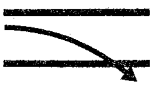
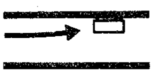
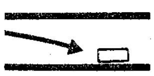
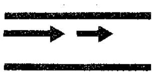
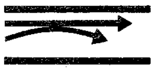
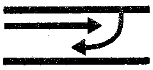
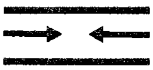
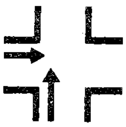
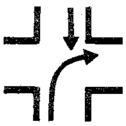
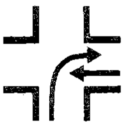
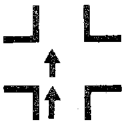
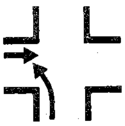
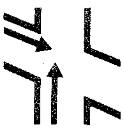
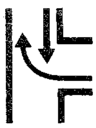
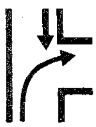
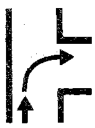
APPENDIX 1: VEHICLE MOVEMENTS IN COLLISIONS INVOLVING CARS AND CAR-DERIVATIVES

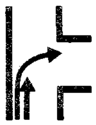
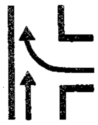
Vehicle Movements	Type of Traffic Control and Location				
	Intersection			Midblock	Total
	Signalised	Sign-Controlled	Uncontrolled	Uncontrolled	
(1)  roll on carriageway	-	-	-	1	1
(2)  roll off road to left	-	-	-	2	2
(3)  yaw off road to left	-	-	-	2	2
(4)  yaw off road to right	-	-	-	2	2
(5)  run off road to left	-	1	4	14	19
(6)  run off road to right	-	1	3	5	9
(7)  parked vehicle	-	-	-	10	10
(8)  parked vehicle, far side.	-	-	-	1	1
(9) 	-	-	-	12	12

Type of Traffic Control and Location

Vehicle Movements	Intersection			Midblock	Total
	Signalised	Sign-Controlled	Uncontrolled	Uncontrolled	
(10) 	-	-	-	7	7
(11) 	-	-	-	2	2
(12) 	-	-	-	2	2
(13) 	-	-	-	2	2
(14) 	-	-	-	2	2
(15) 	-	-	-	1	1
(16) 	-	-	-	1	1
(17)  reverse onto roadway	-	-	-	1	1
(18) 	7	10	40	-	57
(19) 	26	2	2	-	30

	Type of Traffic Control and Location				
	Intersection			Midblock	
Vehicle Movements	Signalised	Sign-Controlled	Uncontrolled	Uncontrolled	Total
(20) 	1	1	1	-	3
(21) 	2	-	-	-	2
(22) 	1	-	-	-	1
(23) 	-	-	2	-	2
(24) 	2	12	4	-	18
(25) 	1	5	3	-	9
(26) 	-	4	2	-	6
(27) 	-	-	1	-	1

Type of Traffic Control and Location

Vehicle Movements	Intersection			Midblock	Total
	Signalised	Sign-Controlled	Uncontrolled	Uncontrolled	
(28) 	-	-	1	-	1
(29) 	-	1	-	-	1
(30) 	-	1	-	-	1
(31) Roundabout	-	1	-	-	1
(32) Railway level Crossing	1	-	-	-	1
(33) Other	-	6	-	-	6
Total	41	45	63	67	216
Collision with Pedestrian	2	-	-	29[1]	31
Collision with Pedal cyclist	1	3	5	6	15
Total	44	48	68	102	262

Note: [1] Includes one accident at a pedestrian crossing.

APPENDIX 2: ACCIDENTS INVOLVING RELEVANT VEHICLE DEFECTS IN PASSENGER CARS

This Appendix contains descriptions of those accidents in which one or more defects in a passenger car played a role in the causation of the crash, either as a major cause, or as a significant or possible contributing factor.

Major Causal Factors

In these three accidents the vehicle defect, or defects, were a major causal factor. The first two to be described each involved a young, inexperienced driver who lost control of a car when attempting to negotiate a curve on a wet road. While the driver's lack of experience was certainly a factor in each of these accidents, the vehicle defects made the task of controlling the car much more difficult. The third accident was caused solely by the failure of the modified rear suspension of the car.

Accident 062

A 1965 Valiant sedan, driven by a 16 year old male, spun through 180° whilst negotiating a gradual right hand curve on wet bitumen. The rear end of the vehicle collided with a utility pole on the far side of the carriageway (Figure A2.1).

Both rear tyres were devoid of tread pattern over at least half of the width of the tyre. In addition, the left hand rear tyre was of radial-ply construction mounted on a six inch wide rim which was offset to increase the wheel track, whereas the right hand rear tyre was a cross-ply mounted on a standard five inch wide rim.

Although the inexperience of the driver was relevant in that he entered the curve at too high a speed and was not able to regain control of the car once the slide began, the low coefficient of friction between the wet bitumen and the bald rear tyres was a major factor in the causation of the accident.

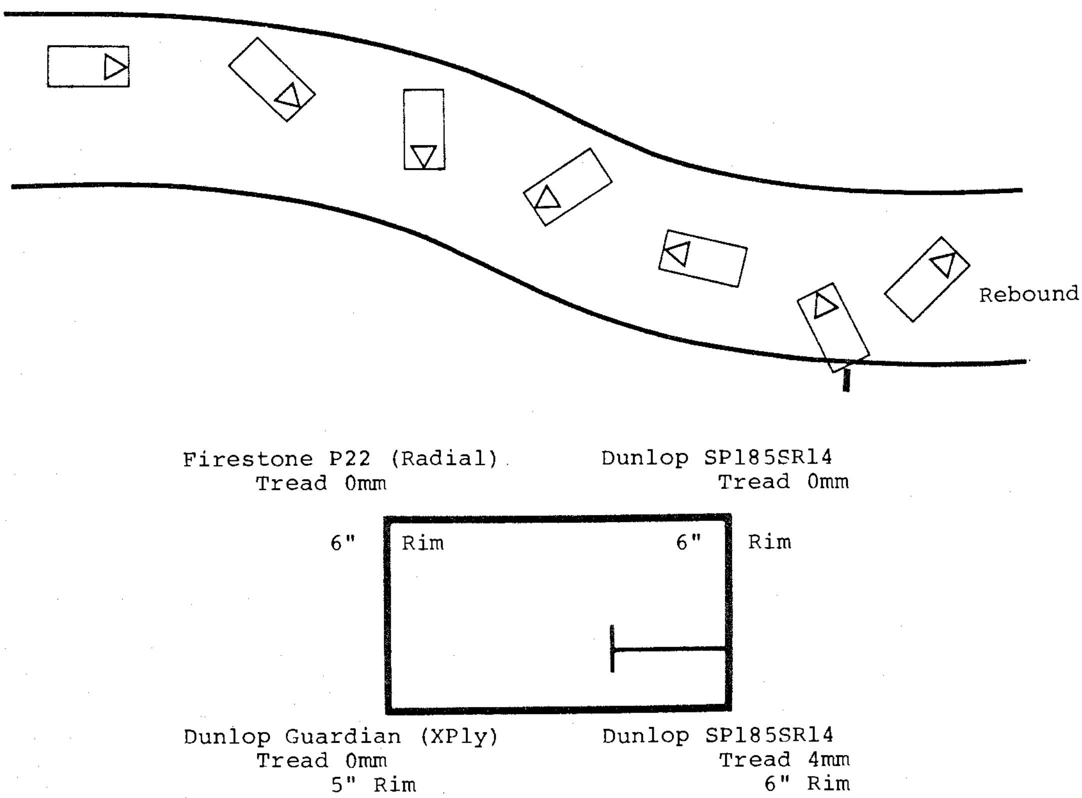


FIGURE A2.1: Accident 062: Vehicle Movements and Tyre Specifications

Accident 132

A 1968 Holden HK sedan, driven by a 17 year old male, was negotiating a left hand uphill curve. The bitumen surface was damp but had dried out over the path taken by the traffic passing through the curve.

At the entry to the curve, the car yawed in an anti-clockwise direction and then yawed clockwise through 180° and slid diagonally across the carriageway, hitting two cars parked at the far kerb (Figure A2.2).

The loss of control may have been due in part to the inexperience of the young driver, as noted above, but it is clear that the mismatch in carcase construction, tread and sidewall stiffness of the tyres on the rear axle, together with the low coefficient of friction at the bald left hand rear tyre, would have made the vehicle extremely difficult to control under such circumstances.

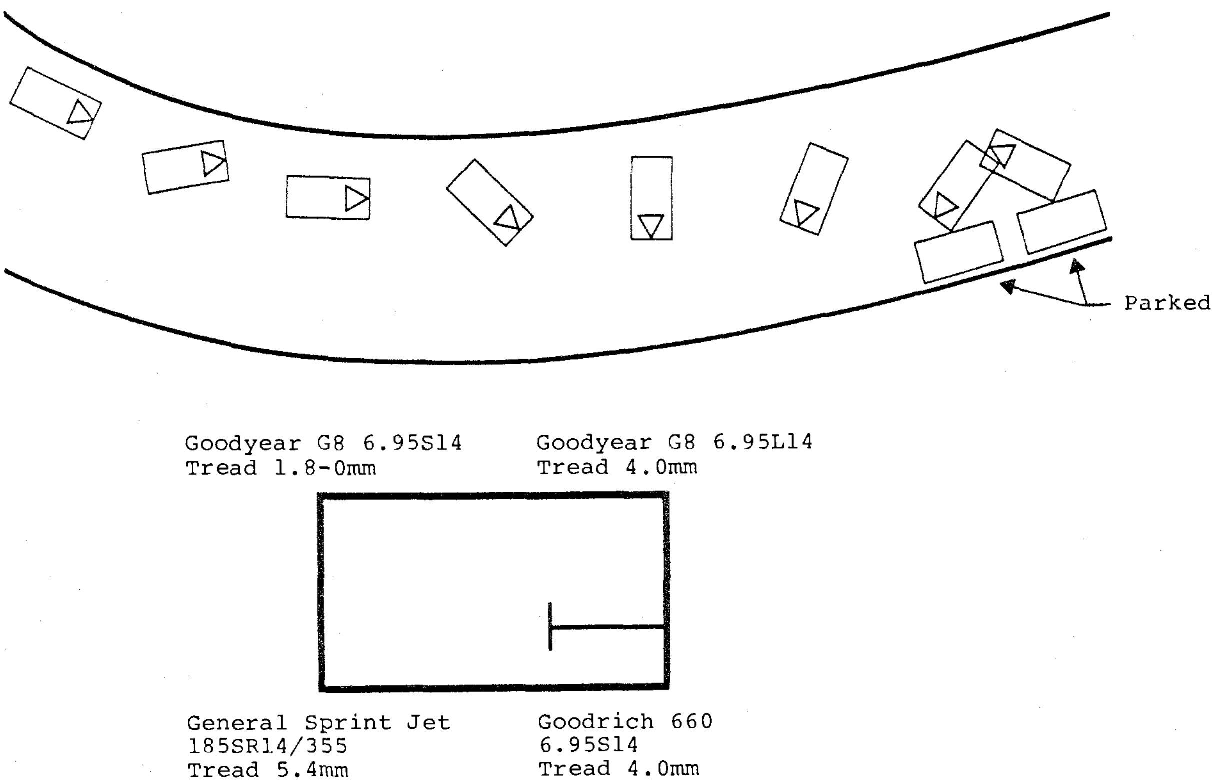


FIGURE A2.2: Accident 132: Vehicle Movements and Tyre Specifications

Accident 291

A 1972 Chrysler Galant sedan was being driven by a 21 year old male on a straight section of road when the spring seat separated from the right hand rear leaf spring. The resulting movement of the rear axle caused the car to turn violently to the left. After turning through about 90°, the vehicle rolled through a full roll to its right and landed on the boot of a Holden sedan which was parked at the nearside kerb. The Galant then fell onto its left side (Figure A2.3).

Examination of the rear suspension showed that the rear springs had been modified by the addition of a third leaf. The rear spring on this vehicle is gripped by two rubber blocks which are carried in two steel pressings which seat on each other when the two U-bolts are correctly tightened. However, the extra depth of the spring due to the additional leaf prevented this and allowed the whole system to "work". This "working" fractured the U-bolt on the right hand side of the assembly at the right hand end of the rear axle. The other U-bolt in this assembly could not be found at the accident site and had either fractured previously or had not been replaced when the modification had been carried out.

Other modifications to this car included the fitting of 175SR13 tyres on six inch rims to the front and 195/70HR13 tyres on seven inch rims to the rear, the rear tyres having no tread over 70 per cent of the tread width.

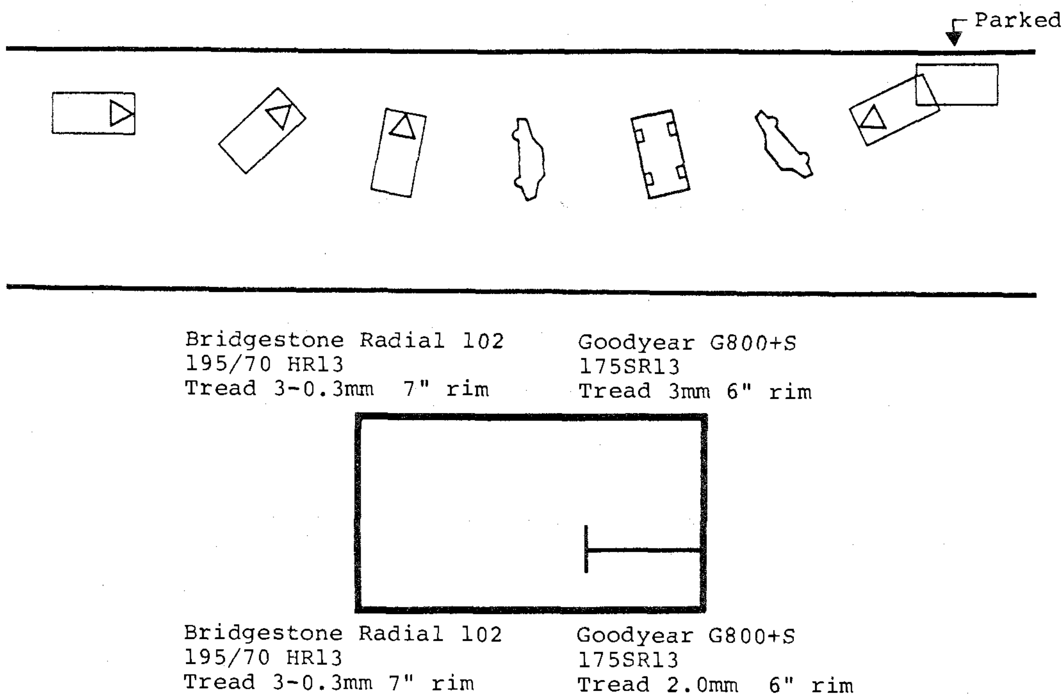


FIGURE A2.3: Accident 291: Vehicle Movements and Tyre Specifications

Significant Causal Factors

Tyre-related defects were the most common among the 11 cars in which a defect was a significant cause of the vehicle being involved in the accident. Faulty braking systems were the next most common type of defect, with the remaining defects being an obstruction of the field of view and an engine fault.

Accident 012

A young woman driving a 1960 Ford Prefect attempted to turn right, into a driveway. The vehicle stalled when across the opposing traffic lane and the driver could not restart in time to prevent being struck by an oncoming vehicle (Figure A2.4).

The distributor and spark plug leads were found to be soaked in oil from the engine breather which may have made the engine difficult to start. Other defects, which were not relevant in the accident, included right hand front and rear tyres with no tread and the left hand rear tyre with 1 mm of tread.

Accident 047

A 1966 Ford Cortina Sedan driven by a 19 year old male approached an intersection at about 80 kph. The driver of a Ford Escort which had stopped at a stop sign, thought that there was enough time to cross in front of the Cortina, which was approaching on her left, and began to cross the intersection. The Cortina driver braked, and his car left skid marks 22 metres long on the damp bitumen, drifting across towards the left-hand kerb as it did so, in effect following the Ford Escort across the intersection and finally colliding with it, the centre of impact being on the left hand rear wheel of the Escort.

The Cortina was fitted with the tyres shown in Figure A2.5.

Even with the estimated approach speed of the Cortina, it seems likely that the collision would have been avoided if the car had decelerated more quickly and in line with its original heading. This probably would have been achieved if the wheels had not locked under braking. Whilst driver skill is obviously relevant in this context, the demand on the driver would have been reduced if the vehicle had been fitted with tyres of the same size and construction and with adequate tread depth.

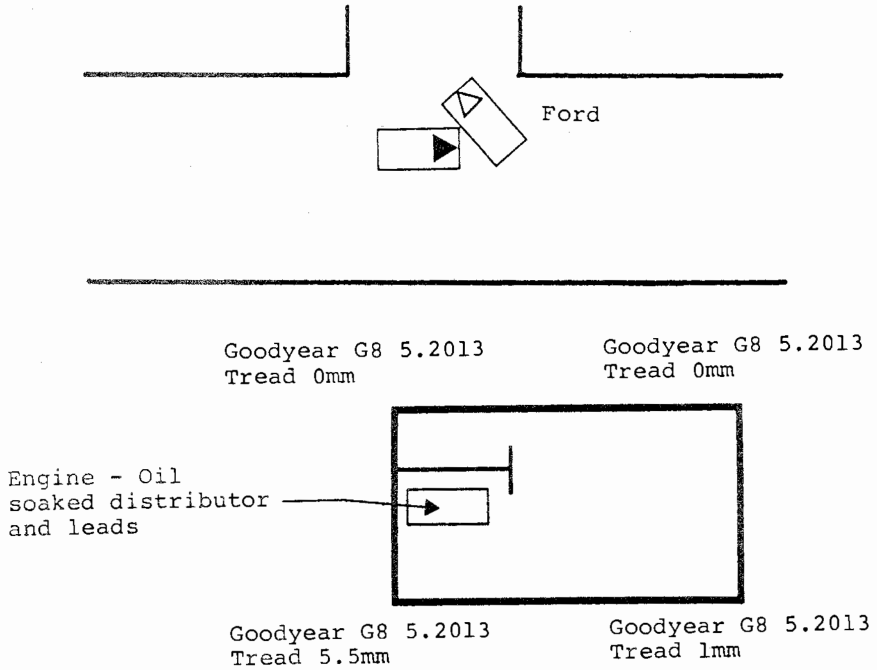


FIGURE A2.4: Accident 012: Vehicle Movements and Tyre Specifications

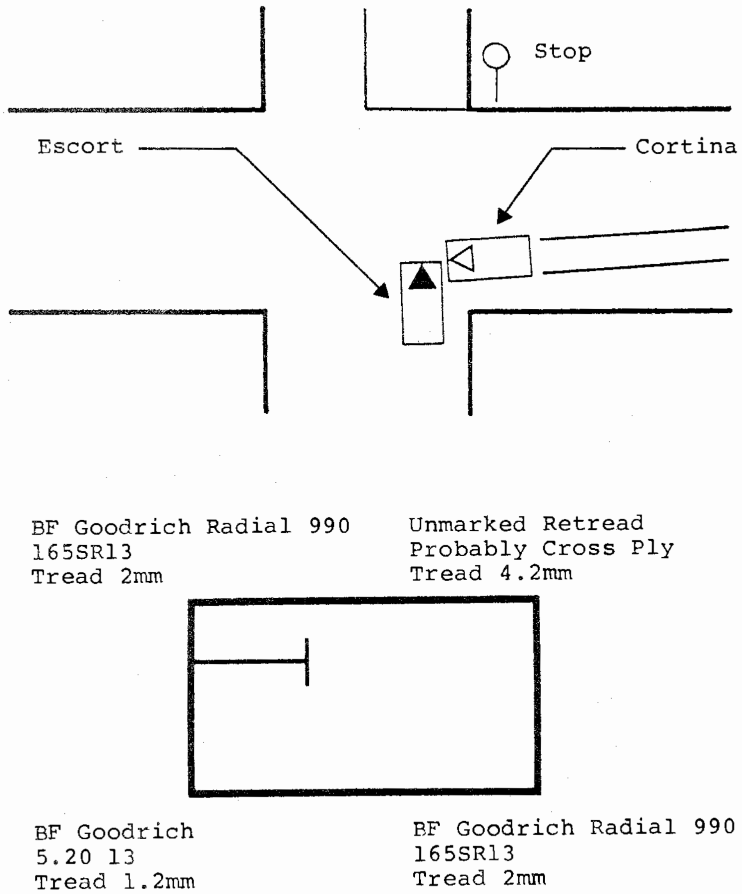


FIGURE A2.5: Accident 047: Vehicle Movements and Tyre Specifications

Accident 053

A 1961 FB Holden Sedan, carrying nine occupants and driven by a 16 year old male, entered an intersection without stopping at a Stop sign and was hit by a bus which had approached from the left (Figure A2.6)

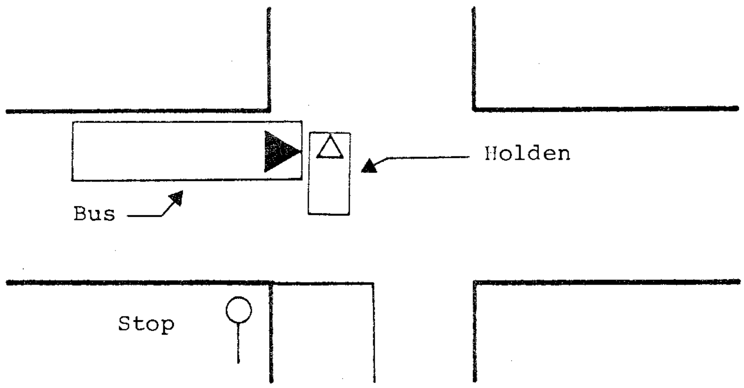
The driver of the Holden alleged that he did not see the Stop sign and first saw the bus when it was 15 metres away and he was in the centre of the intersection. He said that he did not apply the brakes, but swerved to the right to try to avoid the bus. Six of the occupants in the Holden were questioned; one was not sure of any details, three were not sure if the driver had stopped but were sure he had slowed down and two were sure that he had stopped.

The driver of the bus said that he saw the Holden approaching on his left but expected it to stop at the Stop sign. When he saw that the Holden was not going to stop, he applied his brakes and tried to swerve to the left.

Examination of the braking system of the Holden showed that it had not been damaged in the accident but that the pedal required four strokes before any resistance was felt. While it is possible that the collision might still have occurred had the brakes on the car been in good condition, there was no chance of the driver being able to stop in time when repeated pedal applications were required.

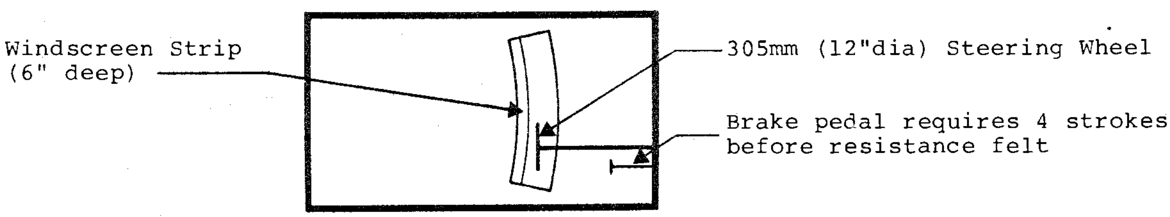
The car also had a black vinyl strip fitted across the top 150mm of the windscreen. This strip markedly restricted the driver's field of view, particularly to the sides (in the direction of the Stop sign). It was also illegal, because it encroached on that area of the windscreen swept by the wiper blades.

Other defects on this vehicle, but which were not of obvious relevance in this accident, included both front tyres worn bald at the inner shoulders, and a smaller-than-standard steering wheel which was 300mm in diameter.



Uniroyal 180 Steelcat
175SR13
Tread 2mm

Bridgestone RD-102
185/70HR13
Tread 0,4,4mm(Across tread, inside to outside)



Uniroyal 180 Steelcat
175SR13
Tread 2mm

Bridgestone RD-102
185/70HR13
Tread 0,3.0mm(Across tread, inside to outside)

FIGURE A2.6: Accident 053: Vehicle Movements and Defects

Accident 087

A 1970 Ford Capri Coupe driven in heavy rain by a 17 year old male, skidded into a cyclist riding across a school crossing. The school crossing lights were not operating at the time.

The front tyres on the car were virtually bald, the one on the right having a tread depth varying between 0.5 and 1.0mm and that on the left having a tread depth of 1.0mm (Figure A2.7)

The point of impact on the Ford was in the area of the front bumper and the leading edge of the bonnet to the right of the centre line of the vehicle, whilst the damage to the bicycle was confined to the rear wheel. This suggests that if the car's rate of deceleration had been a little better then the collision may have been avoided, hence the importance of the worn tyres on the wet road.

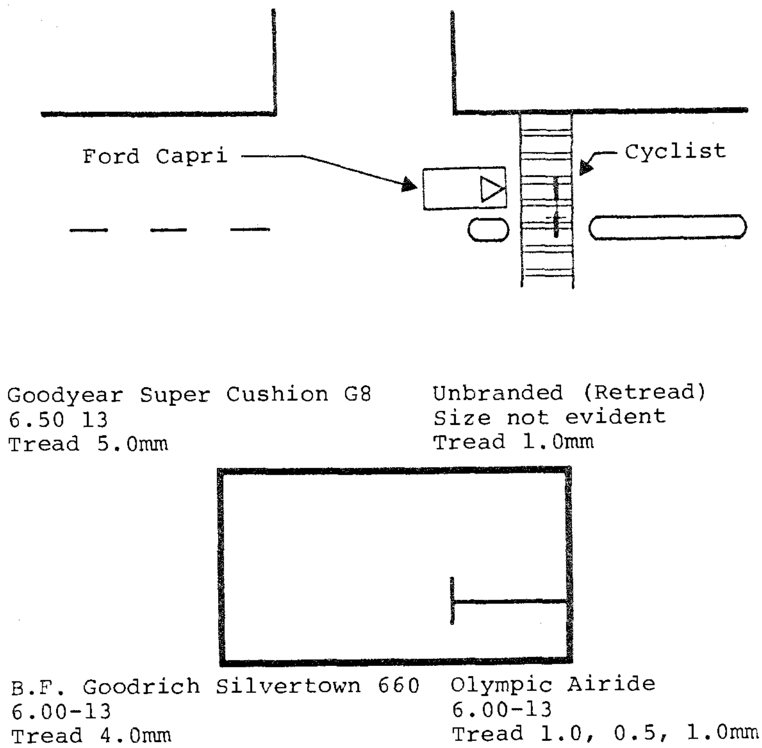


FIGURE A2.7: Accident 087: Vehicle Movements and Tyre Specifications

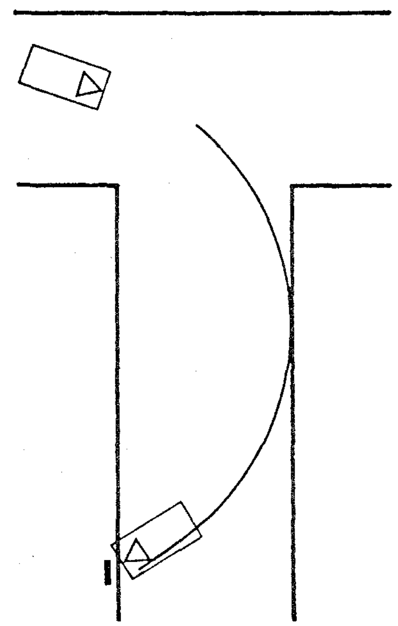
Accident 108

A 1973 Ford Falcon Sedan, driven by a 20 year old male, understeered while making a right hand turn (Figure A2.8). The left hand side wheels struck the nearside kerb and the vehicle then moved diagonally across the carriageway to strike a steel and concrete utility pole on the far footpath.

The front tyres on the vehicle were Michelin ZX 185SR14 on five inch rims, whilst the rear tyres were B.F. Goodrich Radial T/A FR5014 on seven inch rims.

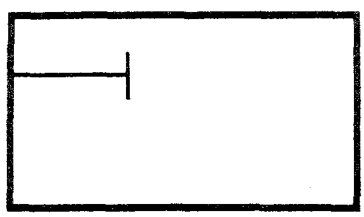
The "defect" in this accident relates to the requirement under the South Australian Road Traffic Act that a vehicle subject to Australian Design Rule 24 (Tyre Section) shall throughout its life be fitted with those tyres listed on the approved tyre placard affixed to the vehicle. In this instance inspection of the compliance plate showed the vehicle to be subject to ADR 24 and the tyre placard showed that a FR5014 tyre on a seven inch rim was not approved.

The effects of gross mismatch in tyres such as displayed on this vehicle will depend on the nature of the vehicle manoeuvre and the condition of the road surface. In this accident the road surface was dry bitumen, free of stones or gravel. The vehicle was executing a right angle, right hand turn and, according to eyewitnesses, was accelerating hard from a stationary position. A tyremark evident at the scene was generated by the left front tyre and indicated that the vehicle was in a severe understeer condition throughout the greater part of the turn. On the basis of the difference in rim widths, section widths and aspect ratios (shown in Figure A2.9) it is not unreasonable to conclude that the FR5014 tyre and rim combination would run at a substantially lower slip angle for a given cornering load than the 185SR14 and that this imbalance was a contributory factor to the accident.



Michelin ZX185SR14
5" Rim
Tread 4mm

BF Goodrich Radial T/A FR5014
7" Rim
Tread 8mm



Michelin ZX 185SR14
5" Rim
Tread 5mm

BF Goodrich Radial T/A FR5014
7" Rim
Tread 8mm

FIGURE A2.8: Accident 108: Vehicle Movements and Tyre Specifications

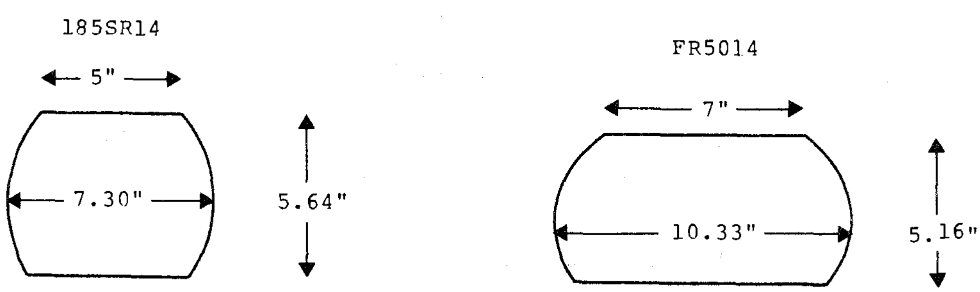


FIGURE A2.9: Accident 108: Rim Widths and Tyre Section Width and Aspect Ratios.

Accident 119

A 1968 Ford Falcon Sedan, driven by a 20 year old male, attempted to negotiate a right hand, left hand, S-bend. As the vehicle entered the right hand curve it yawed clockwise and then anti-clockwise as the driver over-corrected. By this time the vehicle had mounted the far footpath at the exit of the S-bend. It crossed the footpath, continued through a number of fences and crashed into the front wall of a semi-detached house.

The front tyres were without tread, with the left hand tyre showing canvas; the right hand rear tyre had a tread depth which varied between 0 and 0.4mm, whilst the left hand rear tyre had 8.0mm of tread (Figure A2.10).

The braking system was inoperative after the impact due to a severe leak at the union at the master cylinder outlet. It was not possible to conclude whether this failure was present before the impact, but examination of the path of the vehicle, which included some distance travelled over grass, showed no evidence of brake application.

The driver of the vehicle alleged that the bitumen surface of the road was wet and slippery at the time of the accident, and that he entered the S-bend at 45-50 km/h. However, the research team was at the scene seven minutes after the ambulance was summoned and the road surface was quite dry. In addition, the driver, who had a blood alcohol level of 0.11, was engaged in chasing a car, following a fight with the occupants of that vehicle. Under these circumstances it would seem unlikely that he would have slowed to 45-50 km/h to negotiate a relatively minor S-bend. It appears more likely that he approached the S-bend at about 80-90 km/h, and failed to slow down, or was unable to slow due to the faulty brakes. The car then began to yaw in a clockwise direction on entering the bend due to the larger slip angle of the left hand rear tyre relative to the three worn out tyres, over-corrected (the driver's allegation) and yawed in an anti-clockwise direction, mounted the footpath and hit the corner of the front wall of a house. The house and the vehicle were severely damaged to an extent that was consistent with a 50-60 km/h impact.

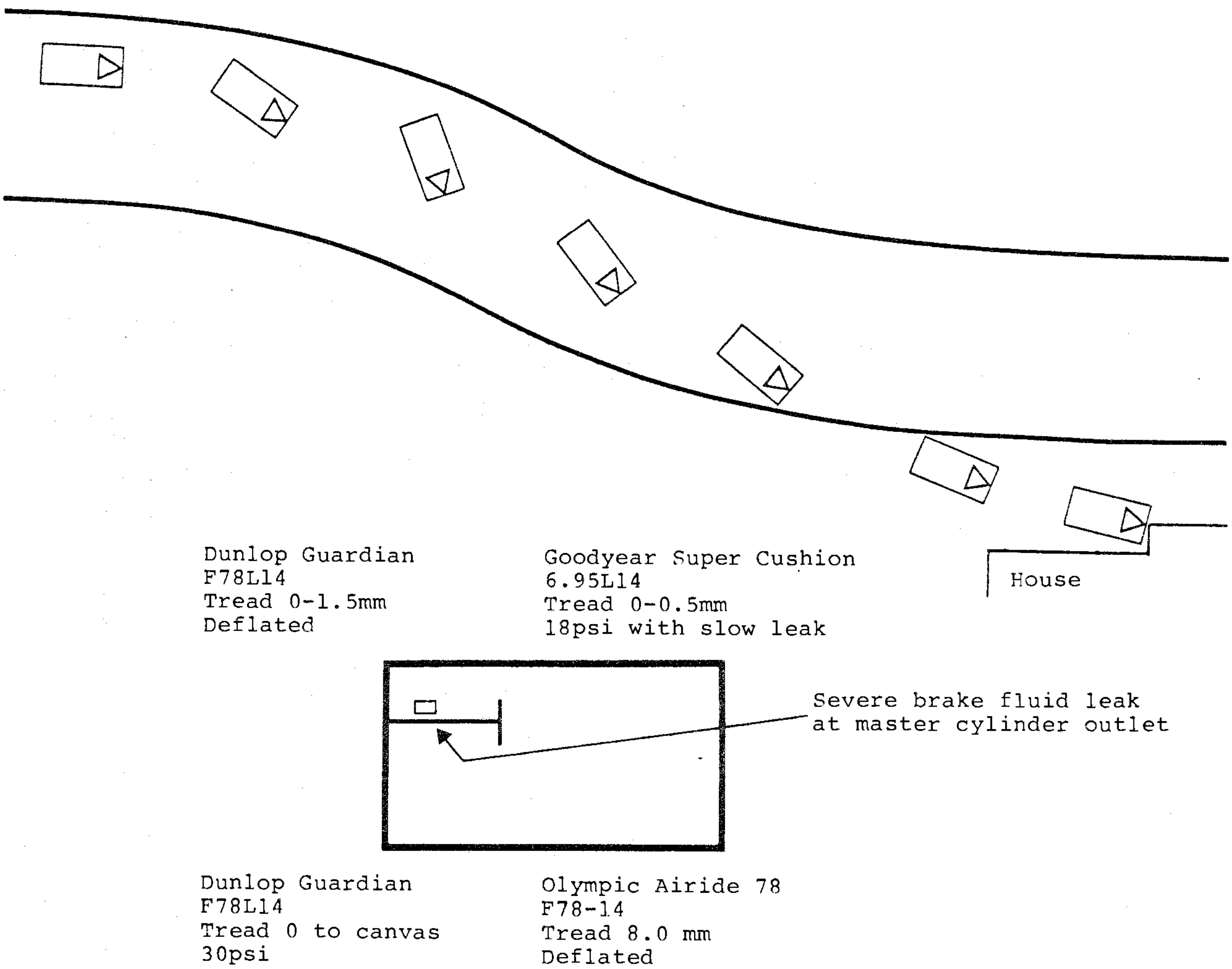


FIGURE A2.10: Accident 119: Vehicle Movements and Tyre Specifications

Accident 161

A 1970 Austin Kimberley, driven by a 63 year old male, entered an uncontrolled intersection at about 15-20 km/h, and ran into the side of the right rear wheel of a large truck which had approached from the left. The brake pedal on the Austin had no resistance; examination of the brake system showed all lines to be intact and there were no fluid leaks, indicating that the lack of pedal resistance was probably a pre-impact condition, possibly due to a malfunction in the brake master cylinder. The brakes could not be tested with the motor running after the crash, and so there might have been some pedal resistance present when the brake servo system, which relies on the low pressure created in the inlet manifold, was operating. Even so, the brake system fitted to this vehicle should remain functional in the absence of servo assistance.

Accident 168

A 16 year old male who was operating on a suspended licence and who had had minimal driving experience, attempted to negotiate a downhill right hand, left hand, S-bend in a borrowed 1963 Volkswagen sedan. On entry to the right hand curve, which had a light covering of fine sand, the vehicle yawed in a clockwise direction and then yawed in an anti-clockwise direction, leaving the S-bend with a yaw angle of approximately 45^{o} relative to the centre line of the carriageway. The vehicle then travelled in a shallow arc with increasing anti-clockwise yaw until the front of the vehicle impacted a gate which had been opened back against a reinforced concrete wall (Figure A2.11).

The brake pedal had no resistance, the master cylinder brake fluid level was low and the brake backing plates were fluid stained, suggesting leaking wheel cylinders. In addition, the right hand rear tyre was devoid of tread pattern and the front and rear seat belts had been removed.

It is likely that the inexperience of the driver, who was alleged by the passengers to have been attempting to catch up with a vehicle ahead of him, together with his BAC of 0.11, were the predominant factors in the accident. However, the lack of an effective braking system eliminated one way in which the driver might have regained control.

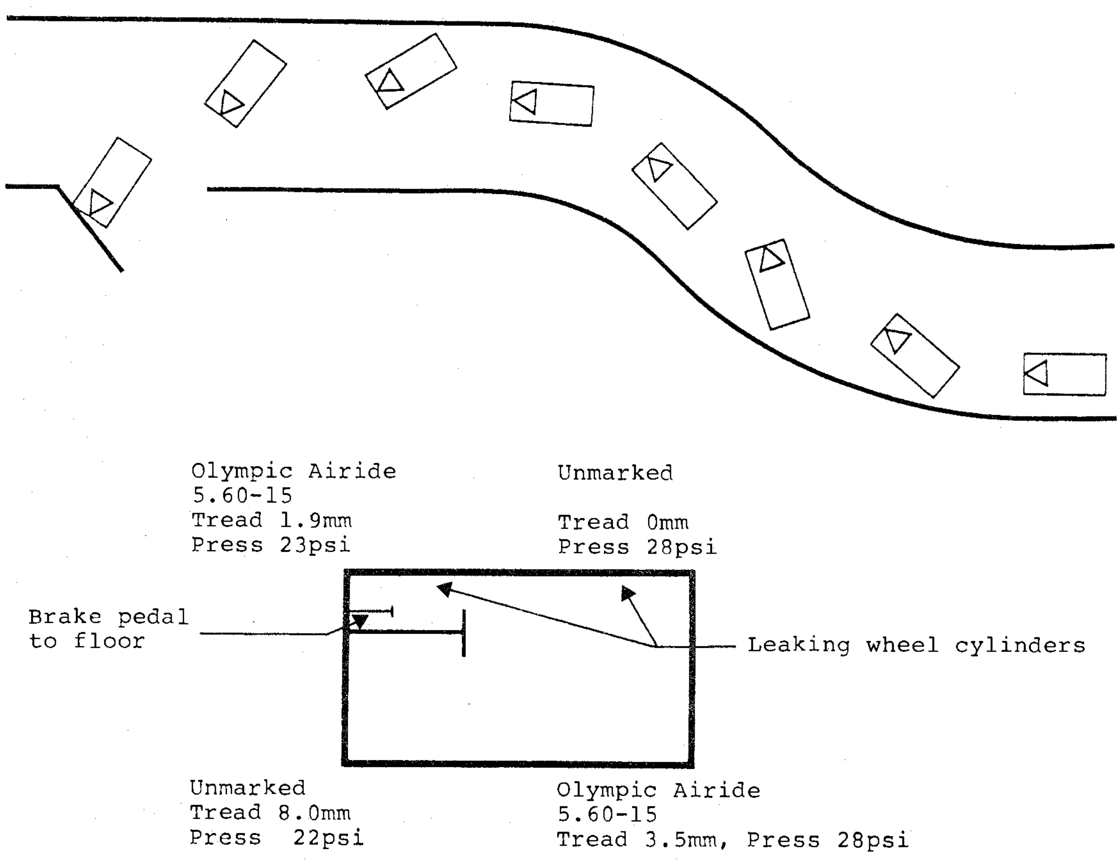


FIGURE A2.11: Accident 168: Vehicle Movements and Defects

Accident 189

A 1950 Holden FX Sedan, driven by a 32 year old male, began to yaw in an anti-clockwise direction at the entry to a left hand curve. As the vehicle negotiated the curve, the yaw angle increased until the vehicle heading was at approximately 90° to its direction of travel along the carriageway. At this point the car rolled onto its right side, roof, left side and back onto its wheels (Figure A2.12).

The probable cause of the skid was a tyre pressure of 10 psi in the right hand rear tyre, relative to a tyre pressure of 30 psi for the left hand rear tyre and 26 and 23 psi for the right and left hand front tyres respectively. It is considered unlikely that a loss of pressure occurred during the rollover since the tyre was fitted with a tube and the tyre did not significantly deflate further in the period between examination of the vehicle after the accident and the more detailed inspection on the following day.

Other items of note were the front left hand tyre devoid of tread, and a gear shift linkage alteration to "floor shift", the head of the gear shift lever being in the form of a hook.

Accident 205

A 1971 Ford Falcon XT Sedan, driven by a 28 year old male, ran into the rear of a 1971 Ford Falcon XW Sedan which was stationary in the centre of the carriageway waiting to turn right. The street lighting at this location was mercury vapour, but the level of illumination was low, an effect that was accentuated by the high-level of illumination (sodium vapour lamps) at the preceding intersection. It is probable that the brake lights on the XW Falcon would have been on when it was stationary since the brake lamps were operational after the impact and the car was equipped with an automatic transmission. It is also possible that the right hand turn signal lamp was flashing, since the driver claimed that it was switched on prior to the impact and the lamp was operational when tested at follow-up.

It was alleged by the mechanic who normally serviced the striking car that he had disconnected the front disc brake power booster unit. This had been done at the owner's instruction when he had been advised that the power booster required an expensive overhaul. This action meant that the braking power of the vehicle was severely impaired, with the expectation of rear wheel locking at very low decelerations.

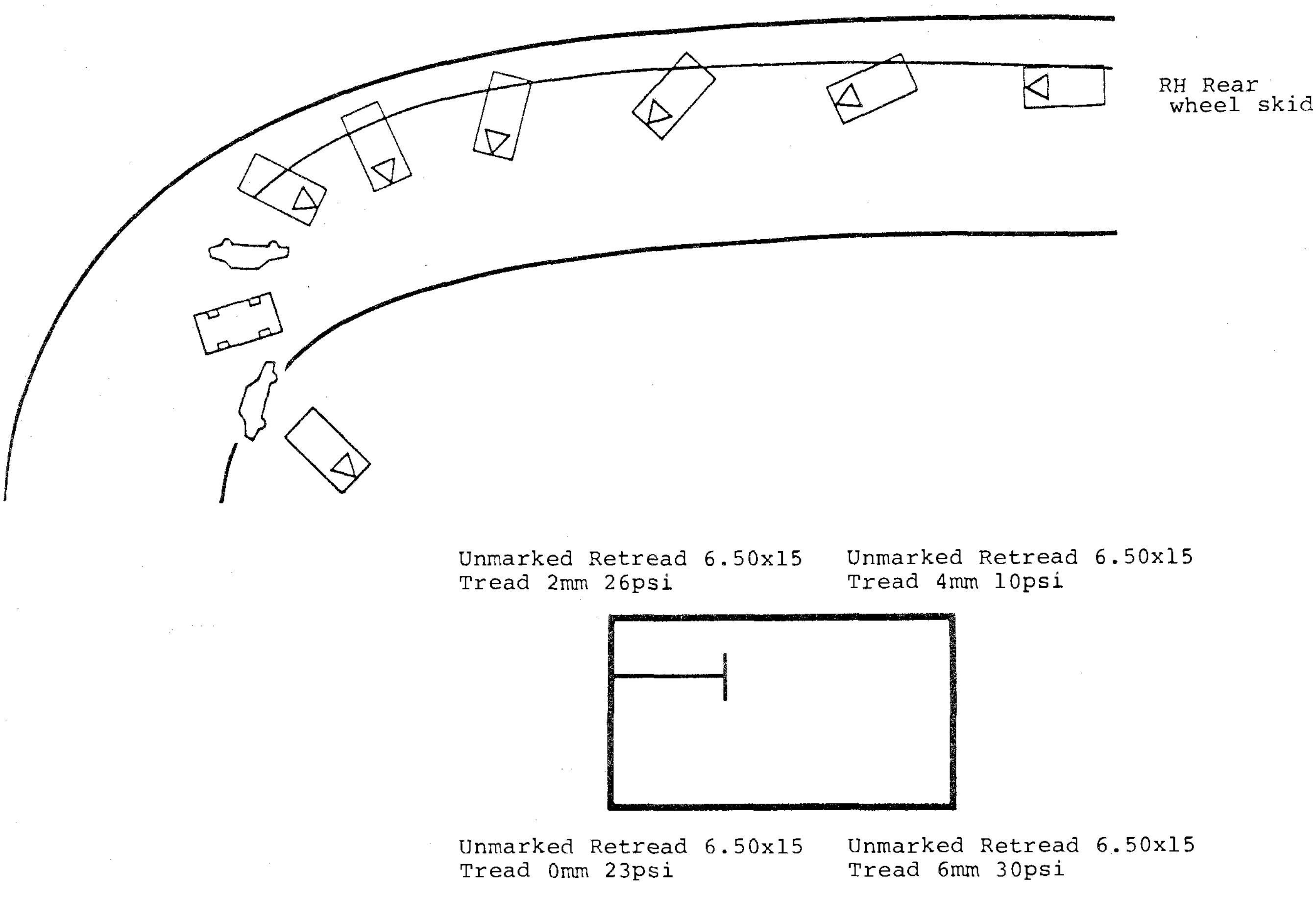


FIGURE A2.12: Accident 189: Vehicle Movements and Tyre Specifications

Other defects on the striking car included a left hand front tyre which had a tread depth that varied from 0 to 5.0mm across the tyre from outer to inner shoulder and a replacement muffler pipe which was abrading and melting its way through the flexible brake hose which runs from the body to the rear axle.

The driver of the striking car had a blood alcohol level of 0.175 and was eating a slice of pizza just before the collision.

Accident 237

A 1974 Valiant Galant, driven by an intoxicated (BAC 0.19) 22 year old male in the inner lane of a straight section of a four lane carriageway, passed a Toyota which was travelling in the outer lane. The Galant then swerved across in front of the Toyota in an attempt to pass a Ford which was travelling in the inner lane about 30 metres ahead of the Toyota. As the Galant overtook the Ford it yawed rapidly in an anti-clockwise direction, rolled onto its right side and then, according to an eyewitness, "flipped forward and rolled end on end four times", crashing through a chain-wire fence and hitting a substantial tree. The speed of the Galant was estimated by the Toyota driver to be "at least 80 mph" and by the Ford driver to be "very fast". The driver of the Galant admitted to 45 to 50 mph (Figure A2.13).

The vehicle was fitted with Goodyear 6.15 L13 tyres with tread depths of between 7 and 8 mm except for the right hand rear tyre which was of smaller section (Goodrich 5.20 13) and which had no tread pattern remaining. In addition, the standard steering wheel, which has a diameter of 365 mm (14 3/8"), had been replaced by a wheel of 290mm (11 3/8") diameter.

The loss of control was typical of that which can result from a rapid lane change manoeuvre, but it is probable that the mismatch in the rear tyre properties, such as tread stiffness and carcase stiffness, and the variation in steering effort and "ratio" due to the reduced diameter of the steering wheel would have made the task of controlling the vehicle substantially more difficult.

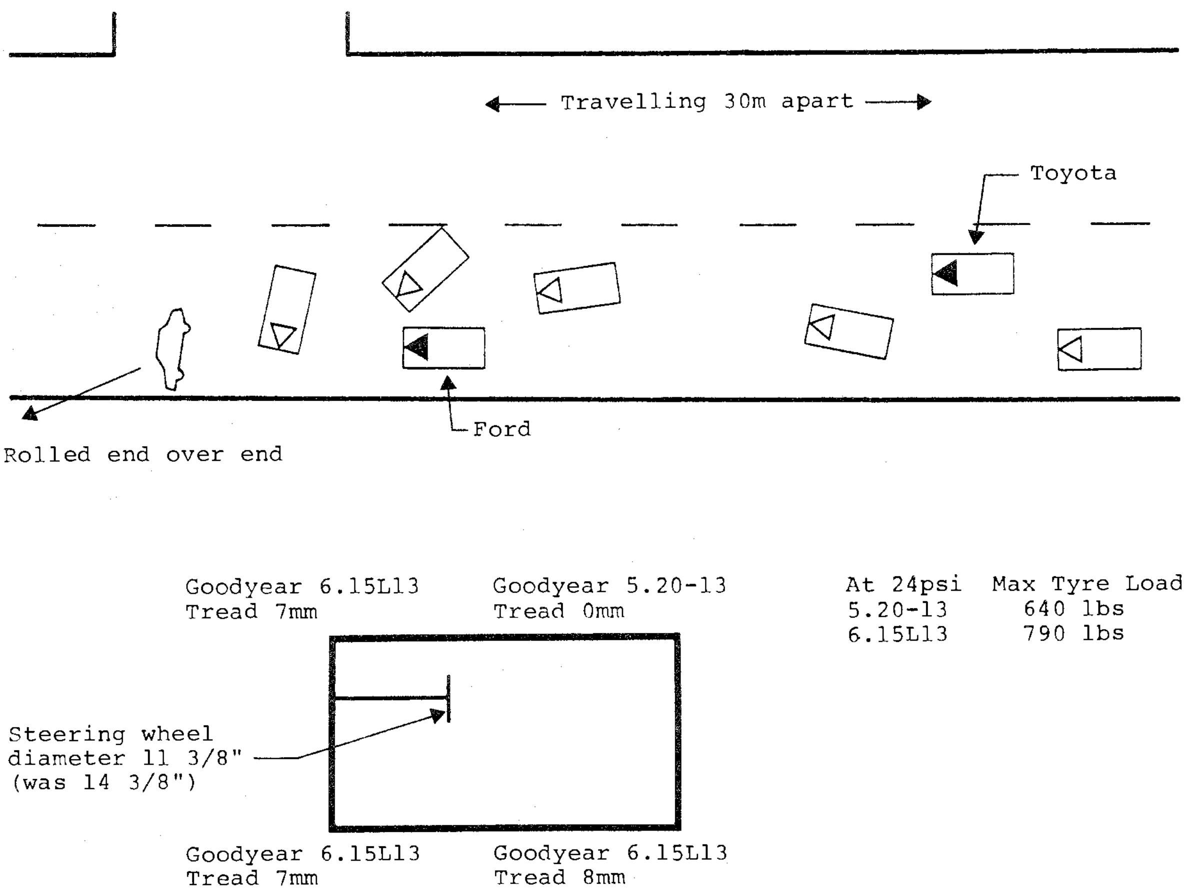


FIGURE A2.13: Accident 237: Vehicle Movements and Tyre Specifications

Possible Causal Factors

These defects were identified in vehicles which almost certainly would still have been involved in the accident had the defect not been present. Nevertheless, the defect may have contributed to the causation of the accident.

Accident 048

A 24 year old woman, driving a 1970 Morris Minor sedan, saw a Valiant sedan approaching on her left at an uncontrolled intersection. She continued on because she thought that the other car would stop. The driver of the Valiant did not see the Mini until immediately before the right front corner of his car struck the left hand door (Figure A2.14). Computer simulation of the accident (McHenry, 1971) estimated the Mini's impact speed to be 44 km/h whilst the Valiant was travelling at 30 km/h.

The possible vehicle defect contribution lies in the fact that the brake pedal on the Mini went straight to the floor when pressure was applied, a "pedal" only being achieved by pumping. There was no accident damage to the braking system or obvious fluid leaks and so it was concluded that the lack of pedal on the first stroke was due to incorrect adjustment of the brake shoes.

Other items related to the standard of maintenance of the vehicle were the right hand rear tyre running at less than 8 psi (not loaded during impact, or accident-damaged), the front wheels were of different design (1" difference in offset) and the right hand petrol tank filler pipe had not been connected to the filler cap.

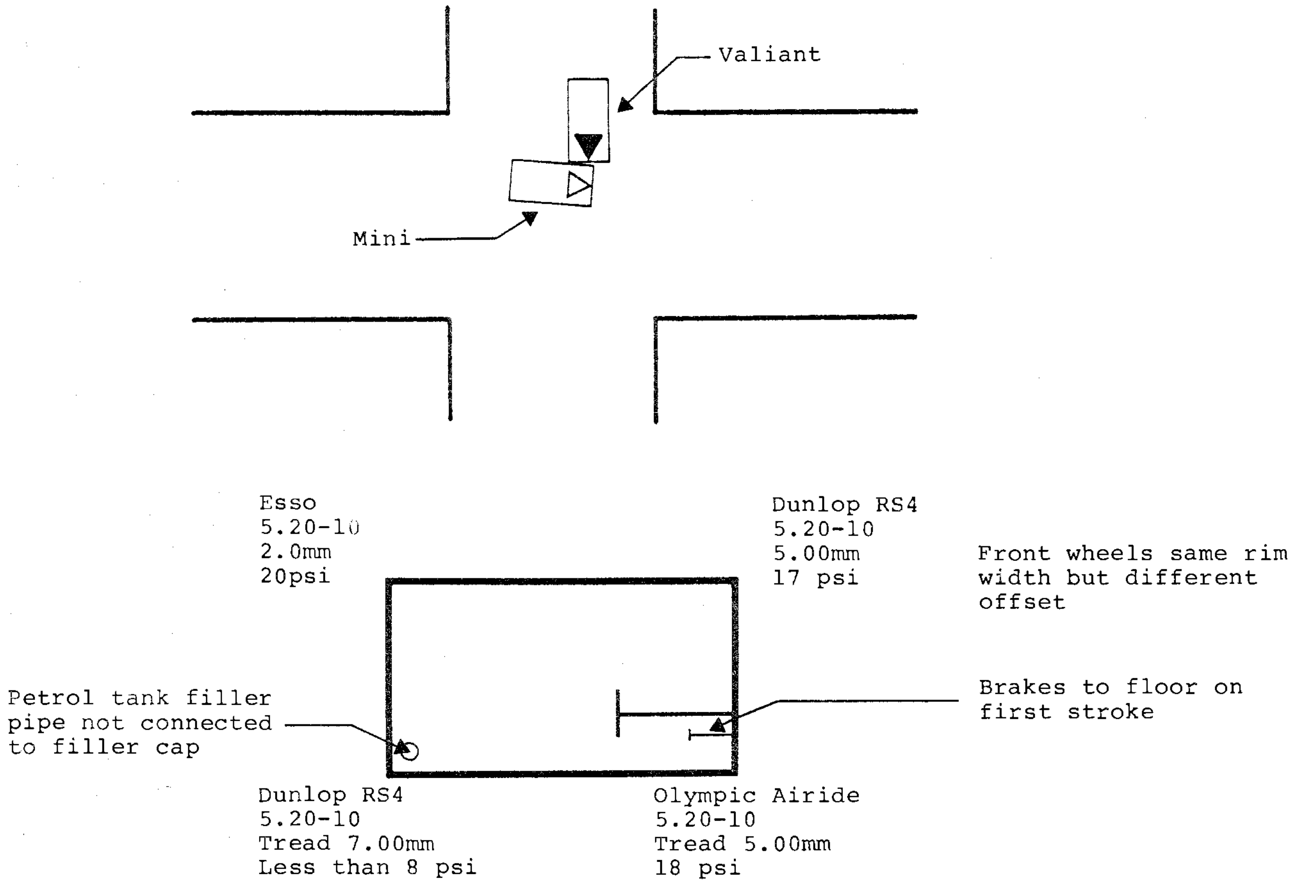


FIGURE A2:14: Accident 048: Vehicle Movements and Defects

Accident 050

A 1973 Mazda 1300 2-door sedan, driven by a 21 year old female, entered an intersection against an amber or red traffic light. A 1974 Chrysler Galant turned right across the path of the Mazda and was struck on the left hand front mudguard (Figure A2.15).

The brake pedal on the Mazda went straight to the floor on the first application, pedal resistance only being achieved by "pumping" the pedal. There was no accident damage to the braking system and it is concluded that the lack of pedal on the first stroke was due to the incorrect adjustment of the brake shoes. It is probable that this accident would have occurred regardless of this brake defect, but the severity of the impact may have been reduced had the brakes been in better condition.

The other defect on this vehicle was a right hand tyre without any tread pattern remaining.

Accident 109

A 1962 VW sedan, driven by a 53 year old female, failed to give way to a vehicle approaching on the right at an uncontrolled intersection.

The brake pedal of the VW offered no resistance when actuated, and when it was held in the fully depressed position the rear wheels could be rotated by hand.

Other defects included two bald front tyres and two front seat belts that would not remain latched (Figure A2.16).

Computer simulation of the accident (McHenry, 1971) showed the pre-impact speed for the Volkswagen to be 50 km/h. Since the safe approach to the intersection for the Volkswagen was 10 km/h, it is probable that the collision would have occurred even if the braking system had been in first class condition.

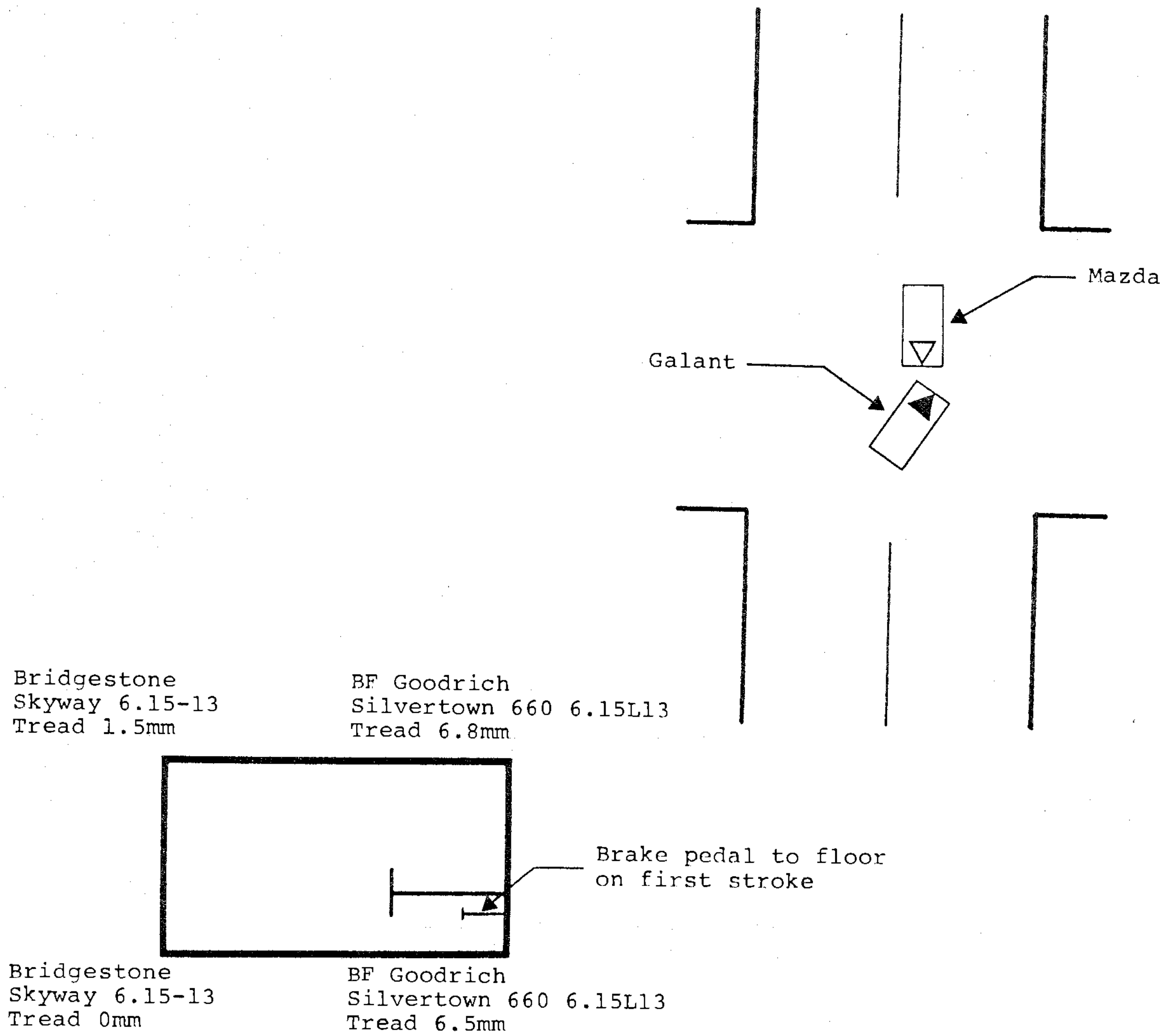


FIGURE A2.15: Accident 050: Vehicle Movements and Defects

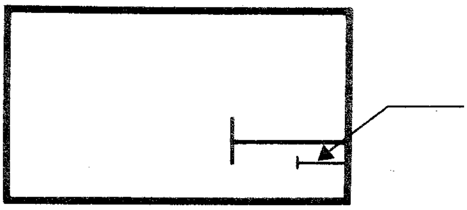


FIGURE A2.16: Accident 109: Tyre Specifications.

Accident 121

A 1963 EJ Holden, driven by a 33 year old male along a straight section of carriageway, diverged to the left, mounted the kerb and struck a large tree with the left hand front corner. Rain had fallen shortly before the research team arrived at the accident scene, but it was not possible to determine whether rain was falling at the time of the impact. This may have been relevant to the causation of the crash because the windscreen wiper blades, arms and linkages had been removed prior to the accident.

The other defect on this vehicle was a left hand front tyre on which the tread depth varied from 4mm at the outer shoulder, to 0mm at the centre and 1.5mm at the inner shoulder (Figure A2.17).

This defect was classified as a possible causal factor because of the uncertainty that the windscreen was obscured by rain and because the driver had a BAC of 0.23, which in itself would account for this type of crash.

Accident 187

A 1962 EJ Holden sedan, driven by a 26 year old male, entered an uncontrolled intersection and collided with the left side of a Valiant sedan which had approached from the right. The impact speed of the Valiant was about 70 km/h, and the impact had been preceded by 9m of locked-wheel braking (rear brakes only). The impact speed of the Holden was 45 km/h, after a minimal distance (0.3m) of locked-wheel braking. The safe approach speed for the Holden was 21 km/h.

The brake pedal on the Holden had to be depressed 110mm before any resistance was felt and then the pedal had to be pumped to maintain pedal height.

Other defects on the Holden were 40° of freeplay of the steering wheel and a broken turn signal lamp switch.

The possibility of the defective brakes on the Holden being relevant to the accident lies in the high speed of the Valiant and the evidence of pre-impact

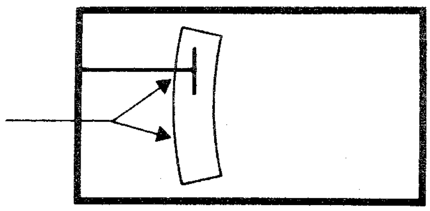


FIGURE A2.17: Accident 021: Vehicle Defects braking of the Holden. Given the impact speeds of the vehicles, the point of impact of the Holden on the left hand front door of the Valiant and the dimensions of the vehicles, it can be shown that the time required for the Valiant to clear the path of the Holden was of the order of 0.18 seconds. It is possible that if the Holden braking system had been in order the driver may have been able to have avoided the collision had he been anticipating the presence of the other vehicle and been ready to brake.