ADELAIDE IN-DEPTH ACCIDENT STUDY

1975-1979

PART 4: MOTORCYCLE ACCIDENTS

by

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ABSTRACT : This report contains descriptions of the causes and consequences of the accidents involving motorcycles in a representative sample of road traffic accidents to which an ambulance was called in metropolitan Adelaide. Reviews of the relevant characteristics of the motorcyclists and drivers, and of the motorcycles, are also included. The role of road and traffic factors is discussed in more detail in a separate report in this series. Sixty-eight, or 22 per cent of the accidents in this survey involved a motorcycle. Most of the riders were young males, many of whom were inexperienced in riding a motorcycle in traffic, and alcohol intoxication was a major factor in those accidents which occurred at night. Few riders were able to make full use of the braking capabilities of their motorcycle in an emergency, and changes are recommended in the method of brake actuation and in motorcycle licence tests. Ninety-six per cent of the motorcyclists were injured. Severe head injuries were less common than were severe injuries to the lower limbs, reflecting the use of effective crash helmets and the high risk of the motorcyclist being struck on the leg in a collision.

*Non IRRD Keywords

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.

ACKNOWLEDGEMENTS

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 attended 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.

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.

The sponsorship and advice of the Office of Road Safety of the Commonwealth Department of Transport and the Australian Road Research Board are gratefully acknowledged.

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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 Department 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 (Part 1: An Overview) together with a review of the types of accidents investigated and an outline of the general conclusions.

This report contains a brief summary of the 68 motorcycle accidents in this sample of accidents to which an ambulance was called. Most of these motorcycle accidents are described in a companion report that deals with road and traffic factors (Part 7) and so there is no section on these factors in this report. Some other accidents involving motorcycles are reviewed in the reports on pedestrian and pedal cycle accidents (Parts 2 and 3). The summary of these motorcycle accidents is followed by a detailed review of the characteristics of the riders who were involved, and a concise presentation of certain characteristics of the drivers whose vehicles collided with a motorcycle. The role of the motorcycle itself in accident causation is then discussed, and the consequences of these motorcycle accidents are considered, with particular emphasis on the nature, severity and causes of the injuries sustained by the riders and pillion passengers. The final sections of the report contain the conclusions and recommendations.

It will be apparent that some factors are reported on in isolation, with little or no discussion of their possible interaction with other factors. This largely single-variate approach has been selected because it was thought to be preferable, with the limited resources at our disposal, to present a reasonably comprehensive view of the range and detail of the information that has been collected rather than to concentrate on a more rigorous investigation of a few specific topics. This means that there is much more that can usefully be done with this information.

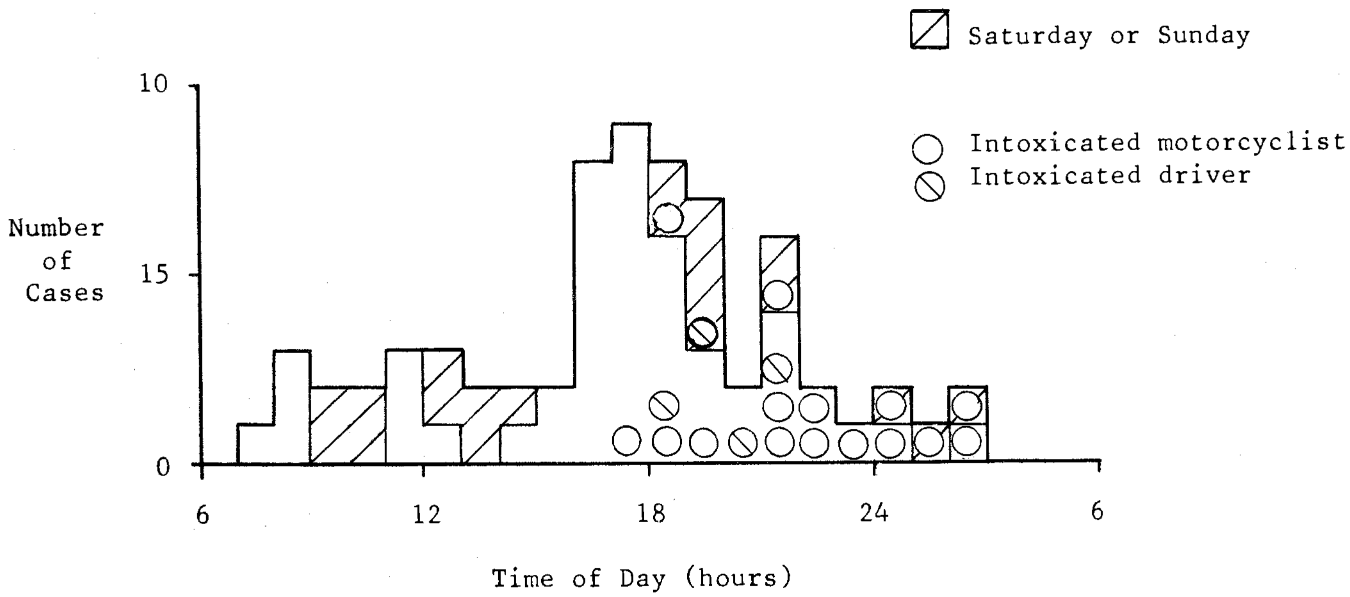


FIGURE 1: Time of day, day of week and alcohol involvement for motorcycle accidents.

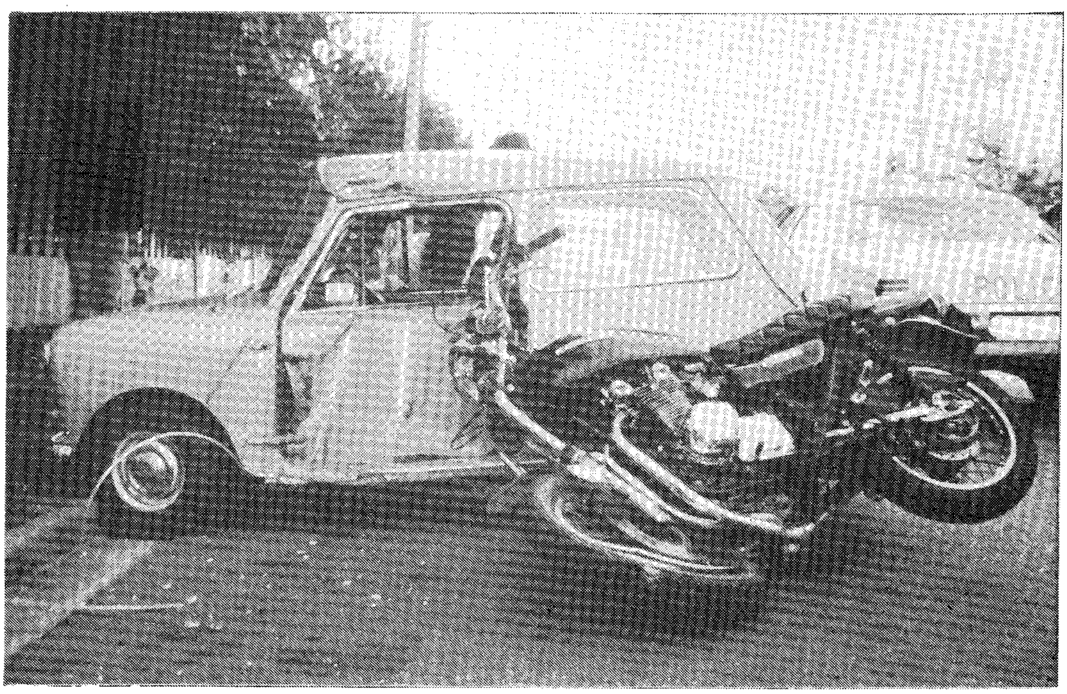


FIGURE 2: Car swerved to right to avoid another car, was struck by oncoming motorcycle. Accident 038.

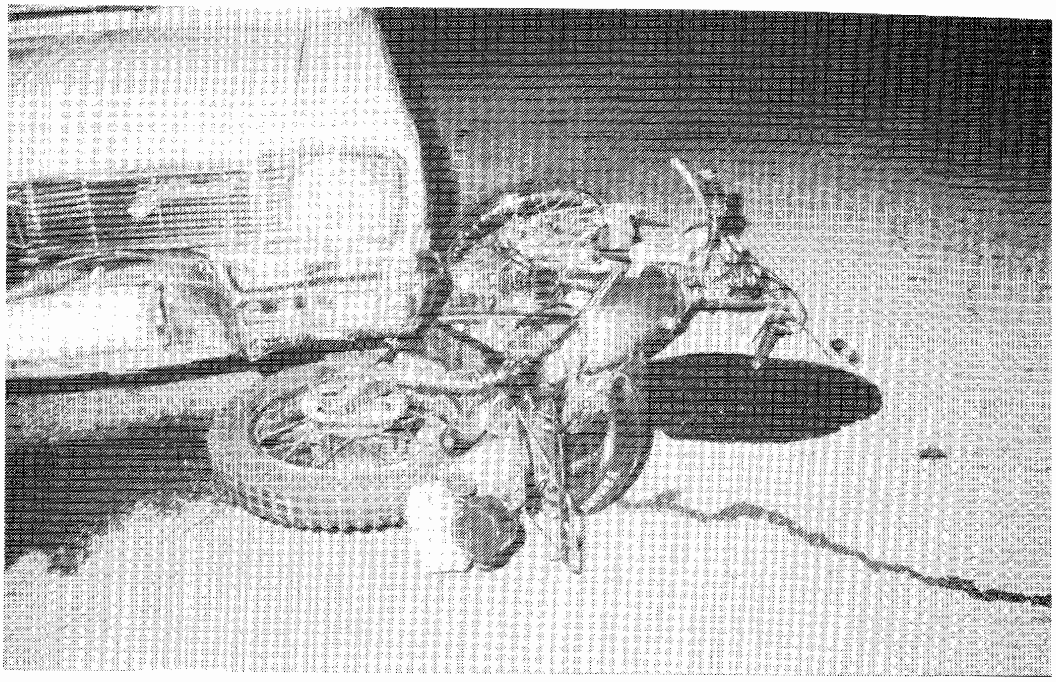


FIGURE 3: Car turning right struck motorcycle which was crossing the intersection from its right. Accident 102.

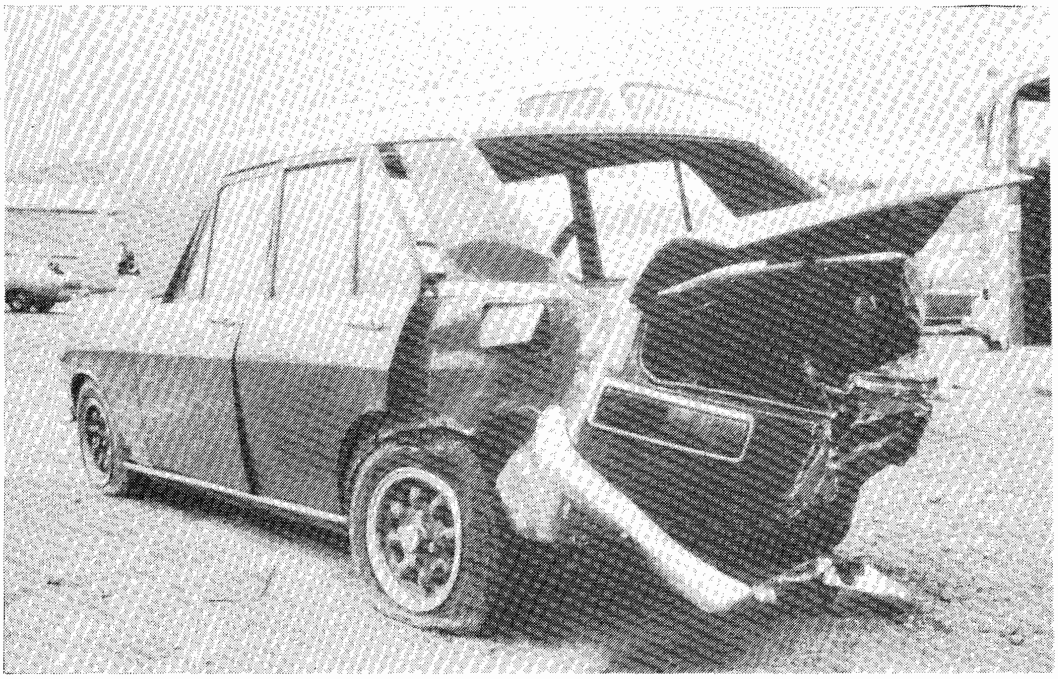


FIGURE 4: Damage due to impact by motorcycle (behind left rear wheel) and subsequent collision with stationary car. See also Figures 5 and 6. Accident 167.

2. THE ACCIDENTS

Sixty-eight accidents, involving 69 motorcycles and riders and 11 pillion passengers, are discussed in this report. One other motorcycle which was marginally involved, as a stationary vehicle, in a chain collision is not included.

2.1 TIME OF DAY, DAY OF WEEK AND ALCOHOL USAGE

The distribution of these accidents by time of day, with weekend cases indicated separately, is shown in Figure 1. Those accidents in which a blood alcohol (BAC) reading above .04 was obtained are also noted. It is apparent in this Figure that almost half of the accidents occurred between 4 p.m. and 8 p.m., and that alcohol was involved in 81 per cent of the accidents after 8 p.m. The role of alcohol intoxication is discussed in detail in Section 3.2.1.

2.2 TYPES OF ACCIDENTS INVOLVING MOTORCYCLES

Table 1 lists the number of these accidents for each category of road layout and type of traffic control. It can be seen that about 40 per cent of these cases occurred at uncontrolled midblock locations.

The type of accident, classified in terms of the initial event, is listed in Table 2. Two-thirds of the accidents were collisions with other moving or, in a few instances, stationary vehicles. The vehicle movements involved in these 46 collisions with other vehicles are presented in Table 3. Rows (1) to (5) in that Table refer to accidents in which the motorcyclist would, in most cases, be considered to have been at fault in the legal sense. Two probable exceptions to this are presented in the first row under 'sign-controlled intersections'. In these two accidents the other vehicle did not give way at a STOP or a GIVE WAY sign. The other vehicle should have yielded to, or otherwise avoided the motorcycle in all of the remaining accidents, listed in rows (6) to (17). In other words, in 36 of these 46 collisions between a motorcycle and another vehicle the other vehicle should have yielded to the motorcycle. Accident causation is rarely simply a matter of which participant was 'in the right', however, and the reader is urged to refer to the descriptions of particular accidents which are presented in the other reports in this series, as noted in the Introduction. The most common types of vehicle movements in the two-vehicle collisions are discussed briefly in the following paragraphs.

ONCOMING VEHICLE TURNS RIGHT, ACROSS PATH OF MOTORCYCLE

There were 13 accidents in which an oncoming vehicle turned right, across the path of the motorcycle (Vehicle Movements 8 and 15 in Table 3). The eight of these accidents that occured in daylight are of particular interest because the conspicuity of the motorcycle may have been a relevant factor. In fact one of these eight was the unintended consequence of an otherwise successful emergency evasive manoeuvre (Accident 038, Figure 2), and so the conspicuity of the motorcycle was not relevant. In three of the remaining seven daytime accidents the headlight of the motorcycle was operational and was switched on, but in each case the car driver's view of the approaching motorcycle was obstructed by cars which were either stationary, to the right of the motorcycle, or moving slowly. In the other four accidents the members of the research team were not able to determine conclusively whether or not the headlight was operational and switched on before the crash, but in three of these accidents, once again, the motorcyclist was passing slower or stationary vehicles on their left and so the car driver did not see him until the last moment before the collision, if at all.

Five of these eight daytime accidents occurred at signalised intersections. In two of these five accidents the riders were young and inexperienced, their ages being 16 and 17 years, and the periods since they had obtained a licence to ride a motorcycle being three weeks and three months respectively. Two other riders in this group were aged 17 and 18 years, and had each had a motorcycle licence for about a year. This suggests that the inexperienced rider does not understand the risks involved in travelling straight through a signalised intersection when, in so doing, he has to pass to the left of vehicles waiting to turn right. These vehicles, of course, can prevent an oncoming driver, who is intending to turn right, from seeing the motorcyclist approaching. The fifth crash at a signalised intersection did not involve any obstruction to vision. The rider in that accident was 21 years old.

OTHER VEHICLES ON MOTORCYCLIST'S LEFT AT AN INTERSECTION

In three of the seven accidents in which

TABLE 1: ACCIDENTS INVOLVING MOTORCYCLES: LOCATION AND TYPE OF TRAFFIC CONTROL

Type of Traffic Control	Location			Total
	Cross Roads	T-Junction	Midblock	
Signals	7	2(1)	-	9(1)
Sign	6(1)[1]	8(1)	-	14(2)
Roundabout	1(1)	-	-	1(1)
Roadworks	-	-	1(1)	1(1)
Uncontrolled	6	10(3)	27(11+3)[2]	43(14+3)
Total	20(2)	20(5)	28(12+3)	68(19+3)

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

[2] Number of pedestrian accidents also listed in parentheses (second figure).

TABLE 2: INITIAL EVENT IN ACCIDENTS INVOLVING MOTORCYCLES

Initial Event		Number of Accidents	
Non-collision:	Fell off	6[1]	
	Ran off road	2	8
Collision with object:			
	Kerb	3	
	Roadworks	1	
	Fallen power line	1	5
Collision with parked vehicle:			
	Car	5	
	Heavy truck	1	6
Collision with pedestrian:			3
Collision with vehicle:			
	Pedal cycle	2	
	Motorcycle	1	
	Car	40[2]	
	Light truck	1	
	Heavy truck	1	
	Semi-trailer	1	46
Total Number of Accidents:			68

Notes: [1] In one of these accidents the rider was struck by a car after falling from his motorcycle.

[2] Includes one accident in which the initial event was a collision between two cars.

the motorcycle collided with a car which had approached from the left at an intersection (Vehicle Movements 6 and 7, Table 3) the motorcyclist had just passed another vehicle on its right, and so the car driver could not see the motorcyclist in time to attempt any avoiding action that could have been effective (Accident 102, Figure 3). In one other accident the driver saw the motorcycle some distance away and thought that there was enough time to cross to the median before turning right, but the motorcyclist tried to pass in front of, rather than behind, the car (Accident 142). Another driver pulled out from the stem of a T-junction without seeing the motorcycle approaching and then appeared to have 'frozen' when she realized that a collision was likely.

One of the two accidents in which the other vehicle was proceeding straight ahead, rather than turning right, happened at a location where the driver's view to his left was severely restricted by an illegally parked vehicle, and so he was concentrating on looking for traffic which could have been approaching from that direction. The second of these two accidents was a collision at an uncontrolled intersection. It was typical of this type of collision in that by the time that the car driver saw the motorcycle it was too late to avoid a collision.

OTHER VEHICLE ON MOTORCYCLIST'S RIGHT AT AN INTERSECTION

This collision configuration is listed as Vehicle Movement 1 in Table 3. The two accidents noted under 'Sign-Controlled Intersections' were ones in which the car should have yielded to the motorcycle, although in Accident 167 (Figures 4 - 6) there was little doubt that the motorcycle was travelling at a speed well above the legal limit of 60 km/h. The rider also had a BAC of .13 which may have diminished his chances of avoiding the collision. The rider in the other crash of this type was also intoxicated (BAC .15) but the circumstances of the accident were such that a sober rider would not have had sufficient warning to have been able to have attempted any avoiding action (Accident 042, Figures 7 - 9).

The three accidents at uncontrolled intersections all involved very young motorcyclists, none of whom had more than four month's riding experience. One rider moved off from a standstill when a car on his left stopped for him. He was not looking to his right (Accident 002). Another rider saw the car on his right slow down, so he assumed that the driver was waiting for him to pass in front of the car. In fact the driver was concentrating on the road entering from her right and had not seen the motorcycle at all, possibly because she had 6/18 vision in her left eye (Accident 128). The motorcyclist in the last of these accidents entered an intersection from a little-used side street and was hit by a car which was travelling, according to the driver, at 'about 40 m.p.h.'. This driver, after the accident, insisted that that speed was 'quite safe because very little traffic crosses this street' (Accident 282).

OTHER VEHICLE TURNS RIGHT AS MOTORCYCLE ABOUT TO OVERTAKE

There were three accidents which involved a car moving off to perform a U-turn just as a motorcycle was about to pass by, and four accidents in which another moving vehicle turned right, across the path of an over-taking motorcycle. These seven accidents (see Vehicle Movements 10 and 13 in Table 3) are all discussed in the report on road and traffic factors (Part 7 in this series). The motorcyclist appeared to contribute to the causation of only one of these seven accidents and that rider, at 17 years of age, was the youngest in this group. The ages of the other riders were distributed uniformly between 18 and 27.

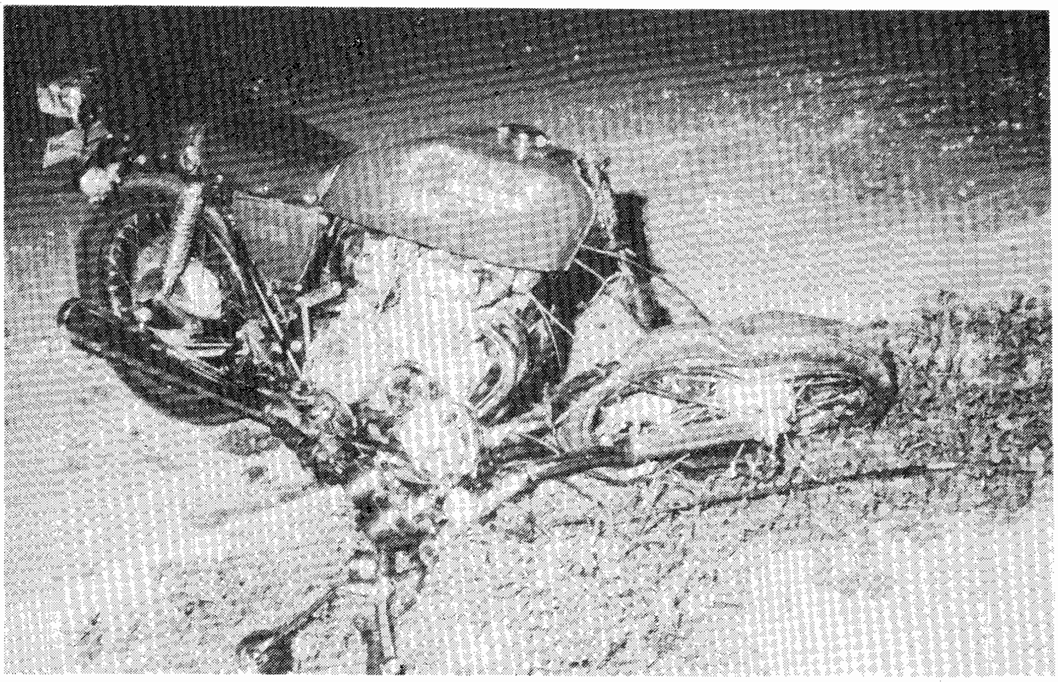


FIGURE 5: Front fork assembly detached from motorcycle after collision with car shown in Figure 4. See also Figure 6. Accident 167.

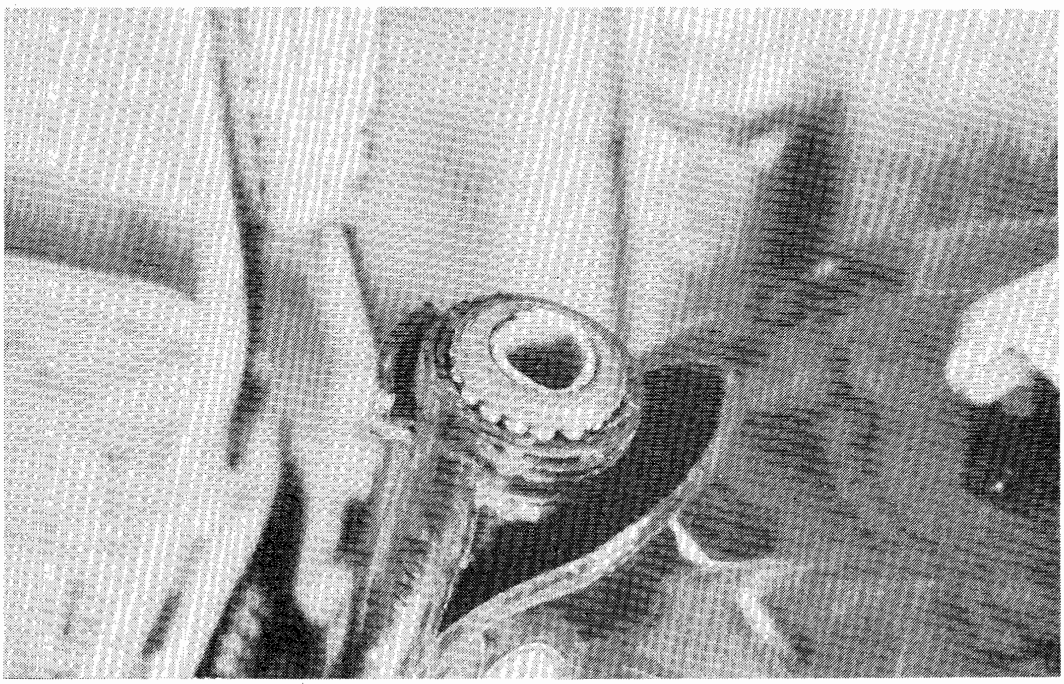


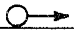
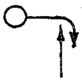
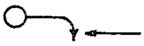
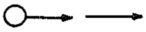
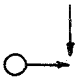
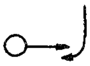
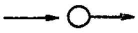
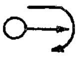
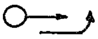
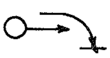
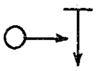
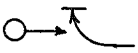
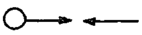
FIGURE 6: Fractured head-stem on motorcycle shown in Figure 5. Accident 167.

FIGURE 7: Car struck by motorcycle shown in Figure 8. Initial impact by front wheel of motorcycle was just behind the front edge of the front door. Damage to roof was largely due to impact from rider and passenger. See also Figure 9. Accident 042.

FIGURE 8:

Damage to motorcycle which struck car shown in Figures 7 and 9. Note front wheel deformed to left. Accident 042.

TABLE 3: VEHICLE MOVEMENTS IN COLLISIONS INVOLVING MOTORCYCLES

Vehicle Movements (motorcycle: )		Type of Traffic Control and Location				
		Intersection			Midlock	
		Signalised	Sign-controlled	Uncontrolled	Uncontrolled	Total
(1)		-	042, 167	002, 128 282	-	5
(2)		127[2]	-	-	-	1
(3)		-	292	-	-	1
(4)		223	-	-	-	1
(5)		-	159	039	015, 243	4
(6)		-	089	261	-	2
(7)		-	139, 142	102, 278 279	-	5
(8)		073, 095 143, 234 295	098, 249 303	038, 101 112, 274	-	12
(9)		-	-	201	-	1
(10)		-	-	-	032, 134 281	3
(11)		014	-	-	-	1
(12)		-	-	-	248	1
(13)		-	-	-	215, 255 297, 298	4
(14)		-	219	-	092	2
(15)		-	-	-	078	1
(16)		-	082	-	-	1
(17)		-	-	-	043	1
Total Number of Accidents		8	12	13	13	46

Notes: [1]  and  indicate vehicle entering and leaving roadway.

[2] Numbers listed in the body of the Table designate specific accidents.

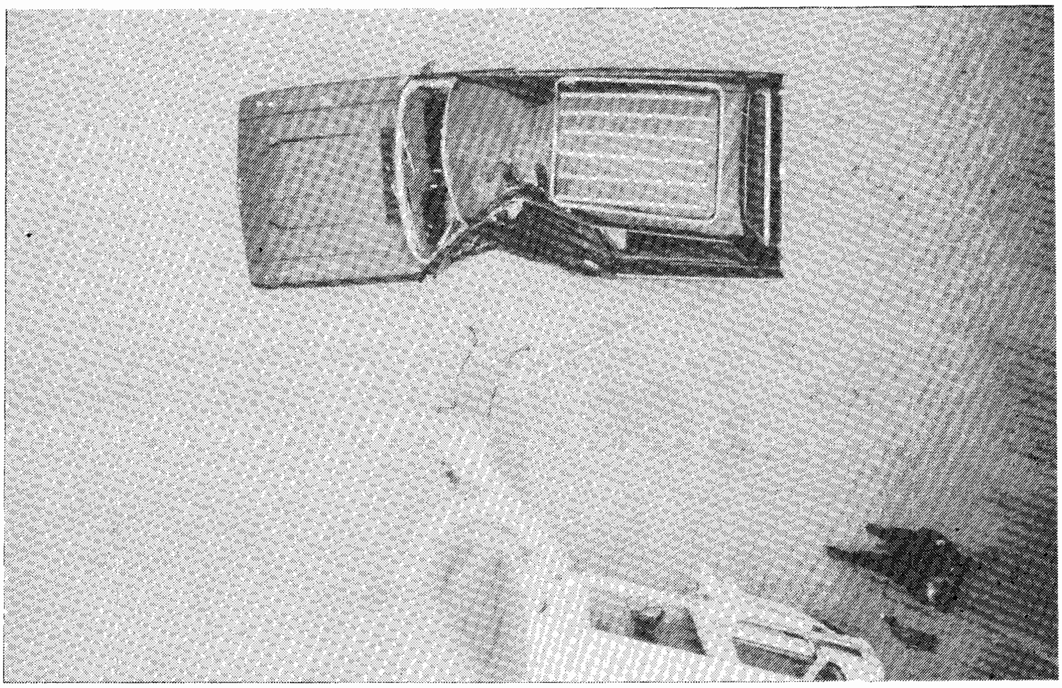


FIGURE 9: Damage to car shown in Figure 7. Accident 042.

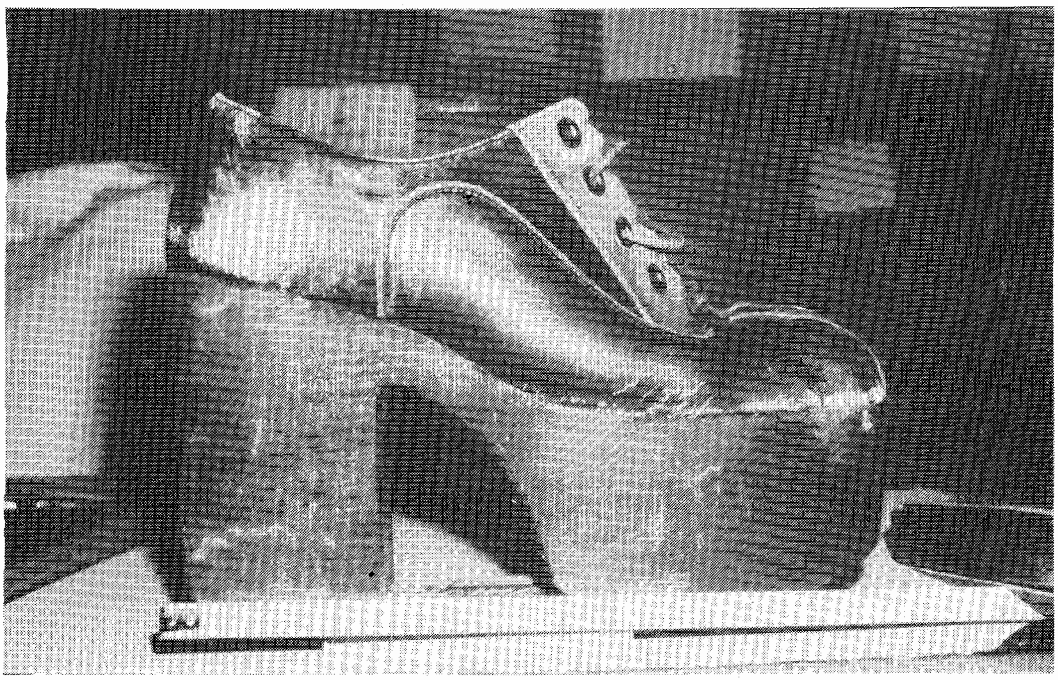


FIGURE 10: Shoe worn by rider in Accident 085.

3. CHARACTERISTICS OF THE MOTORCYCLE RIDERS

This section contains a review of the characteristics of the 69 motorcycle riders who were involved in the 68 accidents which are discussed in the previous section and in companion reports. Pillion passengers are not included in this section.

3.1 MOTORCYCLE RIDERS: DEMOGRAPHIC CHARACTERISTICS

AGE, SEX AND MARITAL STATUS

The age and sex distributions for these 69 riders are shown in Table 4, where it can be seen that only one rider was over 34 years of age and that 83 per cent were under 25 years of age. This percentage is greater than would be expected if these riders were randomly selected from all licensed motorcyclists in South Australia. In other words, the riders in these accidents were a younger group than were licensed motorcyclists in general. This difference, which was unlikely to have been due to chance, was repeated for each year of age from 16 to 20; the accident sample had a higher proportion of young riders than did the population of licensed motorcyclists (Table 5). However it should be noted that the licensed population almost certainly includes many older persons who no longer, or rarely, ride motorcycles. Seven, or about ten per cent, of the 69 riders in this survey were females. Had these riders, once again, been randomly selected from persons holding a motorcycle licence then a greater number of female riders would have been expected (about 14.5 per cent). This difference could readily have arisen by chance, but in any event the licensed population may not accurately represent the motorcyclists who are actually out on the roads, as noted above.

The information on the blood alcohol levels of the accident-involved riders which is listed in Table 4 is discussed under the heading of 'Alcohol' later in this section.

The statistics relating to the marital status of these motorcyclists were consistent with general expectations based on their age distribution and, as such, do not warrant further comment.

EDUCATIONAL AND OCCUPATIONAL STATUS

The educational and occupational status of these riders is shown in Table 6. These data point to the prominence of young unskilled, semi-skilled and skilled workers, with their associated educational backgrounds, among the accident-involved riders. No information was available on relative distances ridden, or other measures of exposure to risk, but about 75 per cent of the riders were in these categories, whereas the only available population statistics for South Australia, derived from the 1971 census, indicated that person from these occupational categories comprised about 50 per cent of the employed population. It is possible that these data merely reflect a preference of young, unskilled, semi-skilled, or skilled males for motorcycles, either as a comparatively cheap form of transport, or as a way of expressing themselves.

If economic considerations were of primary importance, it might be expected that these individuals would prefer smaller capacity, and hence often cheaper, motorcycles. Yet, among the 51 motorcyclists in these three occupational categories (i.e. unskilled, semi-skilled and skilled) only 18 were riding motorcycles of capacity of 250cc or less. Although these observations are not conclusive, they do suggest that financial considerations alone cannot account for the strong representation of these individuals in this accident sample.

Further support for this suggestion is provided by the results obtained by asking these riders why they chose to purchase the motorcycle that they were riding at the time of the accident. Only seven of these 51 riders listed the economy associated with the purchase price among the reasons for buying a motorcycle in preference to a car, and only thirteen listed the economical performance of a motorcycle among their reasons. It is interesting to contrast this group of individuals with those riders who were students. Six of the seven students involved in these motorcycle accidents were riding machines of no greater than 250cc capacity. Also, though information relating to vehicle preference was only available for three students, the economy associated with purchasing and running a motorcycle was cited by all three.

The apparent excess of young unskilled, semi-skilled and skilled workers in this sample may also be due in part to their having been exposed to the risk of being involved in an accident more than were the riders in other occupational categories. Each rider was asked to estimate the usual distance that he travelled on his motorcycle each week, and the riders in the listed occupations averaged about 270 km compared to about 200 km for the other riders.

TABLE 4: MOTORCYCLE RIDERS: AGE, SEX AND ALCOHOL

Age (years)	Sex		Total	
	Male	Female	No.	%
Less than 16	-	-	-	-
16	8*	-	8	11.6
17	8	-	8	11.6
18	5	-	5	7.2
19	8*	2	10	14.5
20	6**	1	7	10.1
21	4#*[1]	3	7	10.1
22	4##**	-	4	5.8
23	5***	-	5	7.2
24	3*	-	3	4.3
25 - 29	6**	-	6	8.7
30 - 34	4	1	5	7.2
35 - 44	-	-	-	-
45 - 49	1	-	1	1.4
More than 49	-	-	-	-
Total	62	7	69	100.0[2]

Notes: [1] Each # indicates one rider with positive BAC but less than .08, and each * indicates one rider with BAC greater than .08.

[2] Percentages do not total 100.0 because of rounding errors.

TABLE 5: AGE DISTRIBUTIONS OF RIDERS IN THESE ACCIDENTS AND ALL LICENSED RIDERS

Age (years)	Percentage of Total: Accident Sample (A)	Percentage of Total: All Licensed Riders (B)	A/B
16	11.6	1.1	10.5
17	11.6	2.3	5.0
18	7.2	3.0	2.4
19	14.5	3.8	3.8
20	10.1	4.5	2.2
21	10.1	5.2	1.9
22	5.8	5.4	1.1
23	7.2	5.2	1.4
24	4.3	5.1	0.8
25 - 29	8.7	19.5	0.4
30+	8.7	45.0	0.2
Total %	100.0	100.0	-
Total No.	69	94,154	-

Note: Percentages may not add to 100.0 because of rounding errors.

TABLE 6: EDUCATIONAL AND OCCUPATIONAL STATUS OF RIDERS INVOLVED IN ACCIDENTS

Educational Status	Occupational Status: Student	Unskilled	Skilled, Semi-skilled	Office or sales	Professional	Total
Post-primary	1	20*	21*	5	-	47
Current secondary	4	-	-	-	-	4
Secondary	-	1	5	3	-	9
Post-secondary	-	-	1	-	-	1
Current tertiary	2	-	-	-	-	2
Graduate	-	-	-	-	3*	3
Unknown	-	2	1	-	-	3
Total	7	23	28	8	3	69

Note: Each asterisk denotes one person then unemployed.

3.2 MOTORCYCLE RIDERS: PHYSIOLOGICAL CONDITIONS

3.2.1 ALCOHOL INTOXICATION

SELF-REPORTED DRINKING BEFORE THE ACCIDENT

Alcohol consumption in the twelve hour period prior to the accident was acknowledged by, or in evidence for, 21 motorcyclists. Thirteen of these motorcyclists had been drinking at hotels, five at the homes of friends or relatives, one at home, and one at a sporting ground. It was not known where one motorcyclist had been drinking prior to the accident. Five motorcyclists had stopped drinking from between three and nine hours before the accident. Four of these persons recorded BAC (blood alcohol, or breath alcohol estimate) readings of zero, and the BAC for the other person was unavailable. The reported quantities of alcohol consumption are shown in Table 7. These quantities are defined in terms of number of glasses consumed, each glass being approximately equivalent in terms of alcohol content to one 8oz glass of beer. The types of alcoholic beverages which these riders said they usually consumed are listed in Table 8.

BLOOD ALCOHOL (BAC) LEVELS

Sixty motorcycle riders were taken to hospital as a consequence of the accident, and blood samples for the determination of alcohol content were taken from all of them. The recorded BAC for one of these riders was unavailable, although he reported that he had consumed two glasses of beer more than three hours before the accident. This persons did not appear to be intoxicated when interviewed at the hospital shortly after the accident.

Breath alcohol readings were obtained by the research team from each of the nine riders who were not taken to hospital. Eight of these readings were zero, and one was .10. The police did not attend the scene of one of these nine accidents, and did not request a breath sample from any of the other eight riders.

The BAC levels for 68 of the 69 riders are listed in Table 9. Sixteen riders recorded positive levels, of which 13 exceeded the legal limit of .08, and only one, at .02, was below .05. A number of studies have shown a deterioration in performance on a variety of simulated or actual driving tasks at BAC levels below .05 (e.g. Laurell, 1977). Thus alcohol intoxication may have been, to varying degrees, a significant factor underlying the accident involvement of as many as 15, or about 22 per cent, of these motorcyclists.

Generally, the reported alcohol consumption, coupled with the period over which alcohol had been consumed, was consistent with the recorded BAC. Two riders cited amounts which were well below expectations based on their recorded levels, and another two had some difficulty in accurately recalling the amount of alcohol they had consumed.

ALCOHOL AND TYPE OF ACCIDENT

Among the 16 riders who recorded positive alcohol levels, ten were involved in single vehicle accidents (although one of these riders was struck by a car after he had fallen from his motorcycle). On the other hand, only nine of the other 53 riders were involved in single vehicle collisions. This observation that accidents in which intoxicated riders are involved are more likely to be single vehicle collisions ($p < 0.01$) is in line with previous studies (e.g. Voas, 1973).

If it is assumed that the general performance of the intoxicated rider is impaired, and there is considerable evidence to indicate an impairment of the associated fundamental skills, then it may be that the probability that a single vehicle accident (e.g. run off road, slide down, etc.) may occur is increased more than the probability of involvement in a multivehicle accident. However, since based on general drinking patterns it is more likely that an intoxicated motorcyclist will be riding later at night when other traffic is relatively scarce, it would seem that the risk of being involved in a single vehicle accident, compared with that of colliding with another vehicle, is relatively greater simply because of this temporal association. In this respect it was notable that the single vehicle accidents involving intoxicated riders all occurred at night after 9 p.m., and six of these accidents occurred after 11.30 p.m. In contrast, five of the six multivehicle accidents involving an intoxicated rider occurred before 8 p.m., while the other occurred at about 10 p.m.

However, although it seems possible that intoxicated motorcyclists may be more likely to be involved in a single vehicle, rather than a multivehicle accident, the above observations do not provide any understanding of the mechanisms underlying this type of accident involvement. The following section will consider some of the possible mechanisms of the alcohol effects underlying single vehicle accident involvement. Unfortunately the difficulties associated with the interpretation of such a small number of accidents are exaggerated by the fact that very little information was available for six motorcyclists. Three of these riders died as a result of injuries sustained in the accident, while the other three could recall very little of the pre-accident circumstances. Nevertheless, despite the limited number of accidents on which the following section is based such

TABLE 7: AMOUNT OF ALCOHOL CONSUMED BY MOTORCYCLE RIDERS IN TWELVE HOURS PRECEDING CRASH

Amount of Alcohol Consumed (Self-Reporting)	Number of Riders
2 glasses	5***
3 glasses	3*
5 glasses	1
6 glasses	1*
8 glasses	2
10 glasses	2
12 glasses	2
18 glasses	1
Considerable quantity: amount unknown)	4
Not applicable (not known to have been drinking)	48
Total	69

Note: Each asterisk denotes one motorcyclist had stopped drinking at least three hours before the accident.

TABLE 8: TYPE OF ALCOHOLIC BEVERAGE USUALLY CONSUMED

Type of Alcoholic Beverage	Number of Riders	
	All Riders	Riders with positive BAC
None	7	-
Beer	41	15
Wine	4	-
Fortified Wine	-	-
Spirits	12	-
Unknown	5	1
Total	69	16

TABLE 9: BLOOD ALCOHOL LEVELS OF MOTORCYCLE RIDERS

BAC Level	Number of Riders
.00	52
.02	1
.05	1
.07	1
.10	1
.11	1
.12	1
.13	1
.14	1
.15	2
.16	1
.17	2
.20	1
.22	2
Unknown	1
Total	69

speculation may be useful for subsequent researchers in that it may lead to the generation of further viable hypotheses regarding the manner in which alcohol increases accident risk. This is in line with Moskowitz's (1973) suggestion regarding the potential usefulness of information obtained from in-depth studies of alcohol-related crashes.

POSSIBLE MECHANISMS OF THE EFFECT OF ALCOHOL ON ACCIDENT INVOLVEMENT

As noted in the Introduction, the limited resources available to us forced a decision to present as much as possible of the available data at the expense of not being able to investigate, at this stage, many potentially important interactions between relevant factors. Consequently the discussion in this section is at the level of relating specific accidents to certain effects of alcohol on performance, as reported in the literature. It is not intended to be conclusive, but rather to indicate what more comprehensive analyses might be based on these data. Similarly it is not suggested that the mechanisms discussed here are the only ones of interest, but rather that they are among those that may have some relevance to the accidents listed.

Mortimer and Sturgis (1975) cited results which suggest that a possible effect of alcohol intoxication is a change in the cue structure used by the driver for lateral control and this involves a reduced emphasis on cues to heading angle and yaw rate. The outcome of this is an increase in lateral position and heading angle errors which are exaggerated by a reduced responsiveness in steering wheel manipulation. The limited information available regarding the pre-accident circumstances indicates that the paths followed by the motorcycle in four of the single vehicle accidents in this sample (Accidents 010, 034, 045, 289) were consistent with the operation of the mechanisms described by these authors. In these accidents the motorcycle either ran off the left side of the road before striking some fixed object, or strayed toward the middle of the road and collided with a median or traffic island. It was notable that one of these motorcyclists (Accident 289) and two others (Accidents 118, 155) appeared to travel, partially out of control, for a considerable distance after leaving the carriageway and before they collided with a fixed object.

This observation suggests at least two interpretations. One possibility is that intoxicated persons may take much longer to initiate a corrective or emergency response to a deviation from the intended path; i.e. they merely take longer to make the translation from the initial loss of control to the appropriate corrective or emergency response. Another possibility is that the intoxicated rider may tend to take greater risks, and try to correct the path of the motorcycle, for example, rather than applying the brakes. Some doubt surrounds the latter interpretation since it has been shown that small financial rewards reduce alcohol-intoxicated risk taking (Snapper and Edwards, 1972), a finding which suggests that although the ability of the rider to control the vehicle may be impaired by alcohol, the judgement of the likelihood of successfully controlling the vehicle may not be impaired.

Another motorcyclist (Accident 217) struck the rear of a parked car which he had detected only fractionally before the impact. Some distance prior to the accident site this person had sneezed, and subsequently had been wiping his nose and eyes. When he completed this secondary activity, he looked up and noticed the parked car. It is possible that even a routine secondary activity may interfere significantly with the primary task performance of an intoxicated person since such a person may take longer and may be preoccupied more fully with the performance of such an activity. Consequently, the monitoring of, and responsiveness to, information relevant to the effective maintenance of the primary task may be impaired. While it is difficult to assess the importance of the effect of alcohol on the interaction of two different activities in this situation, it has been noted in divided attention experiments that alcohol can affect the task not being concentrated on, even though it may cause no decrement to that task when it is performed alone (Moskowitz, 1973).

Five motorcycle riders with recorded BACs of .05 or greater collided with other vehicles. Among these motorcyclists were two (Accident 042, 167) who collided with vehicles which were crossing their paths from the right at an intersection. It was lilely that both motorcyclists were exceeding the speed limit as they approached the accident site. Apparently neither motorcyclist had detected the other vehicle until shortly before the impact, although both motorcyclists did have priority over intersecting traffic. These circumstances may be consistent with findings which suggest that alcohol produces significant reductions in dynamic visual acuity (Brown *et al.*, 1975), but the available sight distance was such that by the time that these riders could see the other vehicle a collision was probably inevitable. Another two motorcyclists (Accidents 159, 243) collided with vehicles in front of them after having moved into traffic lanes adjacent to those in which they had been travelling. Neither motorcyclist had detected the other vehicle until he had entered the adjacent lane. The responses of both motorcyclists were consistent with results that indicate that intoxicated drivers tend to narrow their eye movements within the visual field, increase the latency of individual fixations, and reduce the distance of fixations ahead of the vehicle (Mortimer and Jorgeson, 1972).

The fifth intoxicated motorcyclist (Accident 274) collided with the front of a car which had begun to turn right, across his path, and then stopped. The motorcyclist applied his rear brake only, and his machine then slid down before colliding with the car. It seems likely that he may have avoided the collision if he had applied the front brake. The car had stopped, and there was sufficient space on either side of the car to allow the motorcycle to pass, but it appeared that the motorcyclist, having commenced his emergency action, was committed to that action and unable to initiate a more appropriate course of evasive action. This particular reaction in an emergency was also observed among sober riders, but it is possible that the greater difficulty in making decisions in response to a signal while still carrying out movements in response to a previous signal (that has been identified by Welford (1958) as one of the consequences of the central processing limitations known to accompany old age) may also be a manifestation of the impairments of central processing efficiency that may accompany alcohol intoxication.

These reported effects of alcohol on performance provide some indication of the possible mechanisms of such effects, although the correspondence of these effects with observed pre-accident circumstances can be suggested only tentatively.

USUAL FREQUENCY OF ALCOHOL CONSUMPTION

The following section is concerned with a comparison of the self-reported general alcohol consumption habits of the intoxicated motorcyclists with the other motorcyclists in the sample. The usual frequency of alcohol consumption and the average amounts consumed are shown in Tables 10 and 11 respectively. The general alcohol consumption habits were not known for three of the motorcyclists who were known to have been consuming alcohol prior to the accident. These motorcyclists were males, one aged 22 years and two who were 23 years of age. The other thirteen motorcyclists who had been drinking before the accident were males, ten of whom were aged between 19 and 24 years. The others were aged 16, 27 and 29 years.

As shown in Table 10, four of these motorcyclists reported that they consumed alcohol at least once a week, nine from two to four occasions per week, and two others reportedly drank more frequently. As was the case for the intoxicated pedestrians, all of these motorcyclists were beer drinkers. Excluding individuals who never consumed alcohol, those motorcyclists who had positive BACs consumed alcohol more frequently (i.e. $\geqslant 1$ per week) than those who had a BAC of zero (Table 11).

With four exceptions those riders who recorded positive alcohol levels reported that they regularly consumed amounts of alcohol equivalent to ten glasses or more. Among those motorcyclists who reported that they usually consumed lesser amounts were two for whom, based on other evidence, these amounts almost certainly underestimated their actual drinking patterns. Again, as Table 12 suggests, excluding those individuals who never consumed alcohol, motorcyclists who recorded positive alcohol levels consumed, on average, greater quantities of alcohol, the criterion being ten or more glasses, than those who recorded alcohol levels of zero (Chi-square = 5.34, df = 1, $p < .05$). Taken together these comparisons again indicate a distinct history of regular and substantial alcohol consumption among those motorcyclists who recorded positive BACs when tested after the accident.

Nine of the sixteen motorcyclists who recorded positive blood alcohol levels said that they regularly, or at least occasionally, rode their machines after they had consumed about ten or more glasses of alcoholic beverages. Five of the remaining seven riders recorded blood alcohol levels above .13, and so it is evident that they, too, rode when intoxicated. Furthermore, at least one third of those persons who had a zero BAC reading also followed such a pattern because, although they said that they usually consumed only a relatively small amount of alcohol, they intimated that at times they would ride after having drunk more than their usual amount. Together, therefore, about 43 per cent of these accident-involved riders occasionally (some of them regularly) rode their motorcycles when intoxicated. It may be that associated with such a behaviour pattern is a style of riding that in itself leads to an increased likelihood of accident involvement.

Nine of the 13 riders who had a BAC level above the legal limit of .08 had had their driving licence suspended on at least one occasion, whereas only 14 of the remaining 54 riders (for whom this information was available) had incurred previous licence suspensions.

3.2.2 PRESCRIPTION AND NON-PRESCRIPTION DRUGS

Self-reported information regarding the use of prescription or non-prescription drugs was available for all but one motorcyclist. Three riders were taking a prescribed drug for minor medical conditions, and one was using a non-prescription drug. None of these drugs would be expected to impair the rider's performance and, furthermore, no impairment was in evidence. Although in one case (Accident 034) alcohol also had been consumed by the motorcyclist, the drug taken was not incompatible with alcohol.

TABLE 10: USUAL FREQUENCY OF ALCOHOL CONSUMPTION FOR MOTORCYCLE RIDERS WITH POSITIVE AND ZERO ALCOHOL LEVELS

Usual Frequency of Alcohol Consumption (Self-Reported)	Number of Riders with: Positive Alcohol Levels	Zero Alcohol Levels
Never	-	7
Hardly ever	-	1
Less than once/month	-	4
Once/month	-	5
Once/fortnight	-	4
Once/week	4	7
2-4 times/week	9	21
More than 4 times/week	2	2
Unknown	1	2
Total	16	53

TABLE 11. USUAL FREQUENCY OF ALCOHOL CONSUMPTION EXCLUDING NON-DRINKERS (FROM TABLE 10)

Usual Frequency of Alcohol Consumption	Number of Riders with: Positive Alcohol Levels	Zero Alcohol Levels	Total
Less than once/week	0	14	14
Once/week or more often	15	30	45
Total	15	44	59

(Chi square = 4.62, $p < .05$)

TABLE 12: USUAL AMOUNT OF ALCOHOL CONSUMPTION BY MOTORCYCLE RIDERS WITH POSITIVE AND ZERO ALCOHOL LEVELS

Usual Amount of Alcohol Consumption Per Drinking Session (Self-Reported)		Number of Riders with: Positive Alcohol Level	Zero Alcohol Level
1 glass		-	1
2 glasses		-	6
3 glasses		-	4
4 glasses		1	3
5 glasses		-	2
6 glasses		2	5
8 glasses		1	-
10 glasses		2	5
12 glasses		1	2
Limited quantity:	amount unknown	-	9
Variable quantity:	from one glass daily to more than 10 glasses once per week	2	4
Considerable quantity:	amount unknown	4	1
Not applicable		-	7
Unknown		3	4
Total		16	53

3.2.3 MEDICAL CONDITION AND FATIGUE

MEDICAL CONDITION

Sixty-six motorcycle riders reported that they had been in good health prior to the accident. Two of the three remaining riders were suffering from minor ailments, and the third was in the early stages of pregnancy. However, these conditions apparently did not impair their performance prior to the accident. Furthermore, none of the motorcyclists displayed a history of past illness of any relevance to the pre-accident circumstances. Thus there was no evidence to suggest that the performance of any of these riders was a consequence of a disabling medical condition.

FATIGUE

A comparison of the regular and recent sleep patterns of the motorcyclists provides a crude indication of possible fatigue states among these participants. Although this assessment of fatigue is particularly subjective, in the cases for which this information was available there was little evidence to suggest that fatigue contributed to the accident involvement of these motorcyclists.

3.3 MOTORCYCLE RIDERS: PHYSICAL CHARACTERISTICS

VISION

The administration of Snellen tests of visual acuity and Ishihara tests for colour blindness revealed only minor and apparently irrelevant instances of deficits in the vision of these riders. The wearing of corrective lenses was not a factor in the causation of any of these accidents, with the possible exception of one rider who was wearing photosensitive lenses at night (Accident 131, see below).

Visors on Crash Helmets

One rider was not wearing a crash helmet prior to the accident. Among the remaining riders there were 21 who were known to have had visors fitted to their helmets. Sixteen of them had clear visors and, although in nine cases these visors were scratched or dirty, the condition of the visor did not affect the pre-accident performance of any of these riders.

The helmets of four riders were fitted with clean tinted visors. It is possible that the failure of one of these four riders to detect the parked car with which he collided was related to a reduction in discriminability that may be associated with the use of a tinted visor in poor lighting conditions (Accident 217). However, there were other circumstances underlying this individual's performance which could have accounted entirely for his failure to detect the parked vehicle. These factors are discussed in the earlier section on the effects of alcohol. The wearing of tinted visors by the other three motorcyclists was not a relevant factor in their accidents.

The helmet of one other rider (Accident 131) was fitted with a visor that was tinted and slightly scratched, and he was wearing glasses with photosensitive lenses. In this case the motorcycle collided with a car that was parked near a street light, but on a poorly illuminated stretch of road, because the rider had not noticed the car until momentarily before the impact. Although he had been looking down in an attempt to locate the source of a rattle in his motorcycle, it is possible that his failure to detect the presence of the parked vehicle may have been related to his wearing a tinted visor.

Based on an examination of the literature, Hoffmann (1973) concluded that under night driving conditions tinted windscreens reduce sight distances and also reduce the efficiency of the transmission of critical signals. Furthermore, other evidence (Wolf *et al.*, 1960) reviewed by that author suggests that tinted glass impedes functions such as dark adaptation, visual acuity and depth perception and that it does not reduce the effect of glare. Thus it seems likely that tinted visors should not be used under night driving conditions.

HEARING

None of these riders had any hearing deficiency which was related to their accident involvement.

CONSPICUITY OF RIDER AND MOTORCYCLE

Most of these riders (56 out of 69) were wearing dull or dark clothing. Three of the others were wearing light-coloured clothing, and the remaining ten were dressed in bright clothing at the time of the accident. These figures relate only to the rider's clothing, and not to his crash helmet.

Twenty-four motorcyclists were not detected by the driver of the other vehicle, or by the pedestrian, either at all or not until immediately before the impact. (As shown in Table 2 there were 46 collisions with another vehicle and three with a pedestrian). However in 13 of these 24 collisions the conspicuity of the motorcyclist was not relevant. The driver could not seem him at all until it was too late to avoid the collision in eleven accidents (common obstructions to vision were other vehicles waiting to make a right turn and fixed objects beyond property boundaries at intersections). One other collision was a consequence of a prior collision between two cars (Accident 082) and the remaining one was the result of an otherwise successful emergency evasive manoeuvre (Accident 038).

Five of the eleven accidents in which the driver had a clear view of the approaching motorcycle occurred at night, and in four of these accidents the headlight of the motorcycle was switched on. In the other accident we could not be sure that the headlight was on before the crash. This accident occurred on a relatively well lit road on which it would be possible to ride at night without realizing that the motorcycle headlight was not switched on. Of the four accidents in which the headlight was known to have been switched on, one driver viewed the approaching motorcyclist against a background of headlights of other vehicles (Accident 112), another driver was concentrating on traffic on his left as he moved off from a STOP sign (the motorcycle was approaching on his right, Accident 089). The driver in Accident 078 turned right into a private driveway across the path of an oncoming motorcycle which had just passed through a signalised intersection. This driver said that he had not seen the motorcycle at all before the impact, and was not expecting any vehicles to be approaching since he had waited for a number of vehicles to pass and then the lights had changed to yellow. He had poor eyesight (6:12 and 6:9 in his right and left eyes, respectively) which may have been a partial explanation for his failure to see the motorcycle. The fourth accident in this group (167) involved a motorcyclist who was speeding, as evidenced by the fact that the car with which he collided was spun around by the force of the impact. Although this intersection, which was then sign-controlled but which is now signalised, appeared to offer a clear view of approaching traffic, shrubs planted on the median strip could have prevented the driver, who had moved off from a STOP sign from seeing the motorcycle when it was still some distance away on her left. All five of the riders who were not seen by the driver in a collision at night were dressed in dull or dark clothing.

One accident in which, again, the driver had a clear view of the motorcyclist occurred at dusk (Accident 032). The car driver was attempting a U-turn. The rider was dressed inconspicuously but had a white crash helmet. The headlight of his motorcycle was switched on.

The five day-time collisons in which the conspicuity of the motorcycle and its rider could have been an important factor would be expected to yield more information about the role of the brightness of the rider's clothing, simply because it is more noticeable in daylight than at night, particularly when compared to the conspicuity of the headlight. However none of these riders were thought to have been inconspicuous, even though their clothing ranged from dull or dark colours through to one rider who was wearing bright-coloured clothing. In two of these five accidents the rider said that the headlight of his motorcycle was switched on; in one case the switch was found to be in the 'on' position after the crash (Accident 128), but in the other accident (295) it was not. In this latter accident the motorcycle lights were not operational afterwards, because of the damage caused by the collision, and so it is unlikely that a bystander would have looked for the light switch to turn it off. The switch may, of course, have been knocked to the 'off' position in the crash but, whatever actually occurred, we were not able to find any evidence to support the rider's recollection that the headlamp was on and so we have had to record this item of information as being not known.

Four of the five crash helmets worn by riders who were not seen by the drivers of the other vehicles in daytime collisions were coloured black or mid-blue. The fifth helmet was not available for inspection. In the six collisions noted above which occurred at dusk or at night, three helmets were black or dark blue, one was white and one orange; with one helmet for which the colour was not known. As the helmet colour, like the rider's clothing, is likely to be more significant in this respect by day than by night, there is a suggestion that the darker, less conspicuous colours may be over-represented in these accidents in which the motorcyclist should have been seen sooner than he was (42 per cent of all the helmets inspected, regardless of the type of accident, were brightly coloured). However the number of cases is small, and other factors were present which could have had a bearing on the likelihood of the driver seeing the motorcyclist. For example, the motorcyclist first appeared in the driver's peripheral field of view in seven of these eleven accidents, and centrally in the other four. In three accidents the driver said that he or she had been concentrating on looking for traffic from a direction other than that from which the motorcycle was approaching. In the other four accidents there was another vehicle, or vehicles, ahead of or behind the approaching motorcycle and these vehicles may have attracted the driver's attention more readily than the motorcycle.

Overall, however, the conspicuity of the motorcycle and its rider may have been a factor in about one quarter of these collisions (11/46). This proportion was higher at night and at dusk (6/15) than by day (5/31).

Williams (1976) has reported that lack of conspicuity was a factor in 4.4 per cent of all motorcycle accidents at night, and 10.5 per cent in daylight. The corresponding percentages from this survey are 20.7 and 12.8. Williams eliminated from his study accidents in which other causal factors were reported (such as, the rider or driver had been drinking), and that could be a partial explanation of the difference in the two night-time percentages listed here.

FOOTWEAR

With one exception the nature of the footwear worn by these riders at the time of the accident was identified. Lace-up shoes or boots were worn by 63 riders, one wore slip-on shoes, another wore sandals and a third wore thongs. Two other riders were wearing shoes or boots with platform heels. Although the nature of the footwear worn by these last three motorcyclists conceivably could have impeded any attempt to apply the rear brake, the available information suggests that it was important in only one accident.

In Accident 043 no braking was attempted because the rider was unaware of any possibly hazardous situation, while in Accident 065 the rider considered that any limitation in braking efficiency that may have been associated with the wearing of thongs was over-shadowed completely by the fact that he had never applied a motorcycle footbrake previously. The third rider's motorcycle slid down when the rear wheel locked up on a wet road as he was changing down through the gears and applying the rear brake (Accident 085). This person was wearing shoes with platform heels approximately 12 cm high and soles approximately 6 cm high (Figure 10). The reduced sensitivity accompanying the use of such shoes when applying the rear brake was compounded by the inexperience and intoxication of this motorcyclist.

3.4 MOTORCYCLE RIDERS: PSYCHOLOGICAL FACTORS

JOURNEY SCHEDULE

Fifty-six riders had no reported schedule for their journey. Another nine had an approximate journey schedule, but at the time of the accident their progress was well in accord with that schedule. For three motorcyclists no information regarding journey schedule was available. Only one motorcyclist reported that he was behind schedule being half an hour late for his night classes. However, he said that he was not rushing prior to the accident, and the circumstances of the accident tend to support this assertion (Accident 078).

SOCIAL INTERACTIONS PRIOR TO JOURNEY

Only one rider could recall any pre-journey social interactions that were other than routine in nature. He had had to chase a person who had knocked over and damaged his motorcycle in a hotel car park (Accident 113). He thought that the excited state that he was in following this episode did have a marked effect on his behaviour prior to the accident.

PRE-ACCIDENT EMOTIONAL REACTIONS

Three riders were unable to recall the nature of any ongoing emotional reactions prior to the accident and this information was not available for the three riders who were killed. Sixty-two motorcyclists described themselves as being unemotive or contented prior to the accident. One other rider (Accident 043) reported that she was a little apprehensive prior to the accident because of a near collision some miles previously with the vehicle that eventually collided with her motorcycle. Another person (Accident 300), although apparently not aroused or stressed shortly prior to the accident, reacted in a rather carefree fashion by playing 'chicken' with a friend whom he had noticed playing on the road. Based on the circumstances of these accidents it seems likely that the pre-accident behaviour of only the latter of these two riders was influenced by their transient emotional state. The performance of two other motorcyclists also appeared to be shaped at least in part by their pre-accident emotional states. The exuberant behaviour of one young male (Accident 113), who was engaged in a 'drag-race' with his friends prior to the accident, appeared to be partly a response to his exciting pre-journey interactions, and the apparently hasty behaviour of a young female rider (Accident 251) reflected her excitement associated with an intended meeting with her boyfriend.

PRE-ACCIDENT PREOCCUPATIONS

The discussion in the preceding sections suggests that at least two riders were emotionally aroused and thus not fully occupied with the intended manoeuvre immediately prior to the accident. Mild preoccupations were also reported by three other motorcyclists, but there was no evidence to suggest that any of these preoccupations had a significant influence on their performance before the accident. This view was shared by these three motorcyclists.

Longer term preoccupations, varying in their nature, were reported by nine motorcyclists. Nevertheless, in all cases these preoccupations were intermittent in their impact, and prior to the accident were reportedly not of active concern to these individuals.

INCIDENTS DURING JOURNEY

Although unexpected incidents occurred during the journeys of at least two motorcyclists, there was no evidence to suggest that these incidents contributed to the accident involvement of these riders.

3.5 MOTORCYCLE RIDERS: LICENSING AND EXPERIENCE

3.5.1 LICENSING

TYPE OF LICENCE

The classifications of driving licence which may be obtained in South Australia are listed below.

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 accident-involved motorcyclists are shown in Table 13. Three riders (Accidents 039, 065, 155) did not hold either a learner's permit or a full motorcycle licence at the time of the accident. Two of them (Accidents 065, 155) did hold current Class 1 licences, although for one (Accident 155) that licence was under suspension. The third rider (Accident 039) had held a learner's permit for about three months but it had expired some weeks before the accident. Twenty-three motorcyclists had incurred at least one previous licence suspension, with three of them having incurred two suspensions and another eight having had their licences suspended on more than two occasions. All suspensions had been a consequence of either the accumulation of the maximum number of demerit points or of a single moving violation.

Seven riders only held Class 4 (motorcycle) learner's permits, although four of them were current holders of other full licences. The remaining 59 riders held full motorcycle licences. There were no restrictions associated with any of these licences. Sixty-one motorcyclists had obtained their first licence in South Australia, three in another Australian State, one in Britain and one in Europe. This information was not available for three motorcyclists.

TABLE 13: LICENCE CLASSIFICATION OF MOTORCYCLE RIDERS

Licence Classification	Number of Riders
Class 1	2
Class 4	19***
Class 1 and 4	34***
Class 2 and 4	6
Class 3 and 4	2*
Class 2 and 4 and 5	1
Class 3 and 4 and 5	1
Other Australian State motorcycle licence	2
No licence held	1
Unknown	1
Total	69

Note: Each asterisk denotes one rider who held a Class 4 learner's permit.

3.5.2 EXPERIENCE

Three accidents provided examples of quite direct contributions to the accident of lack of motorcycling experience. One rider collided with a parked car partly because he had not realized that when he was looking down to the side of his motorcycle he was applying pressure to the handlebars and altering the course of the motorcycle (Accident 131). This rider had held a learner's permit for only a few days. Another rider unsuccessfully attempted to change gears with a hand operated control on a motor scooter. A reduction in stability followed this unsuccessful attempt, and this was exaggerated when the small front wheel of the scooter struck a pot hole causing the rider to fall (Accident 203). This person had held a learner's permit for a couple of months, but he had not been riding in that time. The third individual negotiated a relatively sharp left hand bend too rapidly. He was unable to control the path of the motorcycle as he negotiated the bend and the machine struck the kerb on the right hand side of the road before colliding with a parked car. Having hardly ever ridden a motorcycle before, he had not applied the rear brake effectively approaching the bend and had not attempted to use the front brake at all (Accident 065). This person did not hold either a full or a learner's licence, and described his previous motorcycling experience as negligible.

PERIOD MOTORCYCLE LICENCE HELD

A guide to the relative experience of these motorcyclists is provided by Table 14 which lists the length of time that these participants held motorcycle licences. In this examination of motorcycling experience no distinction was made between holders of learner's permits and full licence holders. Almost 32 per cent of these motorcyclists had held the relevant licence for less than one year, while another 20 per cent had been licensed for less than two years. A comparison of average weekly distances travelled showed that riders with less than two years experience averaged 236 km per week ($s = 15.8$) compared with a weekly average of 256 km ($s = 21.0$) for more experienced riders. Hence, for this sample of accident-involved riders, there was no statistically significant difference in the exposure to risk of accident, as measured by weekly distance travelled between experienced and inexperienced riders.

Similar data were not available for motorcyclists who were not involved in accidents, and so no assessment can be made of the relative risk of being involved in an accident. It is, however, interesting to compare these data with corresponding information from all reported motorcycle accidents which occurred within approximately the same area of metropolitan Adelaide during the same period of 1976 - 1977, if only to check on the representativeness of our sample in this regard. As shown in Table 15, motorcyclists who held a Class 4 licence for less than two years were over-represented in the accident sample studied by this Unit when compared with the corresponding distribution in all reported accidents (Chi square = 14.97, $p < 0.001$).

This comparison does not relate to the risk of being involved in an accident, but it does suggest that, at least in this respect, there is a marked difference between the motorcyclists in this sample and those in all reported accidents. This difference may be due in part to the different criteria on which the sample and the accident population data were based. The sample of accidents for this study was based on those accidents to which an ambulance was called, whereas the comparison population data, being based on police accident report files, also included accidents which involved only property damage and to which an ambulance would not have been called. It could also be possible that many inexperienced riders, due to the nature of the riding errors they tended to make or their failure to react appropriately in an emergency situation, may have been involved in more severe impacts in which the likelihood of injury was greater.

A comparison based on samples of South Australian motorcyclists, both accident-involved and accident-free riders, over the year ending March 31, 1973, reported by Johnston, Milne and Cameron (1976), demonstrated an over-involvement in accidents for riders who had less than two years riding experience.

As shown in Table 16 it was notable that among the 22 motorcyclists who had held a Class 4 licence for less than a year were 18 riders who had been licensed for less than six months. This represents about 26 per cent of the riders in this survey, a percentage which intuitively seems likely to be higher than the (unknown) percentage in this category among all active motorcyclists

RIDING EXPERIENCE AND AGE OF RIDER BY SIZE OF MOTORCYCLE

The high rate of accident involvement of inexperienced riders on larger capacity motorcycles (e.g. Johnston *et al.*, 1976) has lead to the introduction, or suggested introduction, of graded licence schemes which restrict the motorcyclist to a machine of less than 250cc capacity unless the licence test was passed on a larger machine, or until a certain amount of experience has been accumulated on below 250cc machines. As is noted elsewhere in this report (Table 29, Section 5.1), motorcycles exceeding 250cc capacity were over-represented among the 69 machines involved in the accidents covered by this study. It is therefore of some importance to consider the extent to which young and/or inexperienced riders were using the larger machines. Interpretation of this information is seriously restricted by

TABLE 14: MOTORCYCLING EXPERIENCE: NUMBER OF YEARS CLASS 4 LICENCE HELD

Years Class 4 Licence Held	Number of Riders
Less than 1 year	22
1 year to less than 2 years	14
2 years to less than 3 years	2
3 years to less than 4 years	6
4 years to less than 5 years	5
5 years to less than 6 years	3
6 years to less than 7 years	4
7 years to less than 8 years	2
10 years to less than 11 years	1
11 years to less than 12 years	2
12 years to less than 13 years	1
13 years to less than 14 years	1
Long period (number of years unknown)	1
No licence held	2[1]
Unknown	3
Total	69

Note: [1] Does not include the rider who had an expired Class 4 learner's permit.

TABLE 15: DISTRIBUTION OF PERIOD MOTORCYCLE LICENCE HELD IN THIS ACCIDENT SAMPLE AND IN ALL REPORTED ACCIDENTS

Period Motorcycle Licence Held	Number of Motorcyclists This Sample (A)	Number of Motorcyclists All Reported Accidents (B)	Ratio A/B
Less than one year	22	119	0.18
1 year to less than 2 years	14	42	0.33
2 years to less than 3 years	2	65	0.03
3 years to less than 4 years	6	55	0.11
4 years to less than 5 years	5	46	0.11
5 years to less than 6 years	3	32	0.09
6 years to less than 7 years	4	25	0.16
7 years to less than 8 years	2	12	0.17
8 years to less than 9 years	-	20	-
9 years to less than 10 years	-	10	-
10 years to less than 11 years	1	11	0.09
11 years to less than 21 years	4	45	0.09
Total	63	482	0.13

TABLE 16: MOTORCYCLING EXPERIENCE: NUMBER OF MONTHS CLASS 4 LICENCE HELD BY RIDERS WITH LESS THAN ONE YEAR EXPERIENCE

MONTHS LICENCE HELD	NUMBER OF RIDERS
Less than one month	4
1 month to less than 2 months	3
3 months to less than 4 months	3
4 months to less than 5 months	3
5 months to less than 6 months	1
6 months to less than 7 months	3
7 months to less than 1 year	1
Total	22

the absence of comparable population data relating motorcycling experience, rather than simply the age of the rider, with the capacity of the motorcycle. Nevertheless, some comparison of these relationships in these accidents is possible, as shown in Tables 17 and 18.

In this sample of accident-involved motorcyclists there is no statistically significant association between the number of years a motorcycle licence had been held and the size of the motorcycle that was being ridden (with the class limits being licensed up to two years and an engine capacity of 250cc or less: Chi square = 0.10, $p > 0.7$). But when riders less than 18 years of age are compared with older riders, there is a trend towards the younger riders being on the smaller motorcycles (Chi square = 3.58, $p < 0.10$).

Being an accident-based sample, no conclusion can be drawn about the effect that any of these factors might have on the relative risk of being involved in an accident, but there may be some value in discussing possible reasons why, within the sample, the size of the motorcycle appears to be related more to the age than to the experience of the rider. The first point to be made is that very young riders are less likely to be able to afford to buy the larger machines, and so the accident sample may simply reflect this bias. But if that were so, one would expect to see it also reflected in the experience comparison, because all of these very young riders are in the 'licensed for less than two years' category.

This may imply, and it is emphasised that this is hypothesising beyond the data presented, but nevertheless consistent with impressions gained from the investigation of these accidents, that the main factor in accident-involvement for the inexperienced motorcyclist may be inexperience in operating in the traffic situation rather than any characteristic of the motorcycle. Some older, but inexperienced motorcyclists may be familiar with driving a car in traffic and so, for them, a characteristic of the motorcycle such as its engine capacity may become the major determinant of their risk of being involved in an accident.

3.5.3 RIDER TRAINING

In two cases no information was available regarding the type of motorcycle riding instruction that the riders had received. One person had had very limited tuition at a commercial driving school when learning to drive a car, and another had received informal tuition in connection with his employment. A third individual had learned to ride a motorcycle as a member of the police force and had completed their advanced course. The remaining 56 motorcyclists had not received any formal instruction. They had been guided informally by friends or relatives, or had taught themselves.

When this information is considered in conjunction with the apparently high frequency of accident involvement of recently licensed riders, it seems likely that many motorcyclists may obtain their licences before they have acquired, or possibly even become aware of the need for, some of the skills fundamental to the effective handling of a motorcycle. Further consideration is given to this issue in Section 3.7.

3.5.4 ACCIDENT AND VIOLATION HISTORY

PREVIOUS TRAFFIC VIOLATIONS

Thirty-nine motorcyclists reported at least one previous traffic violation. About 88 per cent of the 86 violations that were recalled by these individuals were for speeding. Twenty-four motorcyclists, or about 35 per cent of the sample, had more than one traffic violation. At the time of the accident 28 of the 39 motorcyclists with one or more violations were riding machines exceeding 250cc. Twelve of these machines were between 347 and 498ccs, while the rest exceeded 650ccs. The data in Table 19 show that motorcyclists with one or more violations were more likely to have been riding larger machines at the time of the accident than were riders with no violations.

Twelve of the 39 individuals with one or more violations had been consuming alcohol prior to the accident, and all but two of these 12 persons recorded alcohol levels exceeding the legal limit of .08.

PREVIOUS ACCIDENTS

Forty-two motorcyclists had been involved in previous accidents, although not all had been motorcycle accidents. Among the 23 riders who had been in two or more accidents were 16 who also had recorded two or more violations. The data shown in Table 20 indicates that motorcyclists who reported having had one or more previous accidents were more likely to have been riding larger capacity motorcycles at the time of the accident than were riders with no previous accidents.

The comparisons based on Tables 19 and 20 show that the previously-noted over-representation of larger capacity motorcycles was more marked among those riders who had a history of previous violations and accidents. Because, in this sample, younger riders tended to be on the smaller machines (Table 18) it might be thought that the association shown in Table 20 is largely an artifact arising from younger riders (of smaller motorcycles) having had fewer years of riding experience in which to have had accidents. In fact this is not the case; even when controlling for age of rider, or for experience, the above association remains. This suggests that there may be value in a graded licence scheme based on the motorcyclist's accident record rather than on riding experience.

TABLE 17: MOTORCYCLING EXPERIENCE BY CAPACITY OF MACHINE

Number of Years Class 4 Licence Held	Capacity of Motorcycle ≤250cc	>250cc
Less than 1 year	11	11
1 year to less than 2 years	3	11
2 years to less than 3 years	-	2
3 years to less than 4 years	3	3
4 years to less than 5 years	2	3
5 years to less than 6 years	2	1
6 years to less than 7 years	-	4
7 years to less than 8 years	1	1
10 years to less than 11 years	-	1
11 years to less than 12 years	1	1
12 years to less than 13 years	1	-
13 years to less than 14 years	1	-
Long period (number of years unknown)	1	-
Not applicable	2	-
Unknown	1	2
Total	29	40

TABLE 18: AGE OF RIDER BY CAPACITY OF MOTORCYCLE

Age of Rider (years)	Capacity of Motorcycle ≤250cc	>250cc
16	6	2
17	4	4
18	1	4
19	4	6
20	2	5
21	1	6
22	2	2
23	2	3
24	0	3
25	0	1
Over 25	7	4
Total	29	40

TABLE 19: VIOLATION FREQUENCY BY MOTORCYCLE CAPACITY

Number of Violations per Rider	Capacity of Motorcycle ≤ 250cc	> 250cc	Total
None	17	11	28
One or more	11	28	39
Unknown	1	1	2
Total	29	40	69

Chi square (omitting Unknowns) = 5.8, $p < 0.05$.

TABLE 20: NUMBER OF PREVIOUS ACCIDENTS BY CAPACITY OF MOTORCYCLE

Number of Previous Accidents per Rider	Capacity of Motorcycle ≤ 250cc	> 250cc	Total
None	16	9	25
One or more	12	30	42
Unknown	1	1	2
Total	29	40	69

Chi square (omitting Unknowns) = 6.7, $p < 0.01$.

3.5.5 FAMILIARITY WITH THE MOTORCYCLE

Fifty-five motorcyclists were riding their own motorcycles at the time of the accident, and with five exceptions these machines were used daily by the rider. Three riders used their motorcycles four or five times per week, one once per week and the fifth rider once per month. No information regarding frequency of use was available for one motorcyclist, although it seemed likely that he regularly rode his motorcycle. Although another three motorcyclists were riding machines that were owned by another family member, they had been using these motorcycles on a daily basis. The same could be said for three riders whose machines were owned by their employers.

Seven motorcyclists were riding machines that were owned by friends. Four of these riders used the motorcycle at least two or three times per week, but two of them had not ridden the motorcycle before (Accidents 065, 203), and a third had been using the motorcycle only during the previous few days (Accident 131). One of these last three riders did not have a Class 4 licence (Accident 065), while the other two only held learner's permits. The rider in Accident 203 had had little motorcycling experience and had hardly ever ridden his motor scooter before the test ride on which he lost control. Lack of familiarity with the motorcycle was unlikely to have been a significant factor in the causation of the accident for the other two riders.

The accidents of three individuals who rode motorcycles regularly derived, at least in part, from a lack of familiarity with the motorcycle being used at the time of the accident. One motorcyclist (Accident 198) attempted to sound the horn to warn a pedestrian who was walking into his path. However, even though the motor scooter that he was riding was identical to one which he normally used at work, the horn button was located on the opposite side of the handlebars. While the rider was fumbling to locate this button he collided with the pedestrian. Another person (Accident 227) had recently been riding her husband's British-manufactured motorcycle more regularly than her own Japanese machine. The British machine had the rear brake pedal on the left hand side, whereas it was on the right on the Japanese motorcycle. Shortly after beginning a journey on her own motorcycle she was required to brake suddenly to avoid colliding with the rear of a stationary vehicle. Her initial reaction was to use her left foot instead of the right to apply the rear wheel brake, a response which was consistent with her most recent experience. Consequently, she was unable to stop the motorcycle as quickly as she normally could have done. The third of these three motorcyclists, who had been riding a Yamaha 650 for several weeks after some previous experience on a Honda 50, lost control of the Yamaha on a damp surface when braking for an intersection (Accident 085). Although this rider's performance undoubtedly was impaired by the platform shoes he was wearing and by the large quantity of alcohol he had consumed, it seemed likely that his lack of experience, particularly in slippery conditions, with this much larger machine contributed to his inability to maintain control.

Thus, the accident-involvement of four motorcyclists may have been due, at least in part, to a lack of familiarity with the motorcycle being used at the time of the accident, although in two instances the difficulty was associated with the location of the controls on otherwise familiar machines.

3.6 RIDER ERRORS

This section contains a description of the more significant errors that were made by some of the riders in this survey. It should be noted, however, that the most reasonable approach to preventing some of these errors may not necessarily be an attempt to change the behaviour of the rider. In one accident noted above, for example, the rider was confused by the (for her) unusual location of the rear brake pedal. This problem could be overcome by requiring a standard location of this control on all new motorcycles.

VISUAL DISTRACTIONS

For 62 motorcyclists there was sufficient information to discount the possibility that their accident involvement was a consequence of some environmental distraction. Nevertheless, in at least one accident the motorcyclist's behaviour prior to the collision did appear to have been, in part, the result of such a distraction. As this rider was approaching a signalised intersection, a car reversed rapidly onto the road from a parking place on the earth shoulder on the left. While monitoring the movements of this vehicle to ensure that they did not collide, the motorcyclist failed to notice that the traffic signals at the intersection had changed from green to yellow. As he entered the intersection, during either the yellow or the red phase, he collided with an oncoming vehicle that was turning right (Accident 073).

FAILURE TO ALLOW FOR A VISUAL RESTRICTION

There was no evidence, nor were there any reports, of restrictions on the field of view for 49 motorcyclists, but for 18 riders there was some such restriction. Table 21 summarizes the nature of these visual restrictions, and highlights those that were considered to have been relevant to the pre-accident performance of the motorcyclist (for three riders there were two apparent sources of restriction).

TABLE 21: FREQUENCY OF POSSIBLE AND RELEVANT VISUAL RESTRICTIONS FOR MOTORCYCLISTS

Type of Visual Restriction	Frequency of Possible Visual Restriction	Frequency of Relevant Visual Restriction
None	49	-
Moving traffic	4 (1)*	1 (1)
Stationary traffic	7	4
Parked vehicles	2 (1)	1
Roadside objects (man-made)	2	-
Roadside objects (trees, etc.)	1 (1)	1
Objects on or behind property boundaries	2	1
Unknown	2	-
Total	69	8

* Number in parentheses indicates a second visual restriction.

The accident involvement of eight motorcyclists was partly a consequence of their not making allowance for restrictions on their field of view before beginning the pre-accident manoeuvre. One of these riders had been licensed for only two months, and two others had held licences for about a year. The other five individuals had been riding motorcycles regularly for periods exceeding five years. Thus, failure to take account of such a restriction was not the particular province of the inexperienced motorcyclist.

Two of these eight riders (Accidents 167 and 243) were intoxicated at the time of the accident, and probably were exceeding the speed limit of 60 km/h as they approached the accident site. Their failure to allow for the restricted field of view may have been related to relatively specific alcohol effects, as noted in Section 3.2.1.

Previous traffic violations were reported by four of the eight riders and six reported previous accident involvement, although generally the previous accidents were not similar in nature to this accident.

A variety of vehicle movements were associated with this particular error. In four accidents (095, 098, 101 and 249) the motorcyclist had overtaken stationary traffic while travelling in the left hand lane or, in one case, between the kerb and stationary traffic, while proceeding towards an intersection. Two riders were proceeding across a four way intersection, and the remaining two were crossing the stem of a T-junction. In each of these eight accidents the motorcycle collided with an oncoming car that had turned right at the intersection, and in each case this car had been obscured from view by stationary traffic to the right of the motorcyclist.

SECONDARY ACTIVITIES

Three motorcyclists, out of the 62 for whom this information was available, were engaged in some secondary activity associated with the motorcycle itself prior to the accident. In each of these accidents this secondary activity significantly impaired the rider's control or guidance of his machine. One rider was looking downward and to the rear because he thought he had heard the sidestand trailing on the ground. He looked up again moments before he collided with the rear of a stationary vehicle that was waiting to make a right hand turn (Accident 039). This rider did not hold a Class 4 licence although he had held a learner's permit that had expired some weeks prior to the accident. Another rider also was looking down in an attempt to locate the source of a rattle. He looked up again just before colliding with a parked car (Accident 131). This person had obtained a Class 4 learner's permit only a few days prior to the accident. Thus, both these riders were extremely inexperienced motorcyclists. The third rider also collided with the right rear of a parked car (Accident 217). He had sneezed when still some distance from the accident site, but had finished wiping his nose and eyes only just prior to colliding with the car. The possible interaction between this secondary activity and the effects of the alcohol he had consumed prior to the accident is discussed earlier in this report (Section 3.2.1).

Nine riders reportedly were engaged in some secondary activity which was not associated with their motorcycle, although in some cases this activity possibly could be regarded as a component of the driving task itself (Table 22), and in four cases the rider's performance was not affected. Two of the remaining five riders whose performance was adversely affected by their having been engaged in a secondary activity were monitoring the changing phases of the traffic signals through which they had to pass, although one was some hundreds of metres from that intersection, and the other was still completing the crossing of the previous intersection. Both motorcycles collided with vehicles that moved into their paths from the left hand side of the road (Accidents 219, 281). Another rider was engaged in a race with some friends at the time of the accident, and was watching the progress of the motorcycle ahead of him when he lost control as he was negotiating a bend (Accident 113). A fourth rider collided at an uncontrolled intersection with a vehicle that had approached from his right (Accident 002). The rider had been attending too closely to stationary vehicles waiting on his left at the intersection, and had not monitored the other approaches to the intersection. The fifth rider was playing 'chicken' with a friend who was playing tennis on the road. As the motorcycle passed the pedestrian it caught on her clothing, causing both persons to fall to the road (Accident 300). One of these five riders had been licensed for a year, and two others had been riding for only a few months.

INADEQUATE MONITORING OF THE RELEVANT ENVIRONMENT

Five riders failed to monitor adequately the roadway ahead or the manoeuvres of the other vehicle involved in the accident. Four of these riders were not aware of the likely collision until they detected the other vehicle momentarily before the impact. The fifth rider was not aware of the other vehicle at all before the impact.

Two of these five riders collided with the rear of a parked vehicle at night. One accident occurred on a relatively well-illuminated section of road (Accident 022). The other motorcycle collided with a parked truck at night under poor lighting conditions (Accident 093). The truck had no warning

TABLE 22: FREQUENCY OF SECONDARY ACTIVITY ENGAGEMENT FOR MOTORCYCLISTS

Type of Secondary Activity	Frequency of Secondary Activity	Frequency of Relevant Secondary Activity
None	51	-
Looking for signpost, traffic signal	2	2
Attempting to follow path of another vehicle	1	1
Looking down at own motorcycle	2	2
Monitoring activity of other vehicle	2	1
Monitoring rear-vision mirror	1	-
Other	4	2
Unknown	6	-
Total	69	8

reflectors placed on the road behind it but its presence was indicated by its silhouette against the area illuminated by a distant street light.

The third rider in this group of five had been waiting at a four-way intersection for the green phase of the traffic signals. When signals changed he turned left and after completing the turn was struck from the rear by a semi-trailer which was still crossing the intersection when the previous phase had ended (Accident 127). The motorcyclist had not looked to his right before moving off from the STOP line. The fourth motorcyclist had approached a T-junction intending to turn right, into the stem of the T. Although the traffic signals were green for the through traffic, according to the pillion passenger the separate right turn phase had not begun. The rider, thinking that it had, started to turn right, thereby crossing into the path of an oncoming car (Accident 223). The rider was familiar with both the intersection and the manoeuvre that he was attempting.

The fifth motorcyclist in this group reported that he was travelling behind a car in the lane nearest the centre of the road. When the car braked relatively suddenly, he veered to the left and passed it, only to collide with the left rear corner of another car that was stationary and waiting to make a right turn into a minor road (Accident 159). Previous discussion of this accident, in Section 3.2.1, has focussed on the possible effect that alcohol intoxication may have had on this rider's performance. In the other four cases there were no indications of any other factors, such as alcohol intoxication, that may have accounted for the motorcyclist's failure to monitor adequately the road and traffic conditions. Two riders said that they were not familiar with the accident site (Accidents 167 and 282) but neither of them appeared to have been disadvantaged by this lack of familiarity.

DISCONNECTION OF BRAKE LIGHT SWITCH

Two motorcyclists who collided with each other were riding machines on which the rear brake light switches had been disconnected (Accident 015). These riders were travelling in single file at night, and when the leading rider braked the following rider had insufficient warning that the motorcycle in front was slowing down. Neither rider was prepared to comment on why he had disconnected the switch.

RIDING A DEFECTIVE MOTORCYCLE

A further nine motorcycles were identified as being defective in some respect but the defects played no obvious role in the causation of any of the accidents. However, it was possible that the presence of some of these defects may have resulted in an increase in the severity of some impacts. For example, in two accidents more effective braking may have been achieved had the brakes been correctly adjusted, but even then the collisions probably would still have occurred.

FAILURE TO RESPOND APPROPRIATELY IN AN EMERGENCY SITUATION

Failure to react appropriately in an emergency situation was a factor in the accident involvement of 16 motorcyclists. In all of these 16 accidents brake application, or the lack thereof, was the critical factor. The behaviour of three riders merits individual discussion.

One rider ran off the road and onto the footpath, where he continued on for a considerable distance before striking his leg on a seat at a bus stop and, some distance later, falling from his motorcycle (Accident 118). This rider apparently had not attempted to brake, but rather had attempted to continue along the footpath until he could re-enter the roadway. This reponse is discussed also in connection with the effects of alcohol on performance (Section 3.2.1).

Another rider was travelling on a priority road when a car that had been stationary on an intersecting road on his left commenced a right turn into the priority road. However it was unable to complete this manoeuvre before it cleared the lane in which the motorcycle was travelling because a preceding car stopped unexpectedly. Confronted with this stationary car, the motorcyclist did not brake but veered to his right as if attempting to pass in front of the car, but in so doing collided with it (Accident 142). The reports of both the rider and the driver seemed to indicate that the motorcyclist 'froze' when confronted with this emergency situation.

The circumstances of the accident in which the third rider was involved have been the subject of some discussion in Section 3.5.5, which was concerned with familiarity with the motorcycle. As mentioned previously this rider's first attempted braking response, in order to avoid colliding with the rear of another vehicle, was ineffective because she was confused by the location of the brake pedal (Accident 227). As she neared the stationary vehicle, she put one foot to the road in a further attempt to prevent a possible collision. However when her foot dragged on the road she lost control of the motorcycle and fell off. She reported later that had she not responded in this way she may have avoided a collision or, at worst, experienced a very minor impact with the rear of the stationary car.

The emergency reactions of the remaining 13 motorcyclists in this group of 16 were similar in nature and are discussed collectively. These riders used only the rear brake when attempting to stop their machines prior to the accident. (Another rider used only the rear brake, but the front brake on that motorcycle was inoperative). Table 23 compares the normal braking methods of the motorcyclists in this study with the methods they employed prior to the accident. Among the 13 motorcyclists who did not activate the front brake prior to the accident were six who claimed that they normally used both front and rear brakes.

TABLE 23: COMPARISON OF NORMAL AND ACCIDENT BRAKING FOR MOTORCYCLISTS

Braking Method	Normal Braking	Accident Braking
Front only	5	4
Rear only	10	14
Front and rear	36	13
Not applied (accident data only)	-	34
Does not normally ride motorcycle	3	-
Unknown	15	4
Total	69	69

The predominant reasons for these motorcyclists not using the front brake appeared to be a concern that instability would result, and a disruption of the normal braking pattern when under the stress associated with an imminent collision. The proportion of inexperienced riders (licensed for less than a year) was similar in this group (6/16) to that in the sample as a whole (22/63). In other words, experienced riders were just as likely to fail to make full use of the braking performance of their motorcycles in an emergency as were those who were relatively inexperienced.

TRAVELLING TOO FAST TO RESPOND APPROPRIATELY

Reports from five motorcyclists, and from observers who witnessed the pre-accident events, indicated that these riders were travelling at a speed that greatly reduced their ability to take effective avoiding action.

Two riders each reported that they were negotiating a bend in the road at a speed well in excess of the 60 km/h limit. One of these riders collided first with a kerb on the right hand side of the road, and then with a stationary car (Accident 065). The other rider lost control of his motorcycle when, as he was negotiating a bend at high speed, the centre stand apparently caught on the rough edge of the bitumen surrounding a manhole cover (Accident 113). He was carrying a pillion passenger, and this may have reduced the clearance between the stand and the road surface.

Another two motorcyclists were travelling along a priority road at a speed which exceeded the legal limit of 60 km/h when they collided, in separate accidents, with a car that had entered from an intersecting road on their right. There was no evidence to suggest that one of these riders took any avoiding action (Accident 042). The other rider did apply the rear brake before the impact (Accident 167).

The fifth motorcyclist in this group had used a parking lane to overtake a stream of traffic travelling in the adjacent lane. However, when confronted with parked vehicles in the parking lane he swerved to his right, into the adjacent lane where he collided with the rear of a vehicle travelling in that lane. He said that he was travelling too fast to take effective avoiding action.

These five riders ranged in age from 19 to 23 years. One had no previous motorcycling experience and was riding a relatively small machine of 247cc capacity. The other four riders, two of whom had been licensed for one year and two for six years, were riding machines ranging in capacity from about 400 to 900ccs; they recorded blood alcohol levels ranging from .10 to .15, and three of them were carrying a pillion passenger. One of these riders did not report any previous traffic violations, but he said that he had been involved in one previous accident. Each of the others had accumulated from two to five traffic violations and had been involved in two previous accidents. It therefore seems likely that the behaviour of these individuals prior to the accident was a reflection of a style of motorcycle riding that often was inappropriate. Appropriate countermeasures for such behaviour are not obvious. However, one sanction that may merit consideration is a restriction of motorcycle capacity in response to a particular riding history, regardless of motorcycling experience.

For two motorcyclists the only apparent error was a breach of the Road Traffic Act. One rider proceeded into an intersection despite the traffic lights showing amber, and possibly red, and collided with a vehicle from the opposing direction that turned across his path (Accident 234). The other rider attempted to overtake on the right a vehicle that was near the centre of the road and indicating a right turn. The motorcyclist had assumed that the driver of this vehicle was intending to turn at an intersection about 50m beyond the accident site. Instead, the vehicle turned into a service station driveway as the motorcyclist began to overtake (Accident 215).

INSUFFICIENT INFORMATION TO DEFINE ERRORS

The performance of seven motorcyclists has not been classified in terms of these error categories since there was insufficient information available on the events preceding the accident. Six of these riders were intoxicated and they were all involved in single vehicle accidents. Three died as a result of injuries sustained in the crash, and the others could not recall any details relating to the accident. The possible effects of alcohol on their performance are discussed in Section 3.2.1 of this report. Another motorcyclist collided with a car which had commenced a right turn into a carpark as the motorcyclist was overtaking (Accident 255). The driver of the car had not noticed the motorcyclist approaching before the collision, but attempts to determine whether he had indicated his intended manoeuvre were unsuccessful.

NO DEFINABLE ERROR

Based on the information available none of the errors discussed in this Section could be identified among those factors contributing to the accident involvement of 19 motorcyclists. However, it should be noted that this does not exclude the possibility of error among these riders. For example, in many cases the performance of these riders prior to the accident may have differed from that of those who narrowly avoided accidents only in terms of a failure to anticipate or predict the events that precede an accident. This non-error group was similar in some respects to the other group of motorcyclists in this sample in terms of period licensed, but only two motorcyclists who had been licensed less than a year were among this non-error group. There was also no significant difference between the two groups in terms of average weekly distances travelled.

3.7 ACCIDENT CAUSATION: A SUMMARY OF RIDER FACTORS

A summary of those physiological and psychological factors underlying the performance of these motorcyclists, and those errors contributing to their accident involvement, is presented in Table 24. As has been pointed out previously, only limited information was available for some motorcyclists, and so the extent of the influence of some of these factors may be underestimated. Furthermore, for the reasons noted in the Introduction, there is likely to be considerable value in further analysis of these data.

Among the relevant psychological and physiological factors alcohol intoxication was of major significance. An attempt already has been made to identify the possible mechanism underlying the effects of alcohol as evidenced in these accidents. A more detailed discussion of the implications of the data relating to alcohol and road user performance is presented in the relevant section of the companion report in this series on car accidents. Similarly, a discussion of the more general aspects of rider skills and training that have been suggested by this examination of errors also appears in that report. Thus, this section will concentrate on issues that pertain particularly to motorcyclists.

The importance of motorcycling experience is discussed at some length in this report (Section 3.5.2). Although Table 24 indicates that inexperience was considered to have contributed directly to the accident involvement of only three motorcyclists, these were the accidents in which the involved motorcyclist apparently had not developed the skills to handle the machine effectively under any conditions. There seems little doubt that lack of motorcycling experience was a relevant factor in many other accidents.

As noted in Section 3.6, the performance of eight riders may have been impaired by their having attempted to carry out a secondary activity. Among these motorcyclists were five who had been licensed for no more than a year (most of them for only a few months). It may be that a lack of skill on the part of some inexperienced motorcyclists requires a greater degree of attention to the primary task to maintain effective control; hence it might be expected that, for them, involvement in a secondary task would be more likely to interfere significantly with their ability to control the motorcycle in a traffic situation.

The most obvious implication of the data relating to motorcycling experience is that many riders obtain the relevant licence even though their motorcycling skills are poorly developed. The introduction of a licence system that is graded according to experience may provide an opportunity for novice motorcyclists to acquire skills related to motorcycle control on a more restrictive or limited machine. On the other hand, as suggested in Section 3.5.2, a graded licence system of this type may not provide the most direct counter-measure for the difficulties encountered by the very young inexperienced motorcyclist. The possibility of increasing the age at which a motorcycle licence can be obtained may be worthy of consideration, since many intending motorcyclists may then have had one or two years of driving experience in a less demanding vehicle, without the same likelihood of incurring serious injury in the event of an accident. Coppin (1977) has suggested a similar approach to this problem.

The summary of errors (Table 24) includes some specific aspects of motorcycling behaviour that were implicated in the accident-involvement of motorcyclists of all levels of experience. Failure to respond appropriately in an emergency situation was an error that characterized the performance of about 23 per cent of these riders; it generally referred to a failure to use the full braking performance of the motorcycle. The tendency to use only the rear brake for both normal braking and for emergency braking, together with the reasons underlying this behaviour, point to serious deficiencies in both the training of motorcyclists and in the basic design of the braking system on motorcycles. The propagation of deficiencies in training procedures appears to be assured given the large proportion of motorcyclists who either teach themselves to ride or who learn from friends or relatives. The prevalence of this failure to use the full braking performance of the motorcycle also suggests that there should be a more thorough evaluation of the degree of mastery of front and rear braking by riders when undergoing their licence tests.

An alternative, or possibly complementary, measure which deserves consideration is the provision of a coupled braking system in which front and rear brakes are linked and operated by a single foot pedal. This system is currently used by one manufacturer (Moto Guzzi). Reports in the motorcycling press have attested to the efficiency, and also the safety, of this particular braking system. Under the stress of an emergency situation even those motorcyclists who normally use both front and rear brakes may fail to respond appropriately. The coupled braking system alone would appear to provide the possibility of counteracting this failure

TABLE 24: FREQUENCY OF OCCURRENCE OF CONTRIBUTING FACTORS AMONG MOTORCYCLE RIDERS

Nature of Contributing Factors	Number of Riders	
Physiological and psychological		
Inappropriate footwear	1	(1.4)*
Tinted visor	1	(1.4)
Alcohol intoxication	15	(21.7)
Emotional stress; preoccupation	3	(4.3)
No motorcycling experience	3	(4.3)
Lack of familiarity with the motorcycle	4	(5.8)
Motorcyclist errors		
Visual distraction	1	(1.4)
Failure to allow for a visual restriction	8	(11.6)
Secondary activity	8	(11.6)
Inadequate monitoring of relevant environment	5	(7.2)
Failure to ensure effective operation of vehicle controls (e.g. lights, etc.)	1	(1.4)
Failure to respond appropriately in emergency situation	16	(23.2)
Travelling too fast to respond appropriately	5	(7.2)
Failure to observe a road traffic rule (no other obvious error)	2	(2.8)
Insufficient information to define an error	7	(10.1)
No definable error	19	(27.5)

* Number in parentheses indicates percentage of total number (69) of motorcycle riders. The percentages are not additive.

to make full use of the braking performance of the motorcycle. In this regard it may be of value to consider the difficulties which would be experienced by a car driver if he had to actuate two controls, one for the front brakes and the other for the rear.

Failure to accommodate to a visual restriction was also prominent among those factors underlying the accident involvement of the motorcyclists in this sample. Although this error was certainly not specific to motorcyclists, as is indicated in the companion report on car accidents (Part 6), at least half the instances of this error among motorcyclists are related to the ability of the motorcycle to filter through stationary traffic. Three of the four accidents of this type involved a motorcycle that was proceeding through an intersection when it collided with an oncoming car which turned right, across its path. In all of these cases the motorcycle was obscured from the turning vehicle, and vice versa, by stationary traffic located in lanes to the right of the motorcycle.

Although three of the four motorcyclists were acting in a legally appropriate manner, none of them appeared to have taken account of the possibility that they may have been obscured from the view of other drivers. Also, none of them apparently reacted to the possibility that the manoeuvrability of their motorcycle often may render their movements less predictable for the drivers of other vehicles. Although this type of collision also involves an error on the part of the other drivers, it is apparent that it is desirable for motorcyclists to develop a riding strategy whereby they take account of the unpredictability that is associated with their greater flexibility of movement.

The importance of familiarity, or lack thereof, with the motorcycle is discussed in Section 3.5.5. Although four instances were reported in which a lack of familiarity with the motorcycle was considered relevant, only one motorcyclist was riding a machine with which he had no previous experience. However, the circumstances of three of these accidents (described in the above-mentioned Section) lend support to the case for the adoption of the Australian Transport Advisory Council Draft Regulation 1805, which specifies standardized locations for the controls on a motorcycle.

It is difficult to assess the degree to which these data represent the importance of factors such as tinted visors and inappropriate footwear (see Section 3.3), but there are apparent limitations associated with each of these factors that possibly may be countered by suitable legislation.

3.8 OBSERVANCE OF TRAFFIC RULES

TRAFFIC CONTROLS

Seventeen motorcycle accidents occurred at sites at which traffic control systems were located. With the possible exception of the motorcyclist who crashed through a light-bollard barricade before being killed in a collision with a wire fence, all 17 riders were aware of and understood the operation of these traffic control systems. The responses of ten motorcyclists to these controls were legally appropriate, but six riders apparently responded in a legally inappropriate manner.

Three of these six riders had entered signalised intersections, either extremely late in the yellow phase or after the beginning of the red phase, intending to proceed straight across the intersection. In each case a collision occurred with a car that had approached the intersection from the opposite direction, waited at the centre of the intersection until the opposing traffic began slowing in response to the changing traffic signal, and then turned right, across the path of the motorcyclist. Another motorcyclist commenced a right turn into the stem of a T-junction when the traffic signals were on the green phase for through traffic, only to collide with a vehicle that was proceeding straight through the intersection from the opposite direction (as noted in Section 3.6, this rider thought that he was turning with a green right-turn arrow).

Two motorcycle accidents occurred at T-junctions on priority roads. In one case the motorcyclist was making a right turn into the priority road when he was struck by a vehicle approaching from his right. The other motorcyclist began a similar manoeuvre while a car was attempting to make a right turn from the priority road into the junction. This motorcyclist, who had not yielded to the car, responded hesitantly as it commenced turning. She then lost control and fell from her motorcycle.

Two of the six motorcyclists who apparently erred at traffic controls were charged with disobeying traffic signals and with failing to give way, and both were fined.

TRAFFIC RULES

The remaining motorcycle accidents occurred at sites at which there were no traffic controls. However, in 24 accidents the motorcyclist apparently failed to observe at least one other traffic rule as defined by the Road Traffic Act. Table 25 summarizes the nature of the traffic rules which these riders transgressed, and the nature of the penalities imposed because

TABLE 25: NATURE AND CONSEQUENCES OF TRAFFIC VIOLATIONS BY MOTORCYCLE RIDERS

Frequency and Consequence of each Violation	>.08 or >.08 and Due Care	Due Care	Failure to give way	Passing Illegally	No Licence	Brake Lamp Inoperative	No Helmet
Number committed	10	2	3	1	2	1	1
Number charged	7	1	2	-	2	-	-
Not known if charged	1	-	-	-	-	-	-
Fine: < $50	2	1	2	-	2	-	-
: $50 - 100	4	-	-	-	-	-	-
: Amount unknown	1	-	-	-	-	-	-
Suspension:							
None	1	1	2	-	2	-	-
< 1 month	1	-	-	-	-	-	-
1 - 3 months	1	-	-	-	-	-	-
> 3 - 6 months	3	-	-	-	-	-	-
Period unknown	1	-	-	-	-	-	-

of those violations. Three fatally injured motorcyclists, one of whom was driving without a licence, recorded BACs that exceeded the legal limit of .08 but they have not been included in this Table. Also, vehicle defects were not listed unless the defect was relevant to the causation of the accident.

Twenty motorcyclists apparently committed breaches of the Road Traffic Act that were related to the causation, or consequences of the accident, although the police did not administer a breath alcohol test to one rider whose reading exceeded .08 on the research team's Alcolmeter, but only 12 motorcyclists were charged with a traffic violation. Another motorcyclist may have been charged but the relevant records were unavailable. There was some ambiguity associated with the legality of the response of one motorcyclist (Accident 255). Nevertheless, this rider was charged with riding without due care, and was fined $20.

In summary, therefore, there were 26 motorcyclists who survived the accident and who were considered by the research team to have committed a violation in relation to a traffic control device or some other traffic rule prior to the accident. Eleven, or possibly 12, of these motorcyclists were not charged with any violation. Thus, among the 38 per cent of motorcyclists who apparently committed a breach of the Road Traffic Act, there was only a little more than a 50 per cent chance that a prosecution would result. This meant that approximately 20 per cent of the accident-involved motorcyclists were prosecuted for a violation arising from the accident.

MOTORCYCLE CRASH HELMET WEARING

All motorcyclists are required by law to wear an approved crash helmet in most circumstances. Fifty-six of these riders regarded the use of crash helmets favourably, while three were ambivalent in their attitudes towards helmet wearing. The opinions of ten motorcyclists were not available. However, all of the other 59 riders said that they nearly always wore their crash helmets. Only one motorcyclists was not wearing a helmet prior to the accident although as is reported in the discussion of injuries to motorcyclists, a number of helmets were dislodged during the accident events.

4. CHARACTERISTICS OF THE DRIVERS

This section reviews the age and sex distributions and also the extent of alcohol involvement among 42 drivers whose vehicles collided with motorcycles. Most of these vehicles were cars, the remainder comprising two trucks and one semi-trailer.

Eighteen of the other 26 accidents involved only the rider. Three of the remaining eight accidents were collisions with pedestrians; two were collisions with pedal cycles and one was a collision between two motorcycles. The final two accidents involved a moving car as the consequence of a prior accident event (a collision between two cars, and a motorcyclist falling from his machine). The drivers of these two cars are not included in the following data (see Notes to Table 2).

AGE AND SEX

The age and sex distributions of the drivers of vehicles which collided with motorcycles are listed in Table 26. The age of one male driver is not known because he refused to cooperate with the research team.

ALCOHOL INTOXICATION

Blood alcohol levels were obtained for 34 of the 42 drivers. Of the remaining eight, six appeared to have been sober at the time of the accident, one appeared slightly intoxicated and one, who alighted from the ambulance before reaching hospital, was reportedly severely intoxicated. Positive BACs were recorded for four drivers; these levels were .02, .09, .12 and .14. It is likely that alcohol intoxication contributed to the accident involvement of four drivers (the three with a BAC > .08 and the one who appeared to be severely intoxicated).

TABLE 26: AGE AND SEX OF DRIVERS INVOLVED IN MOTORCYCLE ACCIDENTS

Age (Years)	Sex: Male	Sex: Female	Total Number of Drivers
16 - 19	4	-	4
20 - 24	4	4	8
25 - 34	8**	4	12
35 - 44	3	2	5
45 - 54	5*	3	8
55 - 64	3	-	3
Over 64	1	-	1
Unknown	1*	-	1
Total	29	13	42

Note: Each asterisk denotes one driver whose performance was thought to have been affected by alcohol.

5. THE MOTORCYCLES

5.1 TYPES OF MOTORCYCLE

BASIC DESIGN FEATURES

The motorcycles involved in these accidents were categorized according to their basic design features as: touring, trail, commuter and scooter. The 'touring' classification refers to those machines designed specifically for main-road use, and includes motorcycles with capacities ranging from 90cc to 1000cc or more. The 'trail' group refers to those motorcycles designed for off-road, on-road use. They have wider handlebars than do the touring bikes, higher ground clearance and an off-road tyre tread pattern. 'Commuters' are low capacity machines having an open frame, often referred to as 'step-through', and are distinguished from the 'scooter' category by the provision of foot rests rather than an open platform. They usually have larger diameter wheels than do the scooters.

In three cases the motorcycle had been modified, but these changes appeared not to be relevant to the crash circumstances and so these machines are listed here according to their original specifications.

The distribution of motorcycle types involved in the 68 accidents is shown in Table 27. Information on the relative proportions of these categories among all registered motorcycles is not available for South Australia; however, there is no clear evidence that the type of motorcycle, as classified in this way, was a significant factor in the causation or consequences of any of these accidents.

ENGINE CAPACITY

The 69 motorcycles have been classified by engine capacity in Table 28. The size of the motorcycle, as defined by the capacity of the engine, has been taken as one of the criteria on which some graded licence schemes are based. Such schemes often use an engine capacity of 250cc to define 'small' or 'low-powered' motorcycles (up to 250cc). Johnston *et al.* (1976) found that riders of 'large' (over 250cc) motorcycles were more than twice as likely (2.2:1) to be involved in an accident than were riders to small motorcycles. When the data shown in Table 28 are grouped into these two categories, and compared with a similar grouping of all motorcycles registered in the Adelaide metropolitan area at July 1, 1976 (Table 29), it can be seen that the over-250cc group was involved in the accidents covered by this survey at a rate which was 3.1 times greater than that for the smaller motorcycles. This result is not independent of the age and experience of the motorcyclist, as is demonstrated in the Sections of this report which deal with licensing and experience (3.5.1 and 3.5.2), and also by Johnston *et al.* (1976). Two other factors which conceivably could contribute to this difference in accident rates are noted below. Both of these factors relate to the use which is made of the motorcycle.

The 'up to 250cc' group includes almost all of the trail bikes which are sold in this State. Many of these motorcycles, although registered, are likely to be used only for trail-riding and not for commuting or as general transportation. This could mean that the number of registered motorcycles shown in Table 29 for the 'up to 250cc' group would overestimate the number likely to be at risk of being involved in an accident on a public road in the metropolitan area. But even if this registered number is reduced by a proportion equal to half the proportion of trail bikes in the accident group, thereby increasing the involvement rate (since the number in the accident group is not reduced in the same way), there is still a large, and statistically significant, difference in the involvement rates of the large and the small machines (2.3:1).

It could also be argued that the over-involvement of larger capacity machines could be due to the fact that some of these machines are quite expensive and so they may be more likely to be the sole means of transport for those persons owning them. If this were the case it would be expected that they would use their bikes more often and hence have a greater exposure factor. Inspection of the riders' estimated weekly distance ridden, again using the 250cc cut-off point, revealed a trend in this direction but the difference was not statistically significant, nor was it large enough to be of practical importance in this comparison.

In summary, there is a marked difference in the accident involvement rates of small and large motorcycles, but the size of the motorcycle alone is not the critical factor.

5.2 MOTORCYCLE MODIFICATIONS, DEFECTS AND ADR COMPLIANCE

MODIFICATIONS TO STANDARD DESIGN

Alterations to the front suspension and to the handlebars were the most common modifications that had been made to the motorcycles in this sample of accidents.

TABLE 27: MOTORCYCLE TYPE CATEGORIZED BY DESIGN FEATURE

Type of Motorcycle	Number of Motorcycles
Touring	43
Trail	21
Commuter	2
Scooter	3
Total	69

TABLE 28: DISTRIBUTION OF MOTORCYCLES BY ENGINE CAPACITY

Engine Capacity (cc)	Number of Motorcycles
Up to 100cc	4
101 - 150	8
151 - 200	9
201 - 250	8
251 - 350	8
351 - 500	10
501 - 650	-
651 - 750	15
751 - 900	7
901 - 1000	-
Above 1000cc	-
Total	69

TABLE 29: MOTORCYCLE ENGINE CAPACITY BY RATE OF INVOLVEMENT IN THESE ACCIDENTS

Engine Capacity	Motorcycles in these Accidents	Registered Motorcycles*	Involvement Rate per 1000 registered motorcycles
≤250cc	29	11,430	2.54
>250cc	40	5,046	7.93
Total	69	16,476	4.19

* Adelaide metropolitan area (Chi square = 25.4, $p < 0.001$)

TABLE 30: TYPES OF FRONT SUSPENSION

Type of Suspension	Number of Motorcycles
Telescopic, standard	59
Telescopic, 'chopper' modified	5
Leading link	3
Trailing link	2
Total	69

FRONT SUSPENSION

The types of front suspension are listed in Table 30, together with the number of each type and of those which have been modified. The 'chopper' modification noted in this Table consists of an extension of the length and an increase in the angle of rake of the front forks.

This modification appeared to be relevant to the consequences of one motorcycle/car collision (Accident 038, Figures 2 and 11). In this accident the motorcycle, a Kawasaki 900, struck the side of a Morris Mini at a speed of about 60 km/h. The rider, who was thrown over the car, sustained concussion, a cut lip and a bruised chest. The pillion passenger was not injured. The extended front forks bent on impact with the car in such a way as to force the front of the motorcycle upwards during the crash, and this action may have been a factor in the relatively moderate injury status of the rider and the absence of any injury to the passenger. Severy, Brink and Blaisdell (1970) have noted that in controlled crashes extended front forks on a motorcycle increased both the crush distance and the amount of energy absorbed in the collision.

There were no accidents in which a rider was obviously disadvantaged by extended front forks. In Accident 295 the rider of such a machine did lose control and his motorcycle slid down as he was attempting to avoid a car which was turning across his path. It may have been that had the front suspension not been modified he would not have lost control, but this sequence of events was a relatively common occurrence among riders on motorcycles which had not been altered in this way.

HANDLEBARS

Thirty-six per cent of these motorcycles had non-standard handlebars fitted, as shown in Table 31. The replacement of standard bars with ones of a similar design but different dimensions has not been included as a modification in this Table.

TABLE 31: TYPES OF HANDLEBARS

Type of Handlebars	Number of Motorcycles with:	
	Standard Equipment Bars	Modified Bars
Flat, or clip-on	26	17
Road, conventional	15	1
Trail	19	-
High rise	9	7
Total	69	25

The riders were questioned about the effect that the handlebars fitted to their machines had on their ability to control the motorcycle immediately before the accident in those cases in which this factor possibly could have been relevant. None of them reported being disadvantaged in any way by the configuration of the handlebars.

DEFECTS IN THESE MOTORCYCLES

Twelve motorcycles were found to be defective, but the defect was relevant to the causation of the accident in only one case. The defects are listed in Table 32.

The two motorcycles on which the actuating mechanism for the brake light switch had been disconnected collided with each other (Accident 015). This accident occurred at night. The two motorcyclists were friends, and had been riding in single file for some distance. The rider in front braked suddenly to turn left into a narrow lane, the entrance to which was unlit. The following rider had no warning that this motorcycle was slowing down, because the brake light did not come on, and the machines collided.

It is possible that some of the 69 motorcycles may have had one or more defective lights (in addition to the brake light defects noted in Table 32). In about half the accidents the motorcycle was so severely damaged that it was impractical to assess accurately the pre-crash condition of the lights and/or the electrical system.

Poorly-adjusted brakes are reviewed in Section 5.5 of this report.

COMPLIANCE WITH THE AUSTRALIAN DESIGN RULES

Three Australian Design Rules (ADRs) apply to motorcycles: ADR7 (hydraulic brake systems), ADR28 (noise emission) and ADR33 (braking performance). Both ADR7 and ADR28 were introduced on 1 July, 1975. ADR33, although introduced on 1 March, 1976, was not enforced in South Australia until October, 1977.

Given the dates of introduction of the ADRs it was not surprising to find that only eight of the sixty-nine motorcycles involved in these accidents carried ADR compliance plates (Table 33). There was no case of a post-1975 motorcycle without a compliance plate.

TABLE 32: TYPES OF DEFECTS IN MOTORCYCLES

Type of Defect		Number of Motorcycles
Worn tyre:	front	2
	rear	2
Rear vision mirror missing:	one mirror	3
	both mirrors	1
Brake light:	switch disconnected	2*
	faulty	1
Rear brake:	faulty	1
Total		12

* One case was relevant to the cause of the accident.

TABLE 33: COMPLIANCE WITH THE AUSTRALIAN DESIGN RULES

ADR No.	Number of Motorcycles in Compliance			Total
	Yes	No	Not applicable	
7	4	-	65	69
28	8	-	61	69
33	3	2	64	69

The two cases of non-compliance were motorcycles with compliance plate dates for ADR33 of May 1976 and July 1976. In the light of the late enforcement of this Design Rule in South Australia, however, these motorcycles were not registered illegally. There were no failures of the hydraulic systems, either on pre-ADR7 machinery or on the later models covered by ADR7. None of the ADR33 motorcycles were involved in braking manoeuvres, so that no comment can be made on the effectiveness of the Rule.

ADR28 (noise emission) was not relevant to this study and so no attempt was made to assess effectiveness.

5.3 STANDARDIZATION OF CONTROLS

Three of the motorcycles in these accidents had the foot brake pedal on the left side of the machine, as opposed to the now common right hand side. The rider of one of these motorcycles said that she was not familiar with it and was confused by the unusual location of the pedal for the foot brake. However, she did manage to brake heavily with the rear brake, although later than would otherwise have been the case.

There was one other case of this type of confusion: the rider of a scooter attempted to sound his horn to warn a pedestrian of his approach. Although he had ridden this scooter for the previous two weeks in the course of his employment, in this emergency he could not find the horn button in time to alert the pedestrian as it was on the opposite side to that with which he was accustomed.

5.4 FUEL LEAKAGE

There were 22 cases in which petrol leaked from the motorcycle either during or after the accident. Table 34 shows the mode of fuel leakage and its frequency of occurrence. In one of these cases the leaking petrol ignited. This occurred when petrol spilled through a closed petrol tank cap as the motorcycle slid along the road and the sparks from the abrading action of the road surface ignited the spilling fuel. The rider suffered severe burns to the leg and the motorcycle was extensively damaged. After the fire had been extinguished, the petrol tank was found to be approximately half fuel. Since the rider had filled the tank immediately before the accident approximately half a tank was lost during and after the crash.

Scrutiny of the make and model of the undamaged motorcycles from which petrol leaked does not reveal any relevant pattern and all four major Japanese manufacturers are represented. Owing to the danger associated with fuel spillage in a post-crash situation and given that in a high proportion (64 per cent) of these cases the leakage was not due to any damage sustained in the accident, there appears to be a need for more satisfactory control of fuel retention when the motorcycle is no longer upright, as after an accident.

TABLE 34: OCCURRENCE OF FUEL LEAKAGE AND SOURCE

Fuel Leakage and Source	Number of Cases	% of Total
Yes, damaged tank or cap	6	9
Yes, undamaged carburettor or tank vent	14	20
Yes, damaged fuel line	2	3
No leakage	47	68
Total	69	100

5.5 SKIDDING WHEN BRAKING

Braking on a conventional motorcycle is effected by the independent operation of two controls. A lever mounted on the right handlebar is squeezed to operate the brake on the front wheel and a foot pedal is depressed to operate the brake on the rear wheel. Thus the rider has a choice of using the front brake, the rear brake, or a combination of the two, but this choice is influenced by the fact that the motorcycle becomes unstable when one or both wheels lock under hard braking. While a limited amount of directional control remains when only the rear wheel is skidding, locking of the front wheel severely negates the dynamic stability of the motorcycle and corrective action by the rider to restore any resultant loss of balance while the wheel remains locked requires a very high level of skill. For this reason many riders are reluctant to use their front brake in an emergency and some refuse to use it at all (Table 23).

WEIGHT TRANSFER UNDER BRAKING

The physical characteristics of a motorcycle are such that the front braking system plays a more critical role than that on a car. When any vehicle is decelerated there is a weight transfer forward. For two vehicles with the centre of gravity at the same height, the vehicle with the shorter wheelbase will be affected more by a transfer of load from the rear wheel to the front wheel under a given deceleration. Therefore the vehicle with the shorter wheelbase will have a correspondingly greater increase in traction under braking at the front wheel, and less at the rear wheel, than will the vehicle with the longer wheelbase. The ratio of height of centre of gravity to wheelbase is much greater for a motorcycle than for a car, and so the motorcycle is far more susceptible to this weight transfer effect under braking.

In an emergency stop, it can be shown that up to 80 per cent of the mass of the motorcycle and rider is concentrated on the front tyre, and so a similar proportion of braking force can optimally be effected through the friction between that tyre and the road surface. Thus it can be seen that the failure of a rider to use the front brake severely limits his braking capability.

From the above discussion it can be appreciated that to maximise the braking capabilities of a motorcycle involves exploiting the forward weight transfer as it occurs, an operation that requires a high level of skill. Under favourable circumstances, however, a highly skilled rider can stop most motorcycles in a distance equal to or less than that achieved by most cars, as can be seen by reference to road test figures in the motoring press.

THE FREQUENCY OF SKIDDING IN THESE ACCIDENTS

The frequency and mode of skidding by the motorcycles in these accidents is listed in Table 35. There was a high incidence (22 per cent) of locked-wheel skidding in the accident sample, principally involving rear brake application. When only those accidents in which the rear brake was applied are considered (27 of the 69 motorcycles) the incidence of skidding when braking increases to 52 per cent.

When interpreting these figures, it should be noted that almost all of these motorcycle accidents (64 out of 68, or 94 per cent) occurred on dry roads, and in two of the accidents on wet roads the riders did not have time to attempt to brake before colliding with a car.

TYRES AND SKIDDING

As could be expected, the distribution of tread patterns follows closely that for motorcycle types as shown in Table 27. The one discrepancy which does occur arises from a motorcycle which was fitted with a trials-pattern front tyre and a road-type rear tyre.

TABLE 35: FREQUENCY AND MODE OF SKIDDING

Mode of Skidding	Number of Cases	% of Total
None	50	72
Front wheel, under braking	1	1
Rear wheel, under braking	14	20
Both wheels, under braking	-	-
Other	1	1
Unknown	3	4
Total	69	100*

* Percentages do not add to 100 because of rounding errors.

TABLE 36: TYPES OF TREAD ON FRONT AND REAR TYRES

Tread Type	Tyre Position	
	Front	Rear
Road, touring	49	50
Trials	18	17
Scramble	2	2
Total	69	69

TABLE 37: INCIDENCE OF SKIDDING WHEN BRAKING BY TYPE OF TREAD ON REAR TYRE

Tread Type	Rear Wheel Braking	
	No. of Cases	Skid Resulted (%)
Road, touring	18	50
Trials	8	50
Scramble	1	100
Total	27	52

TABLE 38: TREAD CONDITION FOR FRONT AND REAR TYRES

Tread Condition	Front Tyre	Rear Tyre
As new	30	32
Good	33	30
Poor	4	5
Bald	2	2
Total	69	69

When only accidents in which the rider used the rear brake (in combination with the front brake in some cases) are considered, there was no discernable association between tread type and rear wheel skidding, although the numbers of cases are small (Table 37). One accident involving rear wheel braking on a wet road and two cases in which a pillion passenger was carried are not listed in this Table.

The condition of the tread on the tyres on these motorcycles was assessed on the basis of tread depth, with those having less than 2mm of tread being classed as 'poor' and those with no tread remaining at any place on the type being classed as 'bald' (Table 38). The presence of only two motorcycles with bald tyres in this accident sample may be a consequence of the basically dry-road conditions which prevailed, as noted above.

There was no apparent association between the depth of tread on the rear tyre and the incidence of rear wheel skidding when using the rear brake.

THE BRAKES

The types of brakes fitted to these motorcycles are listed in Table 39. All of the disc brakes were actuated hydraulically, and the drum brakes by cable (for all of the front brakes) or by a rigid linkage.

The most common fault found in the braking system was poor adjustment, especially in the case of the rear brake. The adjustment of the brakes was recorded for about half of the motorcycles in this survey. Just over 20 per cent of the front brakes were poorly adjusted, as were more than 40 per cent of the rear brakes.

The excessive travel of the foot pedal which was required to produce an adequate braking force may have contributed to the rider's inability to avoid the collision in some accidents. More importantly, when the front brake lever could be squeezed in to touch the handgrip before the maximum braking force had been reached, it was impossible for the rider to effect optimum braking. However, there was only one case recorded in which a rider attempted to use a front brake having a poorly-adjusted actuating mechanism.

SKID TESTING

Although it is apparent that the stopping distance varies with the manner of brake application, information was not readily available on the extent to which it varies when the rear wheel brake is used alone rather than in conjunction with the front brake. Consequently a short series of locked-wheel skid tests were performed (by C.T. Hall).

These tests were carried out on three types of motorcycle; a 125cc trail bike, a 100cc road bike and a 250cc road bike. Each machine had its appropriate type of tyre tread, and the tyres were all inflated to 25 psi. The tests were done on a bituminous surface of uniform aggregate density. Care was taken to choose a flat area and a surface of a type which is common to that on many roads in the metropolitan area of Adelaide. Each motorcycle, in turn, was kept at a steady speed before reaching a marker placed on the road, at which point the clutch was disengaged and the brake(s) applied. The distance to the point at which the motorcycle came to rest was then measured. The length of the skid mark appearing behind the marker was measured to check on the 'anticipation' factor, and it was found that this distance (1.8m average) agreed closely with the wheelbase of these motorcycles. Rear-wheel lockup appeared to occur almost instantaneously on each occasion.

The tests were conducted at 30 km/h, 50 km/h and 60 km/h (except for the 250cc machine). Two types of braking manoeuvres were performed at each speed, a total of four times. The first was braking with front and rear brakes applied, with the rear wheel locked, but not the front. The second type of test

TABLE 39: TYPES OF BRAKES ON FRONT AND REAR WHEELS

Type of Brake		Front Wheel	Rear Wheel
Drum:	leading/trailing shoes	30	66
	twin leading shoes	7	-
Disc:	single	29	3
	twin	3	-
Total		69	69

was rear-wheel lockup without any front brake application. The average was taken of all four readings for each test and the results are shown in Table 40, where it can be seen that applying the front brake in addition to locking the rear wheel approximately halves the stopping distance. This effect appears to be independent of speed, within the speed ranges stated. The different tyre tread patterns did not have a significant effect on these results.

COLLISION AVOIDANCE

On the basis of the results shown in Table 40 the accidents in which only rear wheel braking was attempted were reviewed to determine whether or not the collision could have been avoided had the front brake been used as well. Table 41 lists those accidents in which we believe that we have reasonably reliable information on the approach speeds and in which the rider applied the rear brake alone, locking the wheel. The distance from the start of the rear wheel skid to the point of impact is shown together with the estimated approach speed.

From the data shown in Tables 40 and 41, it is probable that three of the motorcycles in the accidents listed would have avoided the collision had the front brake been applied as well as the rear brake. One other collision may have resulted in only a minor impact, or even been avoided (Accident 032) but the circumstances of Accident 101 suggest that even with front wheel braking the collision would still have occurred.

In Accident 167 the car was moving across the path of the motorcycle at a speed of about 30 km/h. Although use of the front brake would not have stopped the motorcycle before it reached the car, had the car been stationary, such braking would have slowed the motorcycle down at a faster rate, thereby allowing time for the car to move out of its path.

Therefore in those accidents for which we obtained reasonably reliable information on the use of rear wheel only braking, length of the rear wheel skid mark and on the initial approach speed, five of the six collisions probably would have been avoided had the rider employed the full braking capabilities of his motorcycle. This represents seven per cent of the motorcycle accidents in this survey and 15 per cent of the accidents in which the rider tried to brake to avoid the collision.

These results support the suggestion contained in the summary of rider factors in Section 3.7 of this report that there is a need to consider the wider adoption of coupled braking systems on motorcycles, of the type now available on some of the models of motorcycle produced by the Italian manufacturer, Moto Guzzi. With this system disc brakes on both front and rear wheels are actuated simultaneously by a single foot lever. Hydraulic brake lines connect the pedal to the brakes, and a proportioning valve channels approximately 70 per cent of the braking effort to the front wheel and 30 per cent to the rear. Such a system may be more expensive to produce than, say, separate mechanically-actuated front and rear brakes. This is a less serious commercial penalty on an expensive motorcycle, such as these models of Moto Guzzi, than it would be on a much cheaper motorcycle which is intended to be used for commuting. But the potential advantages are likely to be greater on the cheaper machine simply because the rider is less likely to have acquired the degree of skill needed to make adequate use of the conventional separate braking systems.

A coupled brake system has the additional advantage that satisfactory braking can be achieved by the use of a single foot-operated control, as in all other motor vehicles.

TABLE 40. MEAN STOPPING DISTANCE BY MODE OF BRAKING AND TYPE OF MOTORCYCLE

Speed on Braking (km/h)	Type of Motorcycle	Mode of Braking: Rear wheel only (wheel locked) (A)	Mode of Braking: Front wheel, with rear wheel locked (B)	Ratio B/A
30	125cc trial[1]	7.8[4]	4.4[4]	0.63
30	100c road[2]	7.0	3.5	0.50
32	250cc road[3]	7.1	3.6	0.51
48	250cc road	19.2	8.4	0.44
50	125cc trail	21.2	11.6	0.55
50	100cc road	20.2	10.5	0.52
60	125cc trail	29.5	16.7	0.58
60	100cc road	27.5	16.7	0.61

Notes: [1] Yamaha DT 125 trail [2] Yamaha 100 L2 [3] Honda CB 250
[4] Stopping distance in metres

TABLE 41: ESTIMATED APPROACH SPEEDS AND SKID LENGTH TO IMPACT POINT FOR REAR WHEEL BRAKING CASES

Accident No.	Skid Length to Impact Point (m)	Estimated Approach Speed (km/h)
032	16.1	60
035	25.0	60
101	2.3	30
112	22.0	60
167	5.1	75
274	36.4	75

6. THE CONSEQUENCES OF MOTORCYCLE ACCIDENTS

6.1 INJURIES TO THE MOTORCYCLISTS

In almost all of these accidents the motorcyclist was the most severely injured participant. The exceptions were those accidents involving a pedestrian or a pedal cyclist, and they are described in the reports on accidents involving those classes of road user.

PILLION PASSENGERS

Eleven of the 69 motorcycles in these accidents were carrying a pillion passenger. Neither the rider nor the pillion passenger was injured in Accident 221, in which the motorcycle struck a small child, and another pillion passenger was not injured although the motorcycle crashed into a car (Accident 038). Seven of the remaining nine pillion passengers were injured in collisions with cars, one other passenger received minor injuries when the rider lost control on a bend when travelling at about 100 km/h, and one passenger was killed, as was the rider, when they struck a utility pole.

These eleven pillion passengers are included with the 69 riders in the general statistics which follow on motorcyclists' injuries, but their more serious injuries are distinguished from those of the riders later in this section.

6.1.1 OVERALL INJURY SEVERITY

Table 42 lists the distribution of overall injury severity for each category of road user involved in the accidents covered by this survey. Four of the eight persons killed in these 304 accidents were motorcyclists but, apart from these four, the percentage of overall injury severity ratings of severe to critical was considerably less (23.7 per cent) for these riders and pillion passengers than it was for pedal cyclists (34.7 per cent) or for pedestrians (45.4 per cent). The lower rate of severe to critical injury among motorcyclists is probably a consequence of the fact that almost all of them were wearing a crash helmet, and so severe, or worse, head injury was much less common (5.0 per cent of all participants) among motorcyclists than among pedal cyclists (13.6 per cent) or pedestrians (20.6 per cent). The distribution of overall injury severity for the eleven pillion passengers was similar to that for the 69 riders.

INJURY SEVERITY SCORE

The Injury Severity Score (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. Concussion, with a period of unconsciousness of less than 15 minutes, has an AIS rating of two, and therefore a contribution to the overall ISS of four.

Fifty-three per cent of the motorcyclists in this survey had an ISS which was greater than four (including the four persons who were killed). The corresponding percentage for both pedestrians and pedal cyclists was 61, and 13 per cent for car occupants.

6.1.2 BODY REGIONS INJURED AND OBJECTS CAUSING INJURY

BODY REGIONS INJURED

Almost half (46.2 per cent) of the injuries sustained by these motorcyclists were to the lower extremities (Table 43). As noted in the preceding section the frequency of head injury was lower for motorcyclists than would have been expected from the experience of pedestrians and pedal cyclists, an effect which it seems reasonable to attribute to the protection afforded by the crash helmet, a topic which is discussed in more detail later in this report, as is the high frequency of leg injuries, many of which were very severe.

OBJECTS CONTACTED

The road surface was the most frequently contacted object which caused injury (39 per cent of all injuries) as shown in Table 44, but fixed objects accounted for more than one third of all severe injuries (AIS $\geqslant$ 3).

The range of objects contacted by these motorcyclists was greater than that for pedestrians or pedal cyclists largely because motorcycle accidents frequently involve collisions with the sides or the rear of a car or other vehicle. These areas are contacted rarely by these two classes of road user.

The role of many of the listed objects in injury causation is discussed in relation to specific injuries in the following section.

6.1.3 TYPES OF INJURY

FATAL INJURIES

There were four fatalities, two single riders and one accident in which both rider and pillion passenger were killed,

TABLE 42: OVERALL INJURY SEVERITY FOR EACH TYPE OF ROAD USER

Type of Road User	Overall Injury Severity (Per Cent)*							Total Number of cases
	Nil	Minor	Moderate	Severe	Serious	Critical	Fatal	
Pedestrian	2.3	25.0	20.5	29.5	11.4	4.5	6.8	44
Pedal Cyclist	4.3	21.7	39.1	21.7	8.7	4.3	-	23
Motorcyclist	3.7	37.5	30.0	16.2	7.5	-	5.0	80
Car Occupant	52.0	32.9	11.0	2.1	1.1	0.8	0.1	727
Occupant of Light Commerical Vehicle	53.3	20.0	26.7	-	-	-	-	15
Occupant of Heavier Commerical Vehicle	81.0	14.3	4.8	-	-	-	-	21
Bus Occupant	18.2	72.7	9.1	-	-	-	-	11
All Road Users	44.5	32.5	13.9	5.0	2.3	1.0	0.9	921

*Note: The figures for bus occupants show a higher average severity of injury than was actually the case. This is because in one accident the bus was carrying a large number of passengers, possibly as many as sixty, and when the bus stopped after the collision almost all of these passengers transferred to a following bus within a minute or so. Ten car occupants are also not represented in this Table because we were unable to examine them after the accident. One of them probably was injured, the others almost certainly were not.

TABLE 43: MOTORCYCLISTS: FREQUENCY AND SEVERITY OF INJURY BY BODY REGION

Body Region	All Injuries No.	All Injuries %	All Injuries No. of persons	Severe Injuries[1] No.	Severe Injuries[1] %	Severe Injuries[1] No. of persons
Head	22	8.4	20	5	11.1	4
Face	16	6.1	16	1	2.2	1
Neck	9	3.4	8	2	4.4	2
Shoulder	13	5.0	12	-		-
Whole Arm	2	0.8	1	-		-
Upper Arm	3	1.1	2	1	2.2	1
Elbow	7	2.7	7	-		-
Forearm	13	5.0	12	-		-
Wrist/Hand	23	8.7	20	1	2.2	1
Back	4	1.5	4	2	4.4	2
Chest	15	5.7	12	5	11.1	2
Abdomen	5	1.9	3	3	6.7	2
Hip, Pelvis	10	3.8	10	1	2.2	1
Whole Leg	1	0.4	1	-		-
Thigh	23	8.8	20	5	11.1	5
Knee	41	15.6	34	5	11.1	4
Lower Leg	35	13.4	30	11	24.4	9
Ankle/Foot	21	8.0	17	3	6.7	3
Total	262	100.0[3]	-[2]	45	100.0[3]	-[2]

Notes: [1] AIS ⩾ 3.

[2] Column not additive.

[3] Percentages may not add to 100.0 because of rounding errors.

TABLE 44: MOTORCYCLISTS: FREQUENCY AND SEVERITY OF INJURY BY OBJECT CONTACTED

Object Contacted	All Injuries Contacts No.	All Injuries Contacts %	All Injuries Persons No.	Severe Injuries* Contacts No.	Severe Injuries* Contacts %	Severe Injuries* Persons No.
Road surface	103^{8} #	39.3	48	2^{1}	4.4	2
Fixed Object	23	8.7	6	17	37.8	4
Other non-vehicular Object	10	3.8	3	1	2.2	1
Motorcycle:						
Handlebars	21	8.0	14	2	4.4	2
Petrol tank	2^{1}	0.8	1	-	-	-
Crash bars	1^{1}	0.4	1	-	-	-
Front wheel	1^{1}	0.4	1	-	-	-
Accessory equipment	1	0.4	1	-	-	-
Other component	1^{1}	0.4	1	-	-	-
Component unknown	11^{2}	4.2	8	1^{1}	2.2	1
Bumper (front)	5^{1}	1.9	5	3	6.7	3
Leading edge bonnet	3	1.1	3	1	2.2	1
Vertical leading edge of front fender	3	1.1	2	2	4.4	1
Upper surface of bonnet	2	0.8	1	-	-	-
Windscreen-glass	1^{1}	0.4	1	-	-	-
'A' Pillar	1^{1}	0.4	1	-	-	-
Rear window (glass)	1^{1}	0.4	1	-	-	-
Bumper (rear)	5	1.9	4	3	6.7	3
Vertical trailing edge rear fender	3	1.1	2	2	4.4	1
Upper edge front fender	1	0.4	1	-	-	-
Front wheel/tyre	2	0.8	1	2	4.4	1
Side door (closed)	18^{2}	6.9	10	3	6.7	3
Side roof rail	2^{1}	0.8	2	1	2.2	1
Side of rear fender	1	0.4	1	-	-	-
Other front of car	4	1.5	3	-	-	-
Other side of car	7^{3}	2.8	5	3	6.7	2
Other back of car	4^{1}	1.5	3	-	-	-
Undercarriage	2^{1}	0.8	1	1^{1}	2.2	1
Unknown part of car	2^{2}	0.8	1	1	2.2	1
No contact	2	0.8	2	-	-	-
Unknown	19	7.3	13	-	-	-
Total	262^{27}	100.0	-	45^{2}	100.0	-

Notes: * AIS ≥ 3.

Superscript denotes possible contacts.

all as a consequence of striking roadside objects. In each of the three accidents the riders had high blood alcohol levels: .22, .22 and .14. It has not been possible to establish whether the helmets were actually worn at the time of the accident by two of these riders, one of whom died of head injuries. They were both found separated from their helmets. The third rider also died of head injuries. His helmet was shattered by the force of an impact with a roadside utility pole (Figure 14). The pillion passenger's helmet came off, but there was evidence that it had been in place during the impact.

Accident 045:

A 21 year old rider veered off a well-lit road at 2.50 a.m. He was intoxicated (BAC .22), but may also have fallen asleep. The motorcycle mounted the footpath, struck a sign post and bounced back onto the road. The rider continued to slide along the footpath for 12 metres until his head struck the sharp corner of a 100mm square gate post. The force of this impact was sufficient to split the cranium lengthwise, releasing its contents.

The helmet was found undamaged, apart from a few minor abrasions, a few feet from the rider with the chin strap unbuckled (Figure 12). If the helmet was worn, it was either unbuckled or the buckle (two D-shaped rings) released during the crash. Had the helmet stayed on, the outcome may have been altered if the smooth surface of the helmet converted the impact with the post from one of violent deceleration to a glancing blow. The subject of helmet fastening is discussed later in this section.

Accident 155:

A 21 year old rider, also with a BAC of .22, rode through a roadworks warning barrier at midnight. The barrier consisted of steel posts, mounted with flashing lamps, and connected by cord with small orange flags attached. Without appearing to have altered speed the motorcyclist continued across the earth works beyond the barrier and rode through a two-strand wire fence into an open grassed area in a park. The lowermost wire on the fence was snapped by the motorcycle, but the upper wire swept up the rider's torso and caught under his chin. The rider's body was found 20 m, beyond the fence, separated by a few metres from both the motorcycle and the helmet. The helmet strap was not fastened.

There was an abrasion across the rider's neck beneath the angle of the jaw. Post mortem examination revealed an unstable fracture-dislocation of the second and third cervical vertebrate with transection of the spinal cord at this level. Although the helmet would not have played a protective role in this accident, the question once again arises as to whether the strap or buckle mechanism failed (although there was no indication, such as damage to the strap, that this had occurred) or whether the helmet strap had been fastened at the time of the crash.

Accident 289:

This double fatality occurred when a motorcycle ran off the road after turning right into the stem of a T-junction. The rider and pillion passenger both struck a steel and concrete utility pole, even though the motorcycle did not. The pole exhibited paint mark evidence of impact from both helmets (Figure 13). The rider's helmet remained in position, but was grossly deformed (Figure 14). There were extensive fractures of the base of his skull with severe brain injury, particularly in the frontal region. In addition, there was a fracture of the dorsal spine at the D8-9 level and the right auricle of the heart was ruptured.

The shell of the pillion passenger's helmet was also fractured. A scalp laceration and skull fracture corresponding to the helmet fracture indicated that the helmet was being worn at the time of impact. It was found separated from the passenger with the chin strap unbuckled. This subject sustained gross frontal laceration, skull fracture and brain damage, a fractured mid-dorsal spine and ruptured liver. His blood alcohol level was .05. The injuries sustained by the rider suggest that the pillion passenger's outcome would not have differed significantly had the helmet stayed on.

The exact mechanism of these fractures of the dorsal spine is not known. It was not practicable to have post-mortem roentgenograms taken. The rider and pillion were presumably subjected to similar stresses, possibly arising from longitudinal compression, to have both sustained mid-dorsal fractures.

HEAD INJURIES

There were 42 injuries to the head, face and neck in 29 riders and five pillion passengers. The frequencies are presented in Table 45 and are discussed under the headings shown in the Table. Relevant crash helmet information is given below, with a more general crash helmet report in the following section.

Fatal Brain Contusion

These three cases are discussed in the preceding section on fatal injuries. The mechanism of each injury is reviewed in greater detail here.

Helmet stayed on:

This involved a high energy impact with a utility pole (Rider, Accident 289). The

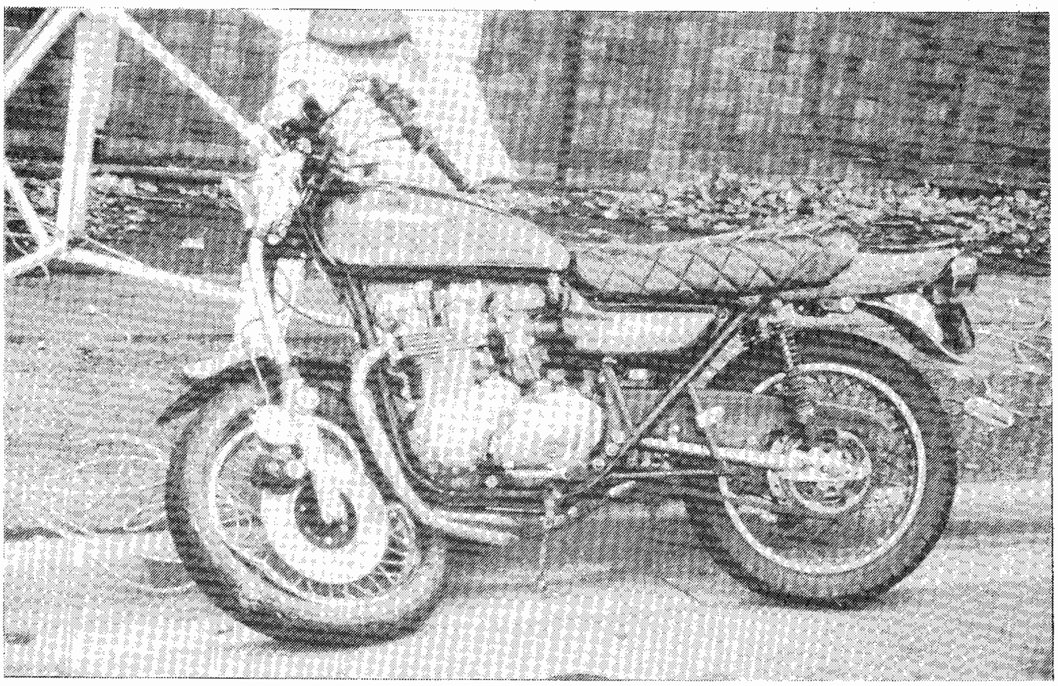


FIGURE 11: Damage due to collision with car (see Figure 2). Note extended front forks. Accident 038.

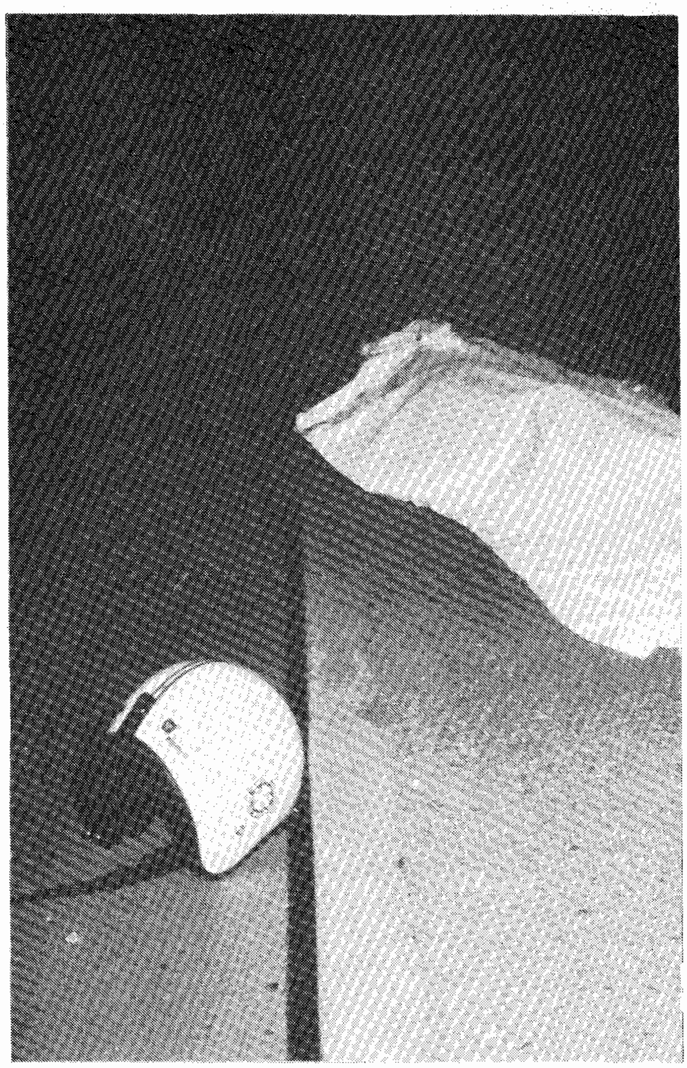


FIGURE 12:

Helmet, with chin strap not fastened, found separated from rider after fatal crash. Accident 045.

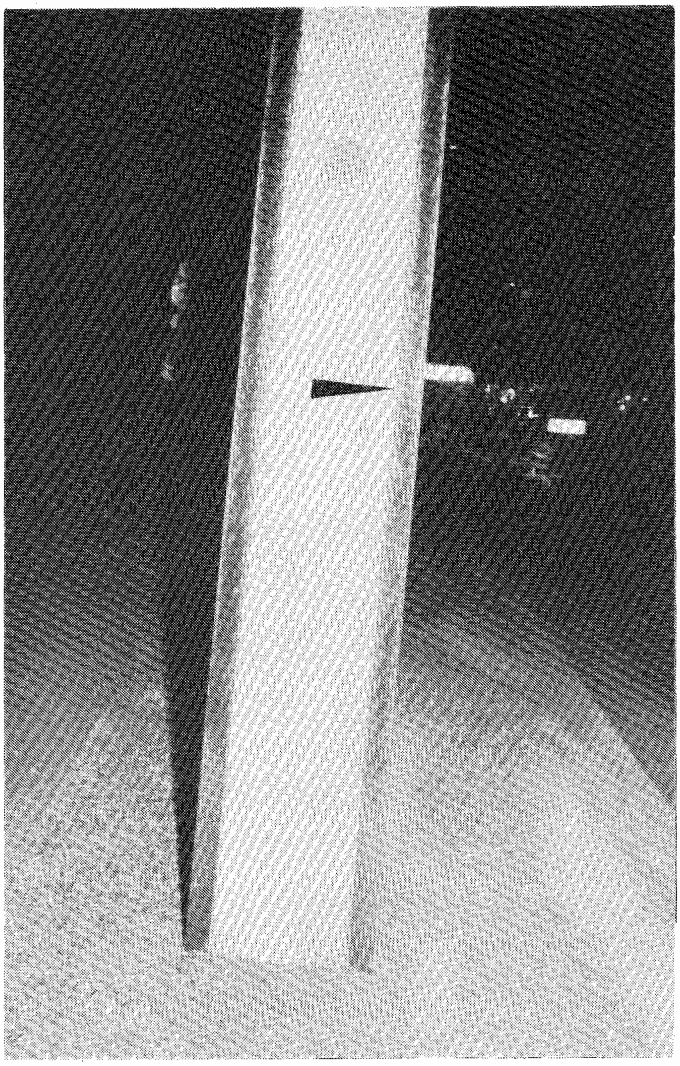


FIGURE 13:

Utility pole struck by rider and pillion passenger. Arrow locates paint mark from helmet impact. Motorcycle passed to right of pole. See also Figure 14. Accident 289.

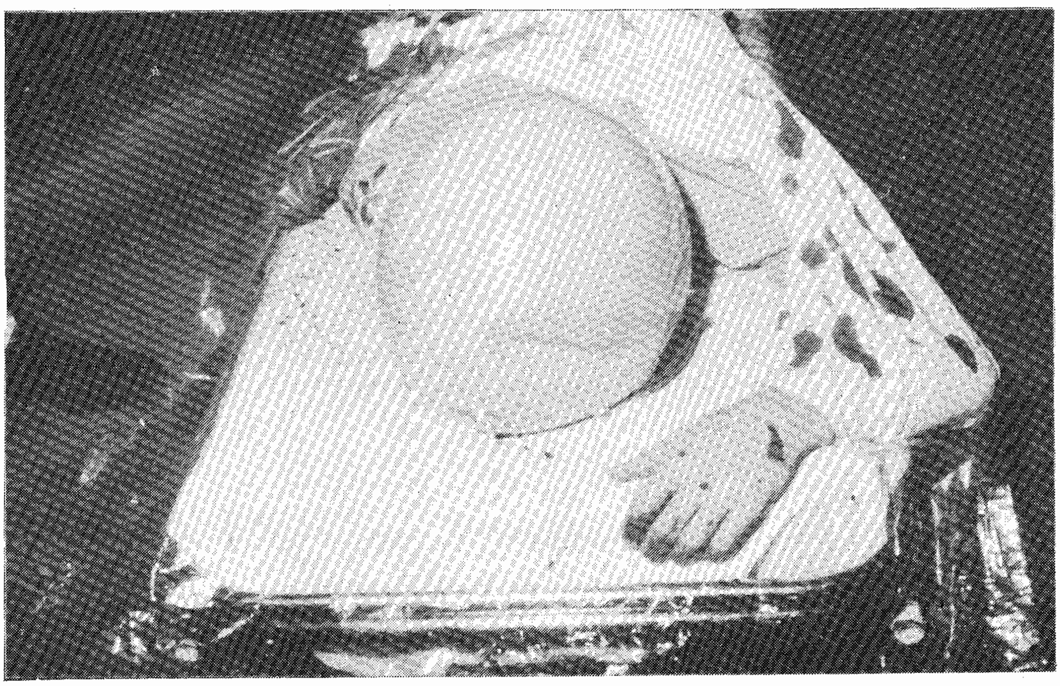


FIGURE 14: Damage to helmet resulting from impact with pole shown in Figure 13. Rider fatally injured. Accident 289.

TABLE 45: MOTORCYCLISTS: INJURIES TO THE HEAD, FACE AND NECK

		Number of Injuries
Head		
	Fatal brain contusion	3
	Concussion	15
	Scalp abrasion	1
Face		
	Facial fractures	3
	Facial lacerations, abrasions and contusions	13
	Broken tooth	1
Neck		
	Cervical spine fracture dislocation	1
	Neck pain	4
	Neck laceration	1
Total		42

jet-style helmet had a polycarbonate shell which underwent gross deformation on striking the steel edge of the pole. The residual deformation consisted of a linear depression in the shell along the line of impact with ovoid distortion of the entire shell (Figure 14). The elastic properties of the material indicate that the dynamic deformation must have been considerably greater. The energy-absorbing liner of the helmet was also grossly deformed.

While this degree of deformation represents failure of the helmet, several factors must be considered. Firstly the impact speed was probably about 60 km/h (16.7 m/sec). Australian Standard AS 1698-1974, Protective Helmets for Vehicle Users, requires adequate energy attenuation in drop testing which attains an impact velocity of 5.99 m/sec. - about one third of the estimated impact velocity in this accident. One of the drop tests involves a flat anvil as the test impact surface, in another the helmet strikes a round anvil of 48mm radius at a lower velocity. The steel edge of the pole which was struck in this crash had a radius of about 5mm. Secondly, the deceleration of the shell of the helmet was likely to have been greater than is compatible with life even if the outer shell had not deformed and the lining had compressed in the most effective way. Lastly it seems that there may have been considerable inertia loading on the spine. The helmet may thus have been subjected to far greater loading than would have been expected from the head alone.

Extensive fractures of the base of the skull were present, involving the middle fossa, the left petrous temporal and the left frontal region. There was a large area of damage to the frontal region of the brain. The mandible was broken centrally and on the left side (this contrasts with the pillion passenger whose helmet provided some facial protection).

It can be assumed that both the pillion passenger and the rider experienced similar impacts with the utility pole, which provides a useful opportunity for a comparison of the performance of the two helmets. As noted above, however, the forces involved were greater than current helmet design could be expected to withstand. The passenger's helmet was of fibreglass construction in full-face style. The impact was against the steel and concrete flat surface of the pole and it resulted in an irregular fracture above the left temporal region. The residual deformation was not as great as that of the polycarbonate helmet of the rider but this gives no indication of the degree of dynamic deformation. There was a deep laceration of the scalp beneath the side of the fracture in the shell of the helmet. The skull was extensively fractured in the front half and in the base. There was no facial fracture detected.

Helmet came off before impact:

The rider in Accident 045 struck the sharp corner of a wooden gate post with the vertex of his skull after falling from his motorcycle, as described earlier in this section. The cranium was split open longitudinally avulsing an entire cerebral hemisphere. The undamaged helmet was found lying alongside the rider.

Concussion

There were 15 cases of concussion among the 80 motorcyclists involved in these accidents. In one accident (082) the helmet came off and the rider's head struck the windscreen of a motor vehicle; it is not known if the helmet was still on at the time of impact. Table 46 lists the incidence of concussion for each type of helmet. Based on these data the type of helmet had little effect on the risk of the rider being concussed, although the numbers of cases are small when the many possible sources of bias in such a comparison are considered. For example, the objects known to have been contacted in these 15 cases of concussion were the road surface (seven cases), and a vehicle (five cases, followed by a second impact with the road surface in two of these cases). The impact properties of a part of a motor vehicle are likely to differ significantly from those of the road surface.

There was only one case (Accident 042) of severe concussion (unconsciousness longer than 15 minutes). In all other cases consciousness was regained within 15 minutes and without neurological deficit.

NECK INJURY

Fatal Neck Injury

The one case of fatal neck injury has been described in the earlier section on fatal injuries (Accident 155).

Neck Pain

Four riders reported neck pain resulting from their accidents, with up to three months absence from work as a consequence. These four motorcyclists were all wearing full-face helmets.

FACIAL INJURIES

There were 16 cases of facial injury, of which eleven were lacerations, abrasions and contusions, three were fractures of the mandible or facial bones, one blood nose and one broken tooth. Facil injuries were far more common among wearers of jet style, rather than full-face helmets (Table 47).

TABLE 46: MOTORCYCLISTS: CONCUSSION BY TYPE OF HELMET

Type of Helmet Worn	Concussion	
	Yes	No
Full face	6	20
Jet	9	33
Jet and face guard	-	4
Hemispherical	-	4
Not known	-	3
None	-	1
Total	15	65

TABLE 47: MOTORCYCLISTS: FACIAL INJURY BY TYPE OF HELMET

Type of Helmet	Facial Injury	No. of Helmets
Full face	1	26
Jet style	13	42
Helmet came off	2	6
Other	-	6
Total	16	80

LOWER LIMB INJURIES

These 80 motorcyclists sustained a total of 262 injuries, of which 121 (46 per cent) involved the lower extremity.

The types of injuries that occurred demonstrate clearly the vulnerability of the motorcyclist's lower limbs. The circumstances of accidents which produce fractures of the lower limb are described below, together with suggested mechanisms of injury.

There were nine cases of fractured femur, 12 cases of fractured tibia and/or fibula, two fractured patella and five fractures about the foot and ankle.

Fractures of the Femur

Collision with the side of a car:

There were three accidents in which the motorcycle struck the side of a car which crossed its path from an intersecting road.

Accident 042:

A motorcycle rider and pillion passenger were travelling at about 75 km/h when their motorcycle crashed into the side of a car which was crossing from their right at a speed of about 25 km/h. The front tyre of the motorcycle left an imprint in the forward part of the left front door of the car. There was significant deformation of the side of the car behind this initial impact point, involving the remainder of the front door, the B-pillar, the rear door and the roof, with gross intrusion of the passenger compartment (Figures 7 to 9).

The front of the motorcycle was carried to the left by the forward motion of the car, causing the motorcycle to rotate to the left until the right side struck the car behind the initial point of impact. The right legs of the rider and the pillion passenger would therefore have been trapped between the motorcycle and car.

Both rider and pillion passenger sustained fractures of the right femur and lacerations of the right knee. In addition, the rider sustained a fractured metacarpal in the right hand and a fracture of the right talus. The pillion passenger also sustained a fractured jaw. Both motorcyclists were concussed, the rider severely. Within 48 hours of admission to hospital both subjects exhibited signs of fat embolism, a potentially life-threatening syndrome associated with fractures of long bones by high energy impacts.

Accident 112:

This was a lower velocity frontal impact into the left side of a car which was crossing from the rider's right. The front of the motorcycle was displaced sideways on impact, in the direction the car was travelling, as evidenced by (i) damage to the right side of the motorcycle, (ii) a small dent in the left rear fender of the car behind the point of impact and (iii) a fracture of the medial condyle at the lower end of the rider's right femur.

Accident 278:

A motorcyclist swerved to the left and braked in an unsuccessful attempt to avoid a car which had stopped in his path while crossing from his left. The front tyre of the motorcycle impacted in the mid-point of the driver's door. The front forks twisted and bent back, allowing the axle, right fork and rear half of the front tyre to leave impressions on the door. Two marks were found on the window of the rear door, corresponding to abrasions on the front left side of the rider's helmet. A dent in the right rear door below the window sill may have been caused by the rider.

The rider's injuries consisted of a laceration of the medial side of the right knee and a crack fracture of the medial condyle of the right femur. He also ruptured the medial collateral ligament of the metacarpo-phalangeal joint of the right thumb which required surgical repair. It was not possible to establish how the laceration of the knee occurred. The thumb injury resulted from force transmitted through the handlebar during the impact.

Rider fell off, then struck another object or vehicle:

A motorcyclist fell from his machine, for reasons which could not be established, and was then struck by an oncoming car, and dragged along underneath the car for some distance. He sustained multiple fractures involving the left humerus, right scapula, pelvis and right femur. He was concussed and his management was complicated by fat embolism.

Accident 065:

An inexperienced rider misjudged a corner and slid the right side of the motorcycle into the front of a parked car. The right lower limb was trapped between the motorcycle and the car, resulting in a midshaft fracture of the right femur.

Accident 010:

An intoxicated motorcyclist fell from his machine on the approach to a signalised intersection. The rider slid along the road with his machine until they struck a traffic signal pole. He sustained a transverse fracture of the midshaft of the right femur, and a fracture of the right radius. The mechanism of injury production in this case is not known. There were no witnesses and the subject suffered retrograde amnesia.

Head-on collision with a car:

Accident 082

This motorcyclist crashed head-on into a car which ran, out of control, across the centreline of the road following a collision with another car.

There was a tyre imprint in the major dent in the front of the car indicating the point of impact of the front wheel. To the right of this point (viewed from the front) there was a shallower, but well defined, dent in the leading edge of the bonnet. There was also a shallow dent in the right side of the motorcycle petrol tank. The motorcycle appears to have swung anticlockwise during the crash, trapping the rider's right leg between the petrol tank and the car bonnet. The rest of his body continued forward over the bonnet, resulting in a fracture of the right femur.

Car turned right, in front of oncoming motorcycle:

Accident 095:

A car turned right at a signalised intersection and struck an oncoming motorcycle. The impact was on the pillion passenger's right leg, and it resulted in a fracture of the right femur.

Fractures of the Tibia and Fibula

Twelve of the 80 motorcyclists sustained fractures of the tibia and/or fibula. All but one of these injuries were a consequence of a collision with another vehicle.

Motorcycle ran into the back of another vehicle:

Accident 022:

When riding along a straight road at dusk, a rider of a small commuter-type motorcycle struck the driver's side rear corner and light assembly of a parked vehicle. He sustained abrasions to the left side of his face, his left elbow, knee and ankle. The mid-shaft of the left fibula was fractured, when the rider's leg struck the corner of the stationary vehicle. A thin fibreglass fairing on the motorcycle afforded little protection to the leg in this frontal impact.

Accident 159:

A motorcyclist swerved to the left to avoid a car which was stationary in the right lane waiting to turn right. The right side of the motorcycle struck the left rear corner of the car with the rider's lower leg taking the brunt of the impact. A compound fracture of the right tibia and fibula was the result. There were dents in the petrol tank and the side cover adjacent to the usual position of the rider's leg.

Accident 217:

A motorcyclist who had a heavy cold sneezed when riding along a straight road at night. While he was trying to wipe his face he struck the right rear corner of a parked car. The initial impact was between the rider's left leg and the rear corner and the tail light assembly of the car. This was followed by his left shoulder striking the rear window and C-pillar. Apart from the left handlebar being bent back there was no damage to the motorcycle. The rider sustained a compound fracture of the proximal ends of the left tibia and fibula, a compound fracture of the left patella and a ruptured lateral ligament of his left knee, together with a dislocation of his left shoulder.

Collision with a car on an intersecting path:

Accident 092:

A car entered a road from a parking area on the left, crossing the path of a motorcyclist who struck the rear fender with a glancing blow, at the same time hooking back the rear bumper bar. The rider sustained a compound fracture of the lower right tibia and fibula, a fracture of the third metatarsal in the right foot and widespread burns after spilt petrol ignited. One year later he still walked with a limp and lacked full movement of the right knee. The object impacting the right tibia was not clearly established, but was probably the bumper bar.

Tubular steel crash bars were fitted to the front of the frame of this motorcycle. The bar on the right side was found to be pushed back and wrapped around the motor. It appeared to have served no protective purpose.

Accident 102:

A car turned right at an uncontrolled intersection and struck a motorcycle, which was crossing from the driver's right, on the left hand side (Figure 3). The rider's left tibia and fibula were fractured.

Accident 139:

A motorcyclist slid down under emergency braking when he tried to avoid a car which had appeared in front of him from the stem of a T-junction. The motorcycle slid broadside into the front of the car. The rider's left tibia was fractured when his leg struck the front bumper bar of the car.

Accident 002:

A motorcycle, carrying a rider and a pillion passenger, was struck on its right side by a car which had approached from its right at an uncontrolled intersection. The impact was towards the rear of the motorcycle, and so the pillion passenger sustained fractures of the tibia and fibula whereas the rider's right leg was not injured.

Car turned right and collided with oncoming motorcycle:

Accident 143:

A motorcycle was struck at an angle on the right side by the front corner of a car which was turning right at a signalised intersection. The rider's right leg was struck by the car, resulting in fractures of the tibia and fibula.

Accident 234:

This accident was similar to Accident 143, except that the rider's leg was hit by the right front headlight of the car. The headlight glass was broken by the impact and the sharp rim which was then exposed gouged a large flap of skin and muscle from the lateral aspect of the rider's leg (Figures 15 and 16). The sural nerve was divided, leaving an area of sensory loss and the tibia's anterior muscle was damaged beyong repair, leaving a permanent weakness of ankle movement. The impact also fractured the rider's right fibula.

Motorcycle turned right and was struck by oncoming car:

Accident 243:

A motorcycle turned right at a signalised intersection into the path of an oncoming car. The car struck the pillion passenger's left leg, producing midshaft fractures of the tibia and fibula.

Motorcyclist run down from the rear by a heavy vehicle:

Accident 127:

A motorcyclist turned left at a signalised intersection when the signal changed to green. He then moved across to the centreline intending to turn right into a lane, but was struck from the rear by a semi-trailer which had been crossing the intersection on the red phase (Figure 17, frontispiece). Cloth from the rider's trousers was found on the tread of the left front tyre of the prime-mover, indicating that the leg was run over. There was a severe crushing and degloving injury to the rider's right leg, with a compound fracture of the right tibia and fibula.

Rider fell from motorcycle:

Accident 203:

This accident occurred when the rider was testing a motor scooter. He experienced some difficulty changing gears, and may have hit a small pothole at the same time. He fell from the scooter and fractured his right tibia. The mechanism of this injury could not be established.

Fractures of the Patella

One accident in which the rider sustained a compound fracture of the patella has been described above (Accident 217). In Accident 035 the rider struck his left knee on the right rear corner of a parked car when he was reportedly trying to avoid another car. The motorcycle was fitted with crash bars which were bent back by the impact and apparently gave no protection to the rider's leg (Figure 18). The rider sustained a compound fracture of the patella and a central fracture dislocation of the left hip. There was no evidence of there having been a lateral blow on the side of the rider's left thigh, which suggests that the hip may have been abducted sufficiently to direct the impact on the knee through to the centre of the acetabulum.

Fractures of the Foot and Ankle

Two of the five accidents which resulted in fractures of the foot or ankle have been discussed above (042 and 092). The rider of the motorcycle in Accident 042 sustained a fracture of his right talus (ankle bone). This injury may have been caused by forced dorsiflexion of the foot, arising from the foot being forced downwards between the motorcycle and the side of the car. The rider in Accident 092 received a fracture of the third metatarsal in his right foot. The mechanism of this injury is not known.

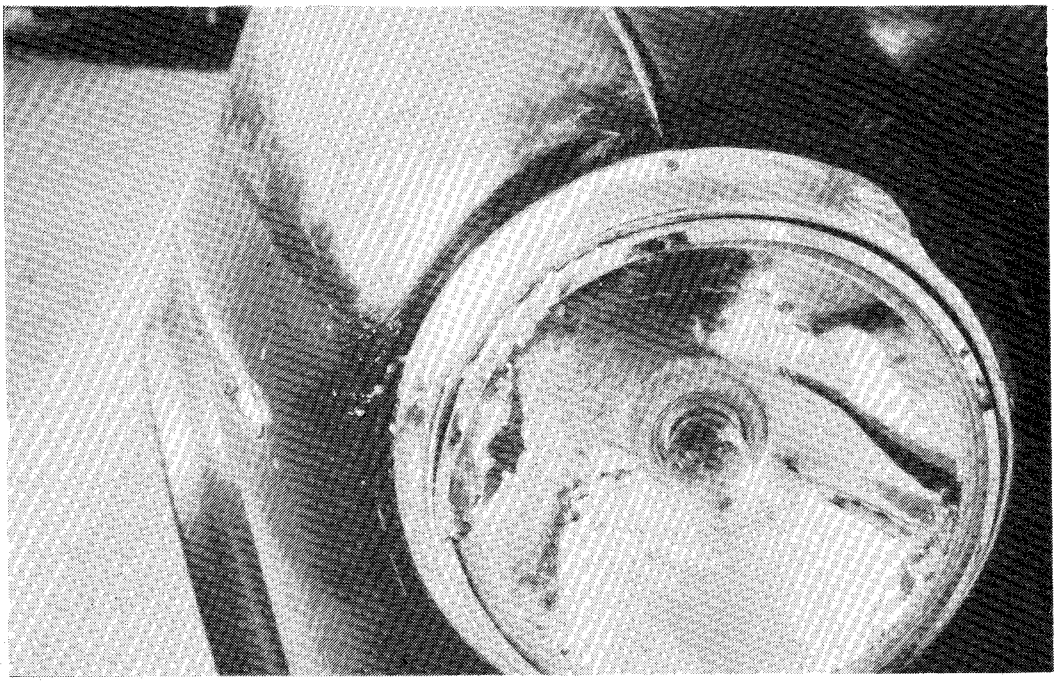


FIGURE 15: Headlight struck by rider's leg (see Figure 16). Accident 234.

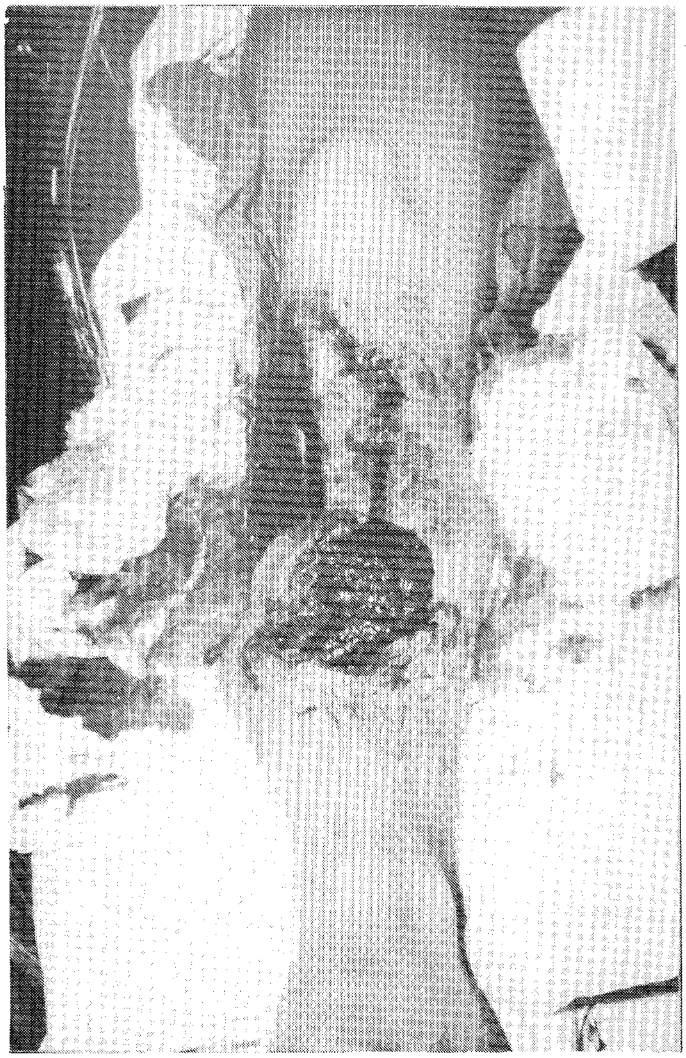


FIGURE 16:

Injury to rider's leg from impact with car headlight shown in Figure 15. Accident 234.

See frontispiece

FIGURE 17: Motorcycle struck from the rear by prime-mover. Accident 127.

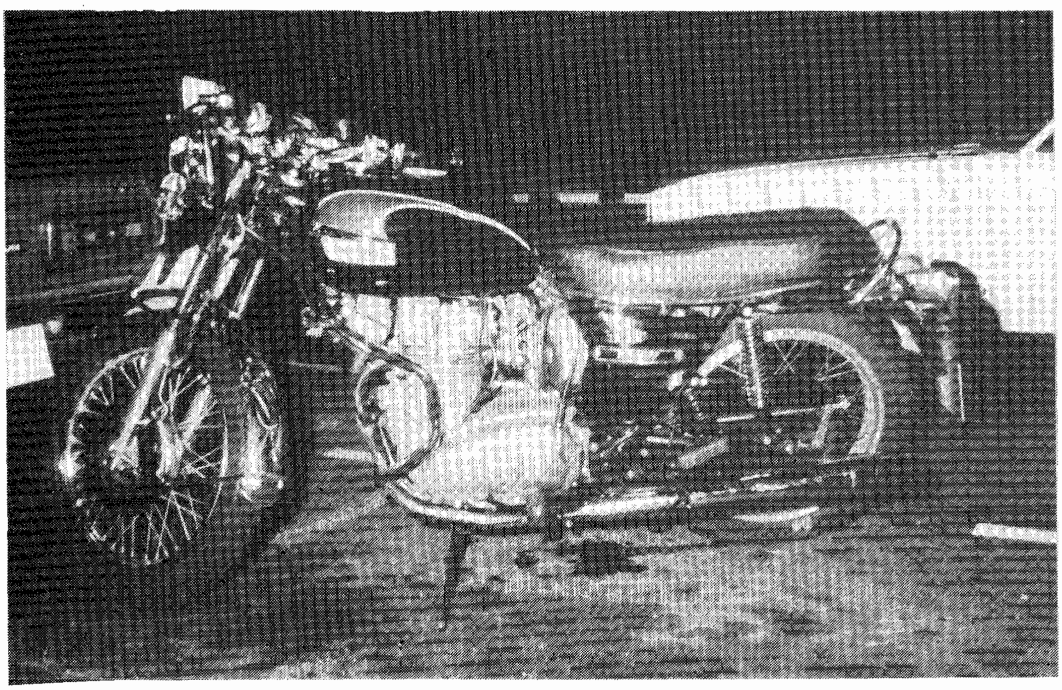


FIGURE 18: Crash bar bent back after impact with rear corner of parked car. Accident 035.

Direct impact with a car:

In Accidents 142 and 281 the motorcycle collided with a car. The rider's left ankle was fractured when his machine hit the front of a car which unexpectedly stopped diagonally across his path in the former accident, and the pillion passenger received a similar injury when a car moved to the right, preparatory to making a U-turn, and hit the passenger on the left leg in Accident 281.

Injury resulting from fall following a collision:

Accident 249:

The rider fell to the roadway when the motorcycle was struck on the side cover and rear suspension unit on the right hand side by an oncoming car which turned right at a signalised intersection. The rider's left ankle was fractured.

UPPER EXTREMITIES

There were nine fractures of the upper extremity and one dislocated shoulder. These injuries tended to result from severe crashes in which the motorcyclist sustained multiple injuries; in eight of these cases there were also fractures of the lower limb.

One of the most severe injuries affecting the upper extremity occurred in Accident 085. The rider fell from his motorcycle on the approach to a roundabout at an intersection. He slid along the road for about 20 metres and then struck the concrete kerb of the roundabout with his left shoulder. This impact resulted in avulsion of his brachial plexus, with paralysis of the rider's left shoulder.

6.1.4 CRASH INJURY PREVENTION

The protection of the motorcyclist from injury when involved in a crash is in some ways even more difficult than it is in the case of the pedestrian or pedal cyclist because the motorcyclist is usually travelling as fast as the vehicle with which he collides.

Two approaches to injury control are discussed here: crash helmets and crash bars.

CRASH HELMETS

Only one of the 80 motorcyclists in these accidents was known to have not been wearing a helmet. In three accidents it was claimed by the motorcyclist that a helmet had been worn, but the helmet was not available for inspection. Three of the four fatally-injured riders were found separated from their helmets. In one of these cases, the pillion passenger in Accident 289, there was damage to the helmet which was consistent with it having been worn, but in the remaining two cases we have had to assume that the helmets were worn, but without the chin straps being fastened.

The types of helmets worn by these riders are listed in Table 46. As noted in the section in which this Table appears, these data do not show any association between the type of helmet and the incidence of concussion.

Helmet Identification

It proved to be very difficult to identify the make of many (39 per cent) of the 76 helmets which were inspected (Table 48), and there was rarely any designation of the model. Similarly, it was exceptional to find any markings in or on the helmet which listed the safety standards with which the helmet complied. Those standards which were claimed to be met are listed in Table 49.

If research into the performance of crash helmets is to be productive it is essential that the make, model, date of manufacture and claims of compliance with helmet safety standards all be readily identifiable, preferably by incorporating the necessary markings into the structure of the helmet in such a way that they can neither be removed nor defaced.

Helmet Damage and Cerebral Injury

The nature and frequency of damage to these crash helmets is listed in Table 50, together with the incidence of concussion and fatal brain damage. As would be expected, those riders whose helmets were severely damaged were all either concussed or killed, whereas the rate of concussion was about ten per cent in those cases in which there was no discernable damage to the helmet, or only abrasions to the shell.

In one accident (102) the rider's helmet hit the road two or three times before he came to rest after being thrown from his motorcycle when it was struck by a car (Figure 3). The shell of the helmet was cracked (Figures 19 and 20) and the energy-absorbing lining was deformed. Although the rider was mildly concussed, this seems to have been a far less severe injury than would have been expected had he not been wearing a helmet.

In Accident 078 (Figures 21 and 22) the motorcycle crashed into the front of an oncoming car which turned right, across its path. The rider was thrown over the bonnet of the car, and struck his helmet on the pavement. Despite the considerable abrasion of the shell of the helmet (Figure 23) the rider was not concussed.

Loss of Helmet During Crash

As noted earlier in this section, six helmets came off in the crash (assuming

TABLE 48: MAKES OF CRASH HELMET WORN BY MOTORCYCLISTS

Make of Helmet	No. of Helmets
AGV	3
ARAI	12
BELL	4
BRYNAC	4
CENTURION	2
DIWS	2
EVEROAK	2
KUNOH	2
RACING MATE	5
SHOEI	9
HA	1
Make not known	30
Helmet not inspected	3
Helmet not worn	1
Total	80

TABLE 49: SAFETY STANDARD APPROVAL MARKINGS IN HELMETS

Helmet Safety Standard	No. of Helmets Marked
S.H.C.A.	1
Snell 1968	3
Snell 1970	11
E33	2
E43	4
AS 1698	5
BS 1869	6
BS 2495	2
Z90	17

Note: Some helmets carried approval markings for more than one standard.

TABLE 50: HELMET DAMAGE AND CEREBRAL INJURY

Nature of Helmet Damage	No Injury to Brain	Concussion	Fatal Brain Damage	Total Cases
No damage	22	2	-	24
Minor abrasion	19	2	-	21
Moderate abrasion	9	1	-	10
Lining deformed	-	1	-	1
Shell cracked	-	3	-	3
Shell deformed	-	1	1	2
Helmet came off	3	1	2*	6
Damage not known	11	1	-	12
Helmet not worn	1	-	-	1
Total	65	12	3	80

* Helmet came off after impact in one case.

that they were worn in three of the fatal cases).

It was not possible in the fatal cases to establish whether the helmet chin strap was buckled at the time of the accident, although all three were found with the strap unbuckled. Two of these had a double D-ring system of buckling, the third had a bar arrangement.

Two of these six helmets were reported by the wearers to have been buckled correctly at the time of the crash. Both were fastened by means of press studs, on the short arm of the webbing, which were clipped together after passing through a ring at the end of the long arm of the webbing.

The remaining helmet loss occurred in a single vehicle crash after which the rider said that he had borrowed both the helmet and the motorcycle to go for a short ride and had not bothered to do up the chin strap on the helmet (Accident 065).

It is possible that the three riders who were killed, all of whom had high blood alcohol levels, had not bothered to do up their chin straps. It may be that the task of threading a piece of webbing through two rings and then back through one is too complex for an intoxicated person. A single action system with a latch fixed to one side of the helmet and a tongue similar to, but smaller than, that associated with a seat belt buckle might reduce this tendency to ride with the helmet strap not securely fastened.

CRASH BARS

Tubular steel crash bars proved to be ineffective in protecting the rider against leg injury in two cases (Accidents 035 and 092), and there was no accident in which these bars, when fitted, appeared to be protective. As shown in Figure 18, the bar is readily bent back flush with the side of the motorcycle.

The one case in which the rider did appear to have avoided a serious leg injury involved a BMW motorcycle (Accident 102, Figure 21) which collided with the front of a turning car (Figure 20) as described above. The right hand cylinder head of the horizontally-opposed twin-cylinder engine struck the car just to the left of the front number plate, as viewed in Figure 20, shattering the rocker cover on the cylinder head but preventing the rider's right leg from being trapped between the motorcycle and the car. From this example it does seem as though some form of 'crash bar' may be of value in reducing the frequency of leg injuries to motorcyclists, but the structural strength required is clearly far in excess of that of the conventional tubular steel bars.

6.2 CONSEQUENCES OF INJURIES TO MOTORCYCLISTS

LENGTH OF HOSPITAL STAY

Twenty of the 35 motorcyclists who were admitted to hospital were there for more

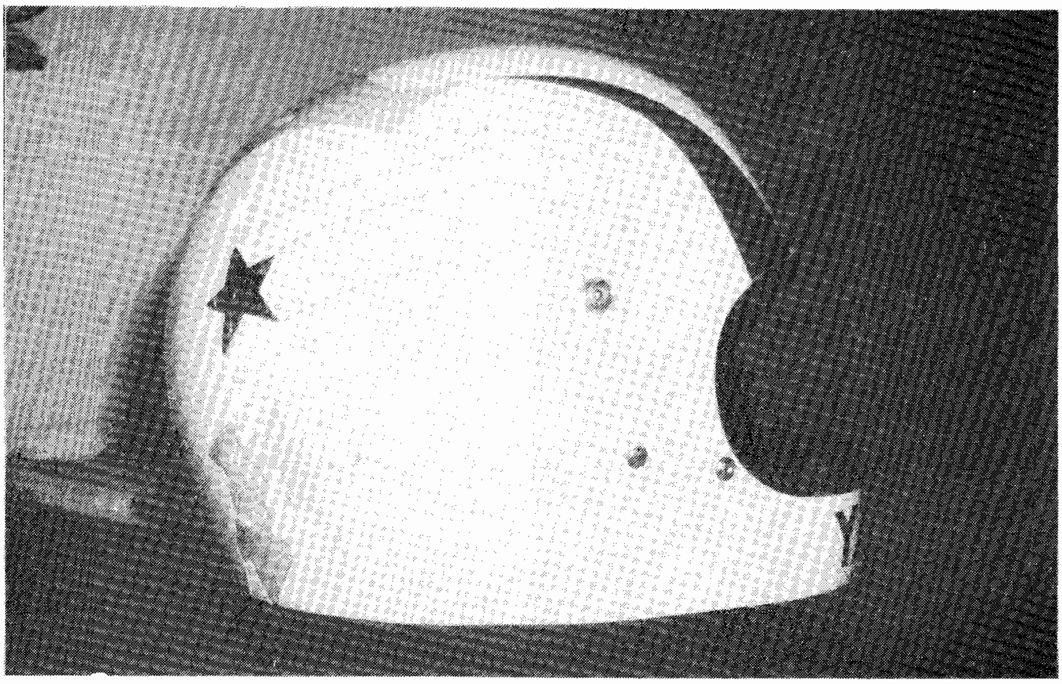


FIGURE 19: Damage to rear of helmet from multiple impacts with road surface following collision shown in Figure 3. See also Figure 20. Accident 102.

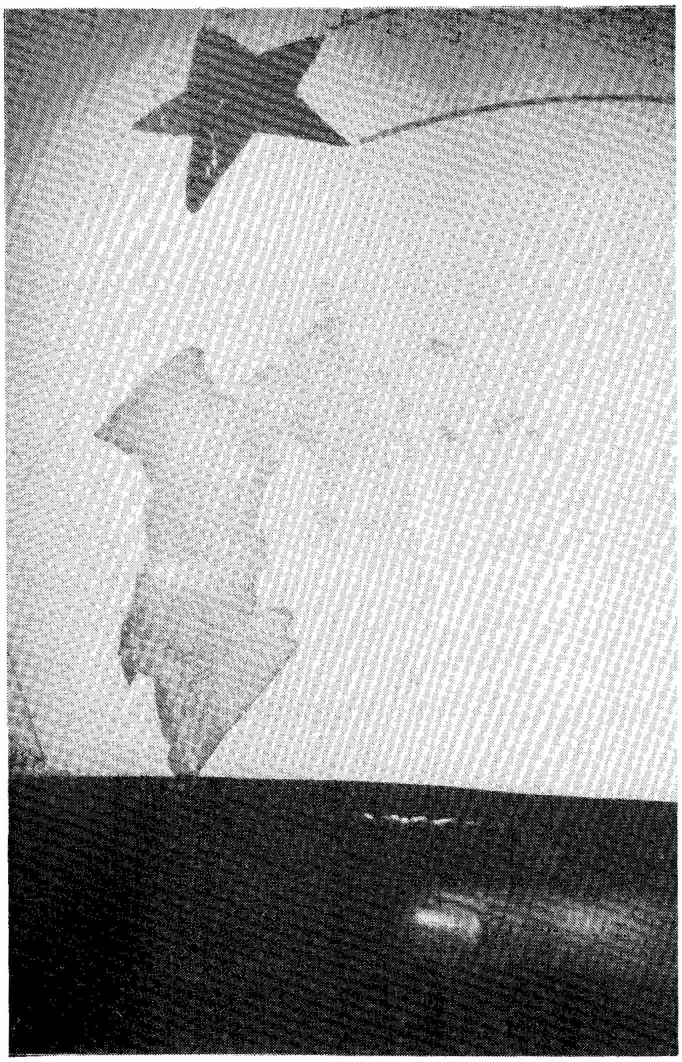


FIGURE 20:

Detail of damage to helmet shown in Figure 19.

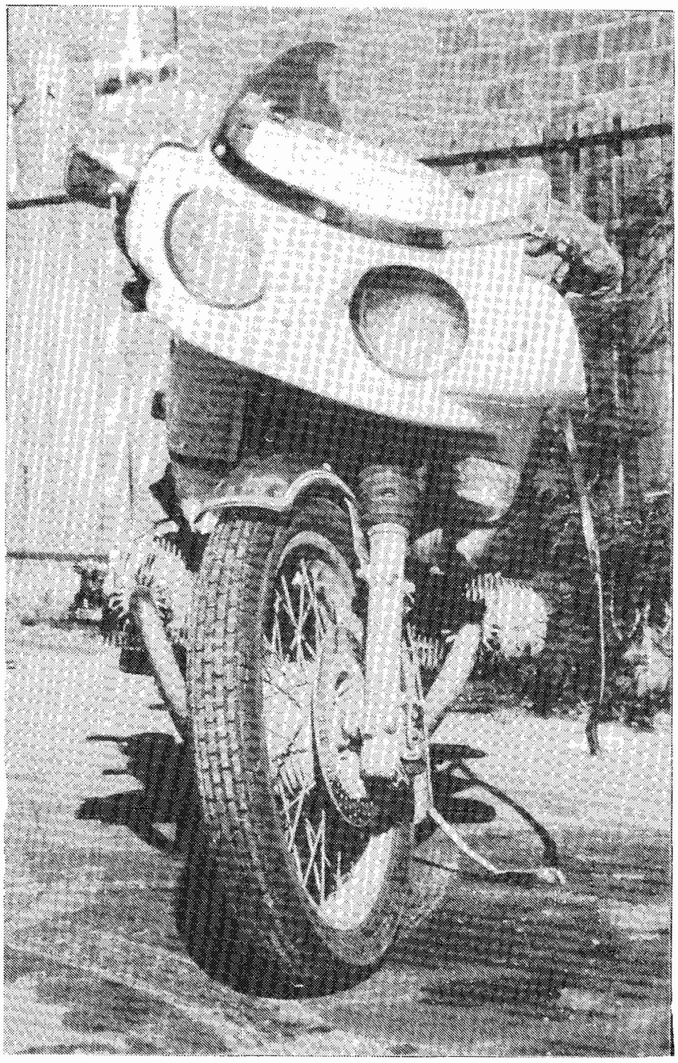


FIGURE 21: Motorcycle involved in collision with car shown in Figure 22. Note damage to rocker cover on right side. Accident 078.

FIGURE 22: Damage to car from collision with motorcycle shown in Figure 21. Accident 078.

than a week, and 12 were there for more than three weeks.

PERIOD OF RESTRICTION OF NORMAL ACTIVITIES

The effect that involvement in the accident had on the motorcyclist's ability to continue with his or her normal activities is shown in Table 51.

EXTENT OF RESIDUAL DISABILITY

Information on the presence and extent of any residual disability was obtained for 68 of the 76 motorcyclists who survived the accident. Forty-eight of these 68 riders and passengers made a complete recovery from the injuries sustained in the accident, 16 were left with a minor permanent disability and four motorcyclists were seriously, and permanently, disabled.

TABLE 51: PERIOD OF RESTRICTION OF NORMAL ACTIVITIES

Period of Restriction		Number of Motorcyclists	Per Cent of Known Cases
Not restricted		13	18
Restricted:	Up to one week	10	14
	Over one week and up to three months	32	43
	Three months or more	15	20
Fatally injured		4	5
Not known if restricted		6	-
Total		80	100

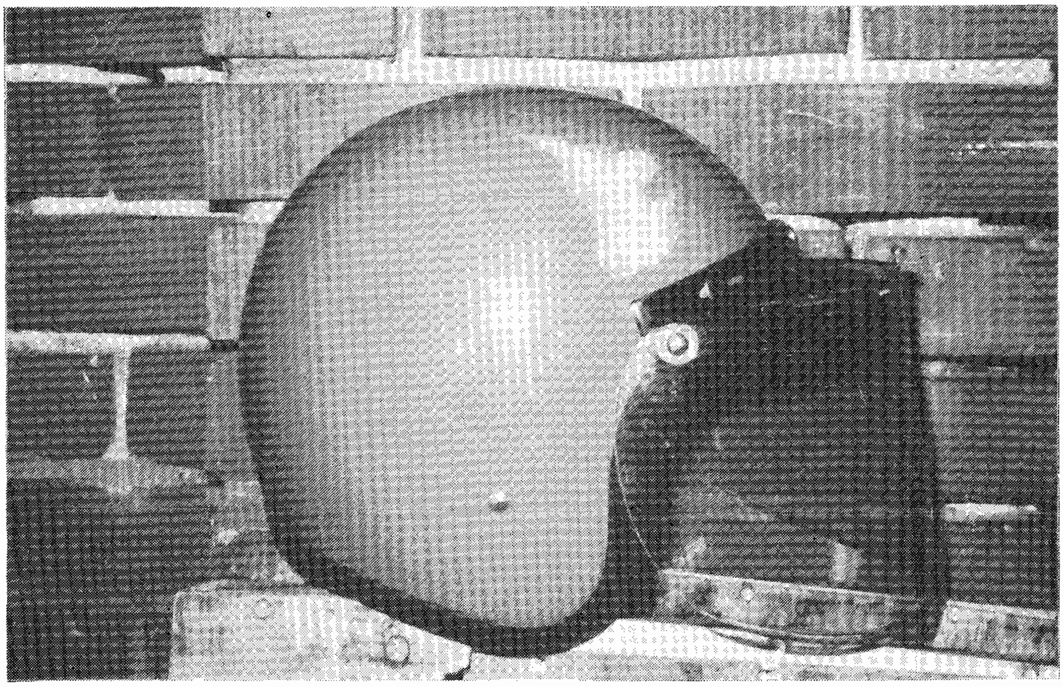


FIGURE 23: Abrasion of helmet shell from impact with pavement. See also Figures 21 and 22. Accident 078.

7. CONCLUSIONS AND RECOMMENDATIONS

Sixty-eight, or 22 per cent, of the accidents in this survey involved a motorcycle, and about two thirds of them were collisions with another vehicle or with a pedestrian. The other vehicle should legally have given way to the motorcycle in two thirds of the collisions.

Road and traffic factors are discussed in detail in the relevant companion report in this series (Part 7), but it can be noted here that 40 per cent of the accidents involving a motorcycle occurred at uncontrolled midblock locations. The skid resistance of the road surface did not appear to be an important factor, possibly because 94 per cent of the motorcycle accidents occurred on dry roads.

Twenty-two per cent of the riders may have been affected by alcohol (BAC > .04), and their crashes were three to four times more likely to have involved the motorcycle alone than were the accidents experienced by the sober riders. They were also more likely not to have fastened the chin strap on their crash helmets. These intoxicated riders had a (self-reported) history of regular and substantial alcohol consumption, and more than two-fifths of all of the riders in this sample of accidents said that they occasionally rode their motorcycles when they were intoxicated, some of them doing so regularly. This drinking behaviour may be associated with the fact that most of these riders were young males, but the consequences of drinking and riding are often so severe that it is recommended that:

Consideration be given to measures to emphasise to motorcyclists that riding while intoxicated places both them and their pillion passengers at an increased risk of crashing and being seriously injured.

Because the intoxicated rider places himself and his passenger at a greater risk of being injured, measures be taken to encourage the motorcyclist to take the time to fasten the chin strap on his helmet even though it may be difficult to do so after he has been drinking.

Simpler methods should be developed, and incorporated as amendments to Australian Standard AS 1698 (Protective Helmets for Vehicle Users), for fastening the chin strap on a crash helmet to ensure that the strap can be secured by an intoxicated rider.

Measures aimed at detecting intoxicated vehicle operators should not omit the motorcyclist.

Just over a quarter of the riders in these 68 accidents had been licensed to ride a motorcycle for less than six months. The youngest inexperienced riders appeared to have difficulty operating safely in traffic, even when on small motorcycles, whereas many older motorcyclists had had one or two years experience of driving a car in traffic before starting to ride a motorcycle. These older riders were less likely to have been in difficulty in traffic immediately before their accident, but they were more likely to have been on a larger machine. On the basis of registration data, the larger motorcycles were over-involved in these accidents possibly because they were more likely to have been ridden by individuals who had a history of previous violations and accidents (one third of the 69 riders had had at least one previous licence suspension). On the basis of impressions gained in the investigation of these accidents rather than on the formal data presented in this report it is suggested that:

Consideration be given to assessing the value of encouraging potential motorcyclists to gain experience in operating a car in traffic before applying for a motorcycle licence, and of restricting the size of motorcycle that can be ridden in the first two years of holding a motorcycle licence, or after a period of licence suspension.

The conspicuity of the rider and the motorcycle could have been a factor in about one fifth of the accidents which occurred at night and in about one eighth of those in the daytime. There were not enough relevant cases to enable a rigorous assessment to be made of the value of the daytime use of headlights, but if all of these riders had ridden with the headlight on during the day, then perhaps ten per cent of the daytime accidents (or four per cent of the total number) may have been prevented.

Almost half of the riders who braked before the accident did not use the front brake. Had they done so, about thirty per cent of these riders probably would have avoided colliding with the other vehicle (a reduction of 15 per cent in the accidents in which the rider braked, or seven per cent overall). The failure to use the front brake was not confined to inexperienced riders, many of whom did not normally use it. Some experienced riders, who used both brakes regularly, used only the back brake in the emergency situation immediately before the crash. A coupled, front and rear, braking system actuated by a foot pedal is available on one make of motorcycle, and so it is recommended that:

The Advisory Committee on Safety in Vehicle Design consider ways to further the wider use of single-control two-wheel braking on motorcycles.

Licensing tests include a requirement that the applicant demonstrate that he can perform an emergency stop using only the front brake.

Two accidents resulted, in part, from the rider being confused by the placement of the controls on the motorcycle. Draft Regulation 1805 of the Australian Transport Advisory Council (ATAC) specifies standard locations for the controls on a motorcycle, and it is recommended that:

State motor vehicle registration authorities require compliance with ATAC Regulation 1805 for all new motorcycles.

Fuel leaked from 22 (32 per cent) of these motorcycles after the accident, and one machine caught fire, seriously burning the rider. In about two thirds of these cases there was no damage to the fuel system. Consequently it is recommended that:

An investigation be made of the sources of fuel leakage from motorcycles when they are placed on their side, in order to identify ways of reducing the frequency of such leakage after an accident.

Fourteen motorcycles were found to be defective, in some cases in respect to the absence of some legally-required component such as a rear vision mirror, but a defect was relevant to the causation of only one accident.

These motorcyclists were the only class of road user in this study for whom head injuries were not the most common severe injury. This was due to the protection afforded by the crash helmets which were worn by all except one of the motorcyclists, and by the high frequency of severe leg injuries. The investigation of the performance of the helmets worn by these riders was greatly hindered by the absence of any markings showing the make, model and compliance with safety standards on most of the helmets. As the continued assessment of the performance of these helmets in crashes is desirable, it is recommended that:

Australian Standard AS 1698 (Protective Helmets for Vehicle Users) be amended to require the affixing to the helmet of a listing of the make, model, year of manufacture and safety standard compliance on the helmet in such a way that it will remain legible for the life of the helmet.

The nature and severity of the leg injuries sustained by these motorcyclists illustrates the need for the development of some form of leg protection. The conventional bolt-on type of crash bar is ineffective, whereas in one accident the protruding cylinder head of a motorcycle having a horizontally opposed twin-cylinder engine did appear to protect the rider's leg from being injured in a collision with a car. Therefore it is recommended that:

An investigation be conducted to establish the requirements for a device which will minimize the risk of a motorcyclist sustaining a severe leg injury when involved in an accident.

As a consequence of their accident-involvement, one fifth of these motorcyclists were prevented from working, or from carrying out their usual activities, for more than three months, and a similar proportion were left with a permanent physical disability, or were fatally injured.

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