SECTION 1: SUMMARY AND RECOMMENDATIONS FROM

TRAFFIC ACCIDENTS

IN ADELAIDE, SOUTH AUSTRALIA

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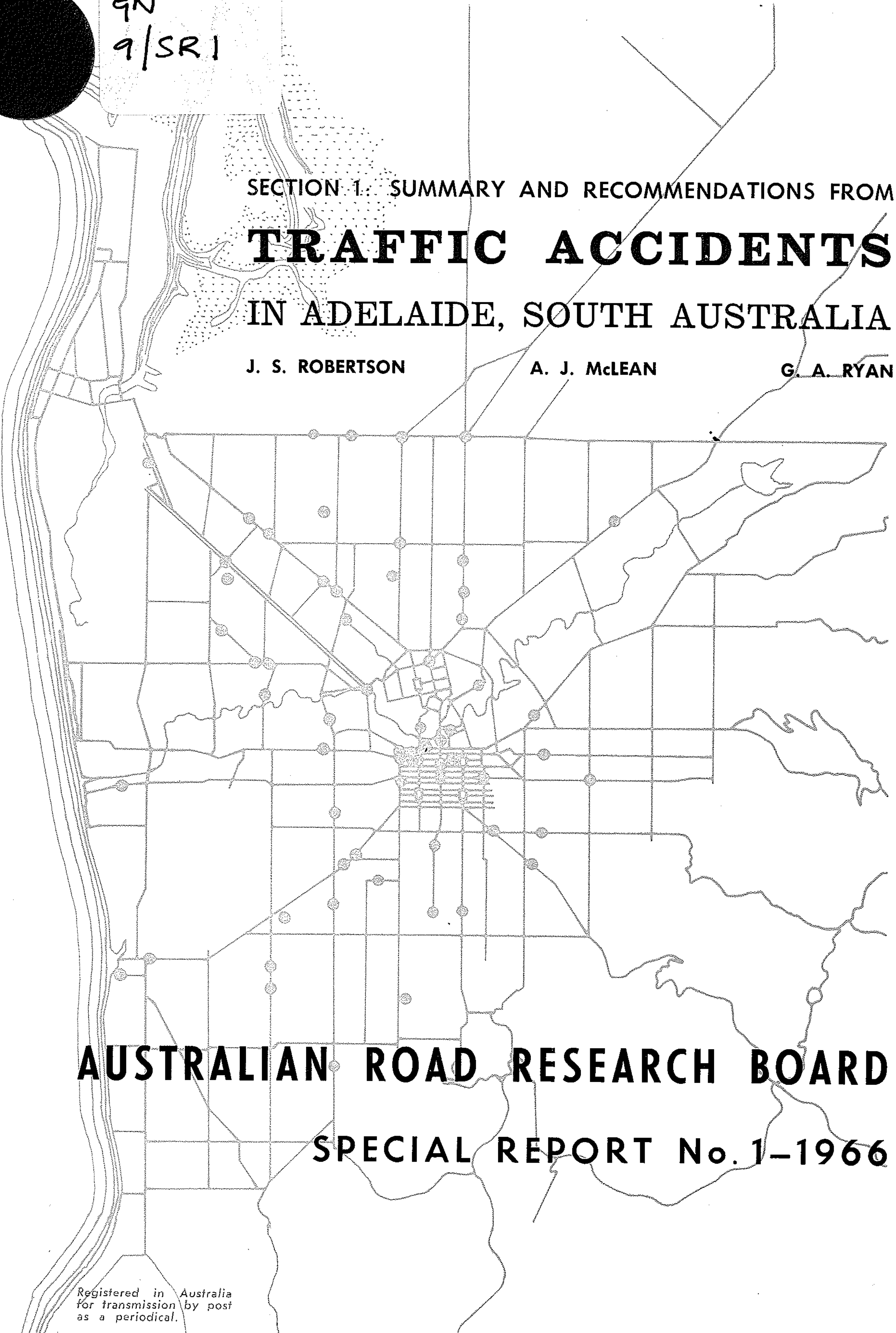

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PREAMBLE

This paper is an offprint of Section 1 (Summary and Recommendations) of a report to the Australian Road Research Board on an investigation by a mobile team staffed by a doctor and a mechanical engineer of a representative sample of 409 traffic accidents in Adelaide, South Australia, during the years 1963 and 1964. The main report is a large and detailed document, profusely illustrated, which is available for sale.* In order to reach a wider audience, it has, however, been decided to distribute this summary, and the recommendations, as a separate pamphlet. It is hoped that they will be useful. Those readers who require more details are referred to the main report.

The project was planned and directed by J. S. Robertson. Work on the roads was carried out by A. J. McLean and G. A. Ryan. It must be emphasized that the conclusions and recommendations derived from analysis of the findings are the responsibility of the authors, and do not necessarily reflect the views of the Australian Road Research Board.

*Persons who wish to purchase Special Report No. 1 should complete the attached subscription form and return it to the Australian Road Research Board.

AUSTRALIAN ROAD RESEARCH BOARD

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An investigation such as ours obviously depends on the goodwill and support of many responsible authorities. Besides those already mentioned we are especially grateful to the Commissioner of Highways, Mr. F. D. Jackman, and to members of his staff, notably Mr. A. K. Johinke and Mr. P. G. Pak-Poy. The St. John Ambulance authorities, particularly Mr. H. G. Berry, also gave us invaluable and essential support; indeed, without their continuing help our work would have been impossible. The Commissioner of Police (Brigadier J. G. McKinna), the head of the Traffic Division (Inspector R. A. Wilson), the members of the Accident Investigation Squad under Sergeant S. Swaine, and all members of the police force whom we met on the road, gave us every possible assistance. Dr. I. N. Capon, Mr. D. W. Simmons and Mr. Murray Bamford of the Computing Centre of the University of Adelaide, also gave us much help. Mr. Norman Stenhouse of the Division of Mathematical Statistics of the Commonwealth Scientific and Industrial Research Organization devoted a great deal of his time to give us expert advice on the statistical aspects of our work. Dr. Alan Miller of the Institute of Highway and Traffic Research of the University of New South Wales has also assisted us with statistical analyses, as has Professor Allen James.

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Dr. P. R. Hodge has performed all the necropsies on those killed and we are grateful for access to his records and reports.

Our colleagues of the Human Factors Committee of the Australian Road Research Board have made many suggestions, after reading earlier interim reports on our work as it progressed. We have adopted these as far as we could. We are particularly grateful to Dr. L. A. Foldvary for help and advice and also to Mr. I. Polson, Mr. Michael Smith and Mr. Bruce Golley for the preparation of charts and diagrams, and to Mr. J. Tang and Mr. A. Kurlender for technical assistance. Miss Jill Turrell has acted as Secretary to the unit almost since its inception, and we owe a great deal to her willingness, energy and initiative. We are particularly grateful to Mr. D. Caville for his expert photographic assistance and for the forbearance and promptness with which he met our often unreasonable requirements.

Mr. D. F. Glynn, Director of the Australian Road Research Board, has given us constant encouragement and support, and has smoothed our path on very many occasions. Indeed, he and Mr. R. W. Cumming and Dr. G. C. Lane were the prime movers in getting this project mounted at all.

Finally, the Australian Road Research Board itself, in fostering an investigation such as this, based on an academic medical department, has shown a breadth of view which we hope will be noted by other authorities concerned with traffic accidents, for the breaking down of traditional departmental boundaries to permit multidisciplinary research offers, in our opinion, perhaps the brightest gleam of hope in the fight to prevent these tragic and costly by-products of our motorized society.

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TRAFFIC ACCIDENTS IN ADELAIDE, SOUTH AUSTRALIA (1963 — 1964)*

SECTION 1 — SUMMARY

OBJECT OF THE INVESTIGATION

1.1 This project was entirely financed by the Australian Road Research Board. Its object was defined as follows: 'To gather data in Australian conditions basic to the design of roads, traffic organization and vehicles, by the objective study of the medical and engineering aspects of injury-producing accidents.'

METHODS

1.2 The investigating team consisted of a doctor (G. A. Ryan) and a mechanical engineer (A. J. McLean) in a vehicle equipped with a two-way voice radio tuned to the ambulance frequency. Working to a carefully designed statistical plan the team attended in 1963 and 1964 a representative sample comprising 12.3 per cent of those traffic accidents in metropolitan Adelaide to which an ambulance was called. Some few sources of bias were present in the sampling procedure, partly avoidable, partly unavoidable. These are discussed in the body of this report (para. 3.26).

1.3 A rapid but thorough investigation was made at the scene of the accident. The doctor recorded age, sex, height, weight and seated positions of the participants, and the details of their injuries, while the engineer studied the vehicular and environmental aspects. A comprehensive set of photographs was taken. Together the two members determined when possible what particular structures caused the injuries. The victims were then followed to the hospitals, where their injuries and personal particulars were recorded in more detail. Their subsequent progress in hospital was followed until discharge or death. A full necropsy was performed on every victim who died.

1.4 In a similar way the vehicles were followed when necessary to the repair shops, where damage could be studied in detail and at leisure. In many cases an estimate of the cost of repair was obtained.

1.5 A measured sketch plan was made of the scene of every accident. In numerous cases the scene was re-visited to complete the details of the site plan, and most of these sketches were subsequently drawn for the permanent record. Many of them are printed in this report.

1.6 As far as possible, the information obtained on both medical and engineering aspects was recorded in a quantitative way so that subsequent statistical analysis could be performed. Some items could be measured with reasonable accuracy, for example the length and direction of skid marks. Others were estimates of varying precision, such as travelling speed of the vehicles and their speed at impact. Other items again, such as the degree of injury to

*This work is a report on a project sponsored by the Australian Road Research Board. The project was planned and directed by J. S. Robertson. The work at the scene of the accidents was carried out by A. J. McLean and G. A. Ryan. The opinions and interpretations of the facts obtained in this study, and the recommendations derived from analysis of the data, are those of the authors, and do not necessarily represent the views of the Australian Road Research Board.

the victim, were recorded as ranked scores according to a predetermined code, which was very similar to and was based on the code used by the Automotive Crash Injury Research organization of Cornell University, U.S.A. In general these estimates and measurements proved satisfactory enough for subsequent quite detailed statistical study, and yet they were simple to obtain, and therefore they would be usable and useful (in our opinion) in the hands of trained but non-professional accident investigators.

RESULTS

The size of the sample

1.7 The unit attended accidents in the Adelaide metropolitan area during two periods, one in 1963 and the other in 1964. Between March 4 and November 5, 1963, 201 accidents out of a total of 1,676 accidents were attended (11.9 per cent), and between February 3 and August 30, 1964, a further 207 accidents were attended out of 1,626 (12.7 per cent). The overall figure of attendance was therefore 408 accidents in 3,302, or 12.3 per cent. This agreed closely with the estimate of 10 to 15 per cent for the possible attendance which was worked out on the basis of the ambulance records during the preliminary planning study. It is considered that this sample was sufficiently large to permit reasonable inferences to be drawn about the total accidents in Adelaide during these two years.

Accidents involving pedestrians

1.8 There were 79 such accidents, involving 82 pedestrians, in the sample of 408 accidents (19.3 per cent), distributed as follows:

63 pedestrians were struck by 61 cars,
7 pedestrians were struck by trucks or buses,
7 pedestrians were struck by motor-cycles,
4 pedestrians were struck by cars with trailer,
1 pedestrian was struck by a pedal cycle.

1.9 There were three main age groups:

(a) chiefly males aged less than 20 years,
(b) chiefly males aged 35 to 64 years, many of whom were affected by alcohol,
(c) males and females older than 65 years.

1.10 Approximately three-quarters of the drivers first saw the pedestrian only when it was too late to avoid the collision. At night no driver saw the pedestrian in the distance.

1.11 Of the 22 pedestrians (37 per cent), who could remember what happened, nearly three-quarters saw the striking vehicle only immediately before impact, or not at all.

1.12 More pedestrians were struck when crossing from the driver's left (46) than from the right (30). Nineteen (41 per cent) of those crossing from the left were obscured by a moving or stationary vehicle, but only four (13 per cent) of those crossing from the right. In 11 of these 23 cases the striking vehicle was overtaking another vehicle.

1.13 Eleven of 76 pedestrians (14.5 per cent) crossing the road were standing in the centre at the time of impact. This is a high proportion of the total, and points to the clear need for more protective measures for pedestrians in this city.

1.14 Thirty-five per cent of the accidents happened within the boundaries of an intersection, 28 per cent were within 20 yards of an intersection and 37 per cent occurred more than 20 yards from an intersection. There were three times as many accidents in the 20 yards 'downstream' from an intersection as in the 20 yards 'upstream'. Those occurring 'downstream' involved more night accidents, and more vehicles which were overtaking or had turned left.

1.15 Eleven (13 per cent) of the 79 accidents occurred at or within 20 yards of pedestrian crossings or signalized intersections.

1.16 Seventy-two of the 79 accidents were on busy roads (5,000 or more vehicles per 12 hours). Nearly half of these were at or near shopping areas. Relatively more old people and children were involved in accidents in the suburbs than in the city proper.

1.17 Responsibility for the accidents was assigned by the unit (not the police) as follows:

Suburban accidents:		
Careless or drunk pedestrian	34	
All reasonable care taken by pedestrian	24	58
City accidents:		
Careless or drunk pedestrian	10	
All reasonable care taken by pedestrian	11	21
Total:		79

1.18 Thus 44 accidents (56 per cent) were due to the carelessness or drunkenness of the pedestrian, but in 35 cases (44 per cent) all reasonable care was taken by the victim and yet the accident occurred. The locations of those accidents due to carelessness or drunkenness cannot be predicted and have little significance for the traffic engineer, but it is disturbing that in almost half the cases all reasonable care was taken by the victim. The locations of these accidents merit very careful study by our traffic engineers, for it seems that more positive measures are needed to protect pedestrians in these and other similar places.

1.19 The injury patterns in the victims have been described in detail. When struck by motor-cycles, trucks and buses, and cars, pedestrians suffer injuries to the lower limbs, pelvis, abdomen and thorax, caused mainly by the vehicles. Injuries to the head and upper limbs are caused mainly by striking the road.

1.20 Concussion was the commonest single head injury (56 per cent of cases). Superficial scalp and face injuries each occurred in half the cases. There were only three injuries to the facial skeleton, but eight of the pedestrians suffered fractures of the skull, and of these eight victims five died.

1.21 There were four injuries to the skeleton of the neck in three cases, all fatal.

1.22 The commonest thoracic injury was fracture of the ribs and bony skeleton without internal injury, but nine pedestrians had internal thoracic injuries. In all nine victims the lungs were injured and in three the heart and great vessels, including two instances of rupture of the aorta. Of the nine persons (11 per cent) with fractured ribs, only one was aged less than 55 years.

1.23 Internal abdominal injuries occurred in six cases, all fatal.

1.24 Eleven pedestrians (of whom six died) suffered fracture of the pelvis.

1.25 There were four fractures of the upper arm and seven of the lower arm, but there were 27 skeletal injuries in the lower limbs. Six of these latter fractures were of the femur and 15 of the tibia (four compound). In addition there were two fractures of the fibula and four skeletal injuries of the ankle joint.

1.26 The motions of the pedestrian during the very brief period of the accident have been worked out in detail and our conclusions can be presented with some confidence. Pedestrians are not 'run over' by cars but are 'run under', for when struck by a car the pedestrian is thrown in the air after the initial impact with the bumper and the front of the car; the thorax and head then strike the bonnet and windscreen. He then falls to the road or, if the speed is higher, he rotates about his head and 'somersaults' onto the roof, whence he falls to the road. Impact with the road from this considerable height and speed (for he is now travelling at the speed of the car) produces further injuries.

1.27 Injuries to the head and thorax are most often serious or fatal. Injuries to the lower limbs are most common. There was an average of 2.7 injuries per pedestrian struck by a car.

1.28 Eleven of the 82 pedestrians (13.5 per cent) were killed. Three died at the scene, one was dead on arrival at the hospital, and six died in hospital. Fifty-seven (70 per cent) were admitted to hospital and survived, ten were given casualty treatment only, and five did not need treatment. The total number admitted to hospital was therefore 63 (77 per cent). For the 57 pedestrians who were admitted to hospital and survived, the mean length of stay was 11 days. Twenty-five (44 per cent) stayed seven days or more.

1.29 Analysis of these accidents has shown that there is a statistically significant difference in injury-producing potential for pedestrians between cars with sloping fronts (e.g. Volkwagens) and cars with the conventional square front (e.g. Ford Falcon). Below 20 m.p.h. a Falcon is more likely to produce severe injuries than is a Volkswagen 1200. Between 20 and 25 m.p.h. the injury-producing potential is the same. Above 25 m.p.h. the Volkswagen 1200 will probably cause more severe injuries than the Falcon.

Pedal cyclists

1.30 We attended 44 accidents (11 per cent of the total 408 accidents) involving 44 pedal cyclists. Forty-two accidents occurred in the suburbs and two in the City proper.

1.31 There was a marked peak of incidence in the 10 to 14 year age group, and 26 of the cyclists (more than half) were aged less than 20 years. There were 40 males and four females.

1.32 Almost half of the accidents occurred in the two hours between 4 p.m. and 6 p.m. Because our sample includes a relatively higher proportion of off-peak accidents it is therefore likely that more than half of all injury-producing pedal cycle accidents occur during these two hours. Although we attended many more pedal cycle accidents on Fridays than on other days, this bias could be due to chance.

1.33 Twelve accidents occurred at night and 32 during the day. Only two children (aged less than 15 years) were involved in night accidents. The other 16 children were injured in daytime accidents, often when making a sudden U-turn or a right-turn in front of a following car.

1.34 Most night-time accidents seemed to occur because drivers did not see the cyclists riding steadily along at the side of the road. The visibility of cyclists at night is therefore important, and depends on how well the cyclist contrasts with his background. On a poorly lit road this is first achieved by the tail light on the bicycle, and we therefore recommend large bright tail lights on bicycles. As the vehicle closes with the cyclist the next stage of visibility is when the headlights illuminate him, and during this process there may be a short period when the contrast between the cyclist and the background may be greatly diminished. This can occur under lighting conditions which may be classed as good. Eleven of our 12 night-time pedal cycle accidents occurred in such conditions.

1.35 In four night-time accidents the driver did not see the cyclist at all. Each of these four drivers had obviously been drinking. One cyclist of the 44 had obviously been drinking.

1.36 Of the 40 vehicles which struck cyclists 28 (70 per cent) were proceeding straight ahead, as were 16 cyclists, but 22 cyclists were changing direction at the moment of impact.

1.37 Seventy per cent of the accidents occurred at or near intersections. This may result from the distracting effect of the intersection on the drivers, with the result that they do not notice the cyclist. Fifteen of 23 drivers told us that they did not see the cyclist at an intersection until it was too late. Therefore a cyclist should be taught that he must not assume that a driver has seen him, particularly at an intersection.

1.38 The types of collisions were as follows:

2 pedal cyclists were struck by motor-cycles
3 pedal cyclists were struck by trucks
1 pedal cyclist struck a pedestrian
3 pedal cyclists fell off without a collision
35 pedal cyclists were struck by cars

1.39 When struck by a car the pedal cyclist, like the pedestrian, has no protection from the impacts with the car and subsequently with the road. In most cases (24/35 of our cases) the front of the car struck the side of the bicycle, and in two-thirds of collisions of this kind (14/24) the rider fell on top of the bonnet of the striking car.

1.40 The motions of the cyclist during and after the impact with the car depend on the relative positions of the centre of gravity of the cycle plus rider and the top of the bonnet of the striking car. When seated normally on the cycle the combined centre of gravity for a rider of medium height is near the front of the saddle, and when the rider is leaning forward over the handlebars the centre of gravity shifts forwards about 7 in. In both postures the centre of gravity is about 33 in. above the ground, just below the saddle height of 35 in. This height is nearly the same as that of the top of the bonnet of a car of conventional frontal design. Therefore when struck from the side by the car, the rider and cycle will momentarily be pushed sideways by the car.

1.41 However the rider and cycle do not behave like a rigid body on impact except at very low speeds (less than 10 m.p.h.), for they are readily separated. The post-impact motions of each can be derived by relating the point and direction of impact to the positions of their individual centres of gravity (considering other factors such as rotational inertias, which influence these motions, in a purely qualitative way). The kinematics of the pedal cycle/car collision are therefore as follows.

1.42 An impact from the side at a height of 33 in.—the height of a car bonnet—will strike the rider on the hip and will cause the cycle to be pushed away in front of the car, while the rider will be rotated about his centre of gravity, his head moving towards the car. His legs, being below the top of the bonnet, will be pushed forwards and will thus assist in rotating his trunk towards the car. The distance back from the front of the car that his head will strike is determined by the speed of the car at impact. With increasing speed the rider strikes successively the top of the bonnet, the windscreen, and at still higher speeds he strikes the roof just above the upper edge of the windscreen. The height of the rider's trajectory will also be affected to some extent by his position, i.e. seated or standing on the pedals, and by his stature. After striking the car the rider then falls to the road on either side or behind the car. If the car stops quickly the rider may be projected onto the road in front of the car. Occasionally the cyclist may be thrown diagonally over the bonnet of the car without touching it, landing directly on the road.

1.43 In a minority of cases the centre of gravity of the cycle and rider at the moment of impact is beyond a corner of the front of the car, so that the cycle and rider pivot about the corner of the car and slide down its side to the road. In impacts directly from the cyclist's rear (five cases) the rider again is thrown directly up the car through a distance proportional to the impact speed.

1.44 Like the pedestrian, therefore, the cyclist suffers multiple impacts with the car and the road, and consequently he also suffers multiple injuries. The 35 pedal cyclists struck by cars sustained a total of 98 injuries to all body areas, an average of 2.8 injuries per cyclist. Injuries to the lower limb were most numerous, but were also all minor. Head injuries were almost as numerous as injuries to the lower limb but were mostly moderate or worse. Three cyclists were killed, with six fatal injuries between them (three to the head, one to the thorax and two to the spine).

1.45 In all, there were 29 head injuries among the 44 cyclists, with 28 cases of concussion, 25 soft-tissue injuries of the face, and 15 soft-tissue injuries of the scalp. Nineteen of the 25 soft-tissue facial injuries were caused by the road as were eight of the 15 scalp injuries. The rest were caused by impact with the striking vehicle. There were two fatal neck injuries with transection of the brain stem (one case) and spinal cord (one case). There was one crush fracture of a lumbar vertebral body and one of fractured lumbar transverse processes.

1.46 There were relatively few thoracic injuries but one of them was a fatal transection of the thoracic aorta. The road and the vehicle each caused about half the thoracic injuries.

1.47 Three pelvic fractures were caused by the vehicle striking the cyclist's hip. Thirteen of the 18 upper limb injuries were abrasions or bruises, almost all caused by the road. In addition there were five fractures or dislocations, all of the left arm, although only two of the impacts were from the right. There were two fractures and 47 soft tissue injuries of the lower limb. Twenty-three of the latter were caused by the front of the car.

1.48 Twenty-eight of the 44 cyclists (64 per cent) were admitted to hospital and three were killed. Details of disposal were as follows:

No treatment required	6
Casualty treatment only	7
Admitted, later discharged	28
Dead on arrival at hospital	2
Dead at scene	1

1.49 The lengths of stay of those admitted to hospital were:

24 hours or less	10
1–2 days	7
3–5 days	4
6–10 days	2
11–15 days	3
16–20 days	1
21–25 days	0
26–30 days	0
More than 30 days	1

Motor-cyclists

1.50 There were 66 accidents, or 16 per cent of the total of 408 accidents. The proportion increased from 14 per cent in 1963 to 18 per cent in 1964, although motor-cycles comprised 4.15 per cent of all registered vehicles in 1963 and 3.48 per cent in 1964. It is possible that as motor-cycles become a smaller fraction of the total traffic their risk of accident involvement increases.

1.51 Forty-five of the 66 accidents happened in the daytime, and 24 of the 66 in the two hours between 4 p.m. and 6 p.m. The peak at this time involves motor-cycles much more than motor-scooters. There is also a slight peak between 12 noon and 2 p.m., and the evening peak continues, although diminished, to between 8 p.m. and 9 p.m.

1.52 The daily number of accidents increased from Monday to Thursday, with the Friday total slightly less than Thursday's. We sampled only alternate Saturdays and very few Sundays, so that our figures for those days are too small to be meaningful.

1.53 Because of the dangers associated with skidding and the obvious relationship between reduced skid resistance and wet roads, it was surprising that only one of the 66 accidents occurred during rain and only three on wet roads. Our figures do not show any significant relationship between poor tyres on the motor-cycle and increased incidence of skidding. Light motor-cycles seem to be less susceptible to skidding while braking than the heavier machines or scooters. A lower speed at impact for the less powerful machines may be a factor here.

1.54 There were 67 riders in the 66 accidents, one of which involved two machines. Sixty were males and seven were females. There were seven pillion passengers of whom four were females and 3 were males. Riders aged 16 to 19 years markedly predominated, while from 20 to 34 years the number of riders was evenly distributed with age. There were very few riders aged more than 35 years. Twenty-three riders (38 per cent) were aged less than 20, and 32 (53 per cent) less than 24 years. Forty-three per cent of motor cycle riders but only 30 per cent of scooter riders were aged less than 20 years. Length of driving experience increases with age and most riders had been driving since reaching the legal minimum age of 16 years. We found that most accidents occur in the second to fifth years of driving experience.

1.55 The types of accidents were as follows:

	No. of Cases
Collision between motor-cycle and car	47
Collision between motor-cycle and pedestrian	7
Collision between motor-cycle and truck	4
Collision between motor-cycle and pedal cycle	2

Collision between motor-cycle and train	1
Motor-cycle alone	6
Total	67

Most of the accidents occurred on busy roads.

1.56 Forty of the 67 accidents occurred at intersections, six within the 20 yards before and six within the 20 yards after an intersection, and 14 not at intersections. Fifty-two (79 per cent) of the cycles were travelling straight ahead before the collision, and only five (8 per cent) were changing direction. However, 33 (70 per cent) of the cars involved were changing direction, and 23 of these were turning right.

1.57 There were six single vehicle accidents. Two of these were collisions with fixed objects, and four were falls when the riders lost control. All these machines were proceeding straight ahead.

1.58 In the seven cases when motor-cycles collided with pedestrians the riders all fell off after the collision. Only one of these accidents was at night, and it is possible that an approaching motor-cycle is more noticeable at night, when its headlight is on, than in the daytime. In collisions between motor-cycles and pedal cycles (two cases) the fall to the road rather than the collision itself caused injury to the motor-cyclist.

1.59 The one death among motor-cyclists was after a collision with a diesel railcar at a level crossing. There was no evidence that the cyclist was thrown on to the guard rail in this accident.

1.60 There were 47 collisions between motor-cycles and cars. Almost half the cars (23) were turning right. The disturbing feature of this latter type of accident is that there is little the motor-cyclist can do to avoid such a collision. In 13 cases the car turned right across the path of the motor-cyclist approaching on the same road, and five of these were at light-controlled intersections. At one of these intersections the layout of the lights is confusing, and at another there is a split green phase which possibly contributed to the accident. Split phase operation of lights appears to place unfair demands on a driver, and we believe that in principle it is not desirable to reduce the safety margin of a control device in an attempt to expedite traffic.

1.61 Accidents involving cars turning right were about equally divided between day and night. The motor-cyclists usually saw the car approaching in the distance, but the car drivers seldom noticed the motor-cyclist until just before the collision. Our data do not show that motor-cyclists involved in this particular kind of accident were travelling unusually fast.

1.62 There were ten cases in which a car turned right from a side road into a through road and hit a motor-cyclist travelling towards the intersection along the other road. Seven of these cases were in daylight, and in four of them the car driver's view was obscured by another vehicle. Again there was little the cyclist could do to avoid the collision.

1.63 In seven cases the cars were attempting a 'U' turn from a parked position against the kerb, and six of these were in daylight. It seems likely that the car drivers underestimated the speed of the motor-cycle and also the time needed to complete a 'U' turn, especially as the average speed of the motor-cycles in these particular accidents was high (between 30 and 40 m.p.h.).

1.64 There were eight collisions at intersections in which both the car and the motor-cycle were proceeding straight across. In one case the car driver moved off because the car on his right had also started to move, without realizing that the latter driver had allowed a motor-cyclist to cross from the right—a relatively common predisposing cause of accidents. In two of these cases the motor-cyclists were travelling unreasonably fast, and in another case the car was travelling much too fast. Accidents involving rear end collisions (three) and cars turning left (two) were few.

1.65 There were four collisions with trucks, two of them at light-controlled intersections.

At one of these the truck entered the intersection just at the end of the green phase. The subsequent amber phase was not long enough to allow the truck to clear the intersection before the light changed to red, and simultaneously to green for the motor-cycle.

1.66 It will be clear from the preceding paragraphs that the motor-cyclist is often the 'victim' in accidents. In only 15 of these 67 cases could the motor-cyclist reasonably be expected to have been able, by his own action, to avoid the collision. Because cyclists are so liable to serious injury the duty of car drivers to look out for them is clear, and needs emphasizing.

1.67 There are two main configurations of collisions between cars and motor-cycles and scooters. These are front impacts, where the front of the machine strikes the car first and the rider travels forwards, and side impacts, where the front of the car strikes the side of the machine and the rider travels sideways. Although there are relatively more front impacts for scooters than for motor-cycles the figures are small and the difference is not significant.

1.68 Motor-scooter riders suffer more moderate and greater injuries than motor-cyclists, but the difference does not quite attain statistical significance. The distribution of regional injuries in the two classes of riders is also quite similar, and therefore both groups of riders can be combined when considering injuries.

1.69 In both front and side impacts most injuries are minor. Injuries to the head and lower limbs are most numerous. Severe and very severe lower limb injuries are relatively more common in side impacts than in front impacts, for the riders are directly struck by the car, and there are more severe head injuries in front impacts than in side impacts, when the riders are thrown head first against the car. Neither of these differences reaches statistical significance.

1.70 There were 29 front impacts and 17 side impacts. There are marked differences in the mechanics of these two types of collision. In the 29 front impacts the parts of the car struck by the cycle were as follows (see para. 6.68 for details):

Front of the car	5
Side of the car	20
Rear of the car	4

In four of the five impacts with the front of the car the cycle was at an angle. None of these riders landed on the top of the bonnet, but all bounced off to one or the other side of the car.

1.71 In impacts with the side of the car the cycle either strikes 'head on' and falls to the road, or the front of the machine is jerked violently to one side by the car, rotating the whole machine. In the first type the rider is thrown directly forward over the handlebars into the side of the car. In the second type he is thrown sideways against the side of the car. Rotation occurs when the speeds of the cycle and the car are approximately the same. 'Head on' impacts without rotation seem to occur when the speed of the cycle is high and that of the car is low. This might be expected from the dynamics of the situation, and presumably rotation would also occur when the speed of the car is high and that of the cycle is low. However, we have no cases of this latter type of collision.

1.72 In 'head on' impacts with the mudguard, the rider may be thrown on to or over the bonnet. One rider fractured the shaft of his femur as it was bent over the mudguard or handlebar. When the machine is rotated there may often be concussion from striking the head against the car, and fractures of the small bones of the rider's hand occur as it grips the handgrip which is swung against the side of the car.

1.73 In 'head on' impacts with the doors rotation is less frequent, and the rider receives head and face injuries when he is thrown directly into the side of the car. If rotation occurs concussion and hand injuries are again seen.

1.74 'Head on' impacts with the rear mudguard produce less severe injuries. However, there were only four such cases. Impacts directly on the rear of the car (four cases) produce rather similar patterns of injury, but in two cases there was fracture of the tibia from striking the bumper bar of the car.

1.75 In side impacts (front of car against side of cycle) the legs of the rider are directly exposed to injury from the front of the car, particularly from the bumper bar, which is generally at a level about 6 to 12 in. above the footrest of the cycle. In consequence severe fractures of the lower half of the tibia and fibula are common, as are fractures of the small bones of the hands, for the hands are also one of the first parts of the rider to be struck.

1.76 Rider and motor-cycle do not part company in side impacts so frequently as do pedal cycles and their riders. Motor-cycles are lower and heavier than pedal cycles, and therefore the centre of gravity of the rider and machine is below the top of the front of the bonnet.

1.77 After the impact with the front of the car the rider is projected on to the road and slides along it. This causes abrasions of the bony prominences, concussion, and (in two of our cases) a fractured skull.

1.78 Ninety-six per cent of motor-cyclists were injured to some degree, and 51 per cent sustained moderate or greater injuries. There was one death (previously mentioned): a collision with a train. Regional injuries were head and neck 55 per cent, thorax 13 per cent, abdomen 6 per cent, spine and pelvis none, upper limb 45 per cent and lower limb 90 per cent. The 74 persons received 148 injuries, or 2.0 injuries per person. Striking the road or—rarely—a fixed object, produced 50 per cent of all injuries to motor-cyclists. Next most common was striking the front or sides of the other vehicle, generally a car. The commonest cause of head injury was striking the road, followed by striking the side of the car. For lower limbs the road was the chief cause of injury, but the front of the car caused the more severe injuries.

1.79 Among 39 persons with head injuries there were 27 soft tissue injuries of the face, seven skeletal injuries of the face, 24 concussions, 16 soft tissue scalp injuries and three fractures of the skull. Twelve concussions were caused by striking the road, eight by striking the car, and the cause of four could not be determined. There were no bony injuries of the neck, spine or pelvis.

1.80 Thoracic injuries were few. There were eight soft tissue injuries, five skeletal injuries, and one internal injury—a pneumothorax.

1.81 Among 32 persons with injuries to the upper limb there were 35 soft tissue injuries and seven skeletal injuries, of which five were fractures of the small bones of the hand. By contrast, there were 64 persons with injuries to the lower limb. There were 80 soft tissue injuries and 16 skeletal injuries. Among the latter there were ten fractures of the tibia, five of them compound, and two fractures of the femur.

1.82 Thirteen (17 per cent) of the 74 motor-cyclists did not require any hospital treatment, 27 (36.5 per cent) were treated in a casualty department and allowed to go home, 33 (45 per cent) were admitted and later discharged. One person (previously mentioned) was killed —at the scene of the accident.

1.83 The length of hospital stay of the 33 persons admitted was:

	No. of Cases
0-1 days	10
1-2 days	2
3-5 days	7
6-10 days	3
11-15 days	0
16-20 days	2
21-25 days	4
26-30 days	2
More than 30 days	3
Total	**33**

Helmets

1.84 Twenty-two of the 74 persons in this survey were wearing crash helmets. More motor-scooter riders (13/35) were wearing helmets than motor-cyclists (9/39). Thirty per cent of those aged less than 20 years wore them, and 56 per cent of those between 20 and 35 years. None of the 14 riders aged more than 35 years wore a helmet.

1.85 The proportion of moderate and greater head injuries in those wearing helmets was not different from that in the group not wearing them. Among the helmet wearers the proportion of those with injuries to both the head and body was reduced slightly but not significantly. Among motor-cyclists wearing helmets there was a slight excess of cases with no head injury; there were no cases of scalp injury; and there were more 'concussion only' cases than expected, but not significantly so. Our data also do not suggest that helmet wearers in our sample had sustained more severe impacts than those not wearing them, for there were proportionately similar numbers of fractures of the face and skull in the two groups. Average estimated impact speeds for both helmet wearers and those not wearing them were the same (16 m.p.h.).

1.86 To attain an impact speed of 20 m.p.h. a rider's head, considered as a free body weighing 10 lb., would have to fall free for a distance of 14 ft., and would therefore have 140 ft-lb of energy. The British Standard for motor-cyclists' helmets (B.S. 2001: 1960) uses a striker of 10 lb mass falling through 9 ft, i.e. an energy content of 90 ft-lb, and the helmet under test must not allow a force greater than 5,000 lb to be developed on the head block holding the helmet. This value of 90 ft-lb is only two-thirds of the force developed in most of the impacts in our survey.

1.87 Australian helmets meet the Australian Standard E33—1959, which is identical with B.S. 2001: 1956. The point of impact on the helmet in the test rig used seems to be towards the top of the front of the helmet, but in our accidents most of the impacts were near the bottom edge of the helmet, and only three of the 13 were on the crown or at the angle at which the test impact is delivered. There is no protective padding at the sides of the helmet near the lower edge where it is most needed, nor does the suspension harness keep the helmet away from the head in impacts in this position.

1.88 Although analyses of figures from large populations of motor-cyclists have shown that helmets save lives, our small series has shown that their efficiency in preventing some of the effects of impacts to the head could be improved.

1.89 We suggest that official consideration be given to requiring that all helmets for motor-cyclists meet the B.S. 1869: 1960—Protective Helmets for Racing Motor-Cyclists. This specifies an enveloping helmet which covers the forehead, ears and occiput, there is a strong webbing suspension and the helmet is completely lined throughout with energy-absorbing material. In addition the shock absorption test should include impacts normal to the shell of the helmet and centred on the headband region.

Accidents involving trucks

1.90 In this section we include all heavy vehicles and some light commercial vehicles. A vehicle weighing up to the arbitrary limit of 2 tons tare weight we classify as a 'light truck', and over this as a 'heavy truck'. There were 27 light trucks and 35 heavy trucks in our survey, and there were 59 accidents involving trucks, comprising 14.4 per cent of the total accidents. There were 34 collisions with cars, 8 multiple vehicle collisions and 7 collisions with pedestrians. Other types of collision were infrequent. Only one-sixth of truck accidents occurred in the central city area.

1.91 There were 62 trucks with 85 occupants involved in the 59 accidents. There were two periods of peak incidence, one between 3 and 4 p.m. and the other between 6 and 7 p.m. This is different from the time distributions for other types of accidents where there is usually only a single peak, between 4 and 6 p.m. It is possible that the bias in our sample towards a greater proportion of off-peak accidents may have contributed to this difference.

1.92 The daily incidence is constant from Monday to Wednesday, but falls on Thursday and Friday. Our data are not adequate to allow conclusions about Saturday and Sunday.

1.93 The age distribution of truck drivers ranged from 17 to 66 years, with peaks at 20 to 29 years and 35 to 39 years. There were 24 passengers whose ages ranged from 5 to 69 years.

1.94 Collisions between trucks and pedestrians, pedal cyclists and motor-cyclists have been described previously. Because the trays of many trucks are close to the level of the head of a motor-cyclist as he is seated on his machine the rider may strike his head on the edge of the tray. Crash barriers below the tray at the rear and the sides would reduce the injury potential in this type of collision. There was one collision between two trucks—a heavy truck and a heavy utility. Both drivers were ejected through doors which came open. We believe that door latches on trucks should be designed to obviate this happening.

1.95 The eight multiple-vehicle collisions were naturally complex. Two were the familiar type of chain collision, but in one case the truck driver was reversing without having a clear view to the rear, and in another, which occurred at a railway level crossing, the truck driver probably mistook the sound of the horn on the railcar for that of a vehicle behind him, and he may also have mistaken the headlight of the railcar for a light of some other kind. It is possible that too much is being expected of motorists at these rail crossings.

1.96 Almost 80 per cent of all collisions between a car and a truck happened at intersections. In some of these truck accidents environmental features were to blame, and in some cases drivers did not stop at stop signs. However, cars and trucks yielded right of way to each other with equal frequency, and we found no evidence that truck drivers, being in the heavier vehicle, are less likely to yield right of way than car drivers.

1.97 There were five cases in which trucks turned right across the path of cars. In two of these the truck turned right from the slow lane of a dual highway and collided with a car travelling in the fast lane in the same direction. In two other cases the truck turned right despite the fact that a car was approaching fast from the opposite direction, the truck drivers probably misjudging the time needed to complete the turn.

1.98 One truck driver was probably under the influence of alcohol, and one car driver who collided with a parked truck had a blood alcohol content of more than 0.08 per cent.

1.99 The injuries of the 85 occupants were as follows: no injury 66, minor injury 15, moderate injury 4, severe injury or worse nil. None of the occupants of trucks which collided with pedestrians, pedal cyclists or motor-cyclists was injured at all. The four persons with moderate injuries all received concussion, but one of these was in a fall from the tray to the road. All other injuries to truck occupants were minor abrasions, bruises and lacerations to the face, scalp and limbs. In those accidents where cars and trucks collided, the occupants of the cars received much more severe injuries than those of the trucks; in fact 35 per cent of the car occupants received moderate or greater injury, as against 1.8 per cent of truck occupants. It is clear that the heavier the vehicle the safer are its occupants in a collision.

Car accidents: general considerations

1.100 Because 80 per cent of motor vehicles are cars, collisions between two cars are the commonest type of car accident. Usually there is only one impact, and both cars come to rest without striking anything else, but in some cases there is a subsequent collision with a third vehicle or with a fixed object. Although collisions are of almost endless variety, they can be categorized into types. Thus in our series there were 108 collisions between two cars without subsequent collision; 32 cases in which there was a subsequent collision, usually with another vehicle, less frequently with a utility pole or other object; 31 single car accidents, including eight collisions with a utility pole, eight cases of rollover only and six collisions with trees; and 13 collisions with parked vehicles.

1.101 The time distribution of 210 accidents (all car-car collisions, all single car accidents and most collisions between cars and trucks) showed a peak about 6 p.m. which gradually fell off to 11 p.m., but the total accidents were almost evenly divided between day (110) and night (100). There was a marked preponderance on Saturday. In 155 of the 210 accidents (74 per cent) an intersection played a significant part. Only 27 occurred on wet roads.

1.102 Five-sixths of drivers were men. The commonest age group of drivers involved in these car accidents was 20 to 24 years, and half were aged less than 35 years. There is a secondary peak at 35 to 39 years, with a subsequent gradual decline. About one-tenth of all drivers had obviously been drinking. When it is recalled that we could make no chemical tests for alcohol consumption, but had to rely on our general impression—which will detect only relatively gross impairment—the true proportion of drinkers is likely to be significantly higher.

1.103 Most front seat passengers were aged 15 to 19 years, and 60 per cent of rear seat passengers were aged less than 20 years, with a peak at 10 to 14 years. We obtained data on the length of driving experience for 265 drivers, and the figures suggest that the rate of accident occurrence falls off rapidly with increasing experience after the first ten years. Thirty-one per cent of the accidents happened to drivers who had been driving less than six years.

1.104 The most common configuration in car to car collisions was for the front of one car to strike the side of another. The 90° grid on which Adelaide streets are laid out, with the consequent large number of right-angled intersections, helps to account for the predominance of the front-to-side configuration. This also has the important consequence that car occupants are injured as often by the sides of the interior of the car as by the front.

1.105 Seventy-nine per cent of the 151 drivers for whom the information was available did not see the other vehicle until it was too late to avoid the collision (see para. 10.5 on 'critical speeds at intersections').

1.106 Forty-four of the 408 accidents (10.8 per cent) were essentially single-car accidents, including 13 collisions with parked vehicles. In two cases the driver collapsed at the wheel and the car swerved off the road into a tree. In two cases there seemed to have been a deliberate attempt to crash the car. In two further cases the driver's attention was distracted and he lost control, and finally there were two cases in which trailers broke loose from their towing vehicle. These last two cases draw attention to the need for specifications of the strength of the safety chains on towing attachments and for their method of attachment to both the trailer and the towing vehicle.

1.107 Apart from the specific causes listed in the preceding paragraph, the effect of alcohol is the most noteworthy feature of the single vehicle accident. Over one-third (16 of 44) of these drivers had obviously been drinking, and the number actually affected by alcohol could have been greater than this.

1.108 Most single car accidents occur at night (27 of 44). Single car rollovers are equally common by day and by night, but collisions with poles, trees and parked cars are more common at night (21 cases at night, nine by day).

1.109 A collision with a utility pole can result in severe damage to the vehicle and severe injury to the occupants. Poles can be modified to minimize the damage to a vehicle which hits one, and the value of introducing such modified poles could be considered.

1.110 There were 12 single car rollovers. In these accidents speeds were much higher than the average for the whole series. The average travelling speed was 35 to 40 m.p.h., and the speed at rollover slightly less—about 35 m.p.h. The averages for all cars in our survey were a travelling speed of 27 m.p.h. and 21 m.p.h. at impact. Nine of the 12 drivers were aged less than 25, with driving experience ranging from four months to nine years with an average of three years. Thus youth and inexperience combine in many cases with alcohol to produce a particularly dangerous combination; and there are yet other factors. Half of the vehicles involved were manufactured before 1955, and five of the 12 vehicles had independent rear suspensions of the swing-axle type. Although the condition of the tyres on these vehicles was generally good, tyre pressures were low in two of six cases, and dangerously so in one of these.

Car accidents: the car

1.111 More than one-third (38.5 per cent) of all cars in the accidents of this survey were produced by the General Motors Corporation (Holden cars). The Ford Motor Company, with

17 per cent of the total, and the British Motor Corporation, with 16 per cent, were the next largest group. 7.4 per cent were Volkswagens.

1.112 The effects of vehicle type and of design changes in particular types of vehicle on injury production are not exactly proportional to the number of these vehicles on the roads, but on the number of such models that are actually involved in accidents. These two proportions are not the same, for some makes of vehicles are over-represented and some are under-represented in accidents. We found that Volkswagens made up 7.4 per cent of all cars in our survey, but only 4.9 per cent of the total metropolitan vehicle population, Ford vehicles 13.9 and 18.1 per cent respectively, and Holdens 38.5 and 39.6 per cent respectively. Thus Holdens appear in accidents about as often as would be expected from their frequency in the vehicle population, while Volkswagens are over-represented and Fords are under-represented. These differences are highly significant statistically, but they do not imply by themselves that Volkswagens are intrinsically more dangerous and Fords intrinsically safer than Holdens. It may be that one particular type of driver, e.g. a young driver, favours the Volkswagen, so that its accident involvement may be more a reflection of the type of driver than of the characteristics of the car.

1.113 It follows from the high proportion of Holdens in our vehicle population, and their appearance in accidents to a corresponding proportion, that even slight improvements in the design of the Holden (such as the new door latches fitted to the 1965 HD model) will eventually (as the improved vehicles replace the old) have an important effect on the injuries received by road users in about a third of all the cars that are involved in accidents. Similarly, improvements in the design of Volkswagens, such as improved door latches or steering column, would be potentially much more effective than the percentage of Volkswagens on our roads would indicate.

1.114 Most of the cars in this survey were manufactured in the years 1960 and 1962. There was a marked scarcity of vehicles manufactured in 1961. This was a time of temporary economic recession in Australia, which may have affected the number of new cars registered in that year. Total vehicles on the register in 1961 were greater than in 1960, but there may have been many more older cars retained in use in 1961 than in 1960.

1.115 Over one-third (148 of 408) of the accidents covered by our survey were primarily collisions between two cars, and to facilitate the description of these collisions we have developed a simple numerical code. We also refer to the particular car we are considering as the 'case car'. The *alignment* of the other car to the case car is described by allocating it to one of twelve positions which are set at 30° intervals to the long axis of the case car, proceeding clockwise from the front around the car as seen from above. The *point of impact* is similarly described by one of twelve positions clockwise around the car (see para. 9.12 for details). Any impact with a second car can now be described by two sets of figures, one indicating the alignment of the other vehicle and the other the point of impact on the case car. It should be noted that these two sets of figures do not necessarily give the point of impact on the other car, nor do they necessarily give the direction of the impact.

1.116 This notation, which allows for 12 possible angles between the cars and for 12 possible points of impact on the case car, gives 144 possible combinations. Some of these are unlikely (such as two cars reversing into each other), while others are common. Therefore when we allocated each of the 296 cars in these 148 accidents to one or other of these 144 categories, only 56 categories were required, and of these only 20 categories contained five or more cases. In fact these 20 categories contained 225 of the total 296 individual cases. The most frequent point of impact is the centre front of the case car, and the least frequent is its left rear corner. The other vehicle is most likely to be aligned at right angles to the case car, either on the left or the right. In other words, right-angled end-to-side collisions against the passenger compartment are most frequent in Adelaide. Most of these are intersection accidents, and possibly reflect the influence of our rectangular grid of streets.

1.117 The sides of the passenger compartment probably deform more easily than any other part of the structure of a car, and our findings therefore suggest that they deserve close attention by designers so that they may be made as strong as possible. The interior sides of the passenger compartment, generally the doors, could easily be made safer on many cars. The arm rest in particular often produces injuries to the occupant who is thrown against it.

1.118 Our traffic engineers also should note the frequency of right-angled end-to-side collisions, for in many locations it is possible to control the angles at which vehicles approach each other, for example by suitably designed traffic islands. However, careful and detailed analysis of the effects of impact geometry on overall vehicle damage and on average severity of injury did not show any significant effects, for the uncontrolled variables such as vehicle weights and speeds, and age, sex and seated position, were such that the variation within categories was greater than that between categories. More data are therefore needed to answer this important question.

1.119 We found, as might have been expected, that the likelihood of a subsequent collision was greatest in rear impacts (at an angle), much less for right-angled impacts on the sides and very small for frontal impacts. Subsequent rollover is rare in both frontal and rear impacts, but occurs in almost one-third of side impacts.

1.120 Injuries to car occupants are almost always caused by striking some part of the interior of the car. As far as we could, we related each injury to the structure which causes it. We also noted the damage to the interior of the car, and tried to determine if this was caused by the deformation of the vehicle body on impact or by an occupant being thrown against it. Four components deserve special mention: these are the steering wheel, the instrument panel, the rear vision mirror and the front seat. Our sample comprised 390 cars of the total of 553 cars (excluding 20 cars which were parked and unoccupied and 143 which struck pedestrians, pedal cyclists or motor cyclists).

Steering wheel

1.121 One hundred and twelve of the 390 cars (28.7 per cent) had the steering wheel damaged by an occupant, usually but not always the driver. In 62 cases the wheel was only slightly damaged, but it was severely damaged in 50 cases. Sometimes the spokes failed, allowing the occupant to strike the more solid hub. This impact is reduced in severity by a 'dished' design. Three spokes seem more effective in this regard than two-spoked designs, and it is to be regretted that some late model cars have changed to two-spoked wheels.

1.122 It is probable that the wheel of a Volkswagen is more likely to be damaged by an occupant being thrown against it than is the case with any of the models of the Holden, but the damage to the wheel is not often severe. Severe injuries were only occasionally produced by the wheel, and then only when the occupant struck the hub.

1.123 A significant hazard is produced if the steering column is pushed back into the passenger compartment, usually by an impact on the front of the car. This is particularly dangerous in the Volkswagen; in one of our cases the steering column of a Volkswagen was forced back almost 10 in. into the compartment, which was not otherwise significantly encroached on and was therefore 'survivable', with the result that the driver fractured his neck with transection of the spinal cord. The attention of the makers should be drawn to the possibility of significant improvement in this design feature.

Instrument panel

1.124 One hundred and thirty-six of these 390 cars (35 per cent) had instrument panels damaged by occupant contact. In 100 of these the damage was minor, but in 36 it was severe. Considering only Holdens and Volkswagens (the two models which occurred most frequently in our survey), there were 44 cases of minor damage and 17 of severe damage. The former caused mostly superficial injuries, but there was one case of bilateral fractures of the patellae, and one of bilateral fractures of the lower legs on a home-made parcel shelf below the panel. In the 17 cases with severe damage to the panel there were two cases with no injuries, 13 superficial injuries, two fractures of the midshaft of the femur and one of dislocation of the hip.

1.125 Minor injuries could be minimized, and more serious injuries reduced in severity, if the instrument panel were designed to present a smooth projection-free surface to the occupants, and to deform readily when struck. In some models 'crash padding' has been installed on the panel, but in many cases we found that it is not located where the occupants most frequently hit the panel, and in others it consists of only a thin layer of sponge rubber, which can absorb a negligible amount of the force of the impact of the occupant with the panel. Much more attention should be given by designers to making panels more 'crash worthy'.

Rear vision mirror

1.126 In 50 cases (12.8 per cent) an occupant hit the rear vision mirror, in 9 cases without damage to the mirror. In the other 41 cases the damage to the mirror varied from a bent standard to shattered glass, with or without a fractured standard which left a jagged end exposed. An occupant is more likely to hit the mirror in a Volkswagen than in a Holden, for he is closer to it. The injuries produced are mostly concussions and lacerations around the eyes and forehead. Design attention should be given to making mirrors safer, particularly to ensure that the glass when broken does not expose sharp edges and that the inertia of the whole assembly is low.

Front seats

1.127 In 25 cases (6.4 per cent) these were directly damaged in the collision, but in 66 cases (16.9 per cent) they were damaged by inertia forces of the seat itself and/or the occupants. In the latter class, failure of the seat mountings was much more frequent in the separate 'bucket' seats of the Volkswagen than in the bench seat of the Holden. Failure of the seat mountings will tend to force the occupants forward against the instrument panel. With a bench seat the occupant may become jammed, and the mass of the seat added to that of the occupant may aggravate his injuries.

Glass

1.128 Annealed plate glass is found only in older types of cars, and is therefore infrequent. Its lacerative potential is obvious. Laminated glass fractures in a similar manner to untreated plate glass, leaving jagged edges which will produce severe lacerations if the screen is penetrated by the occupant. Tempered glass is stronger than laminated glass, and there is a greater risk of concussion if the occupant strikes it. However, the risk of serious laceration is greatly reduced, except from jagged edges which remain in the frame when the screen is broken. Therefore the method of mounting a tempered glass screen determines its lacerative potential.

1.129 We attended one accident at night in which a car fitted with a tinted windshield drove into the back of another car which was stationary waiting to turn right. Had the driver been able to see a little more clearly his accident might not have occurred. The practice of tinting windshields is an undesirable method of reducing day-time glare, because the filter cannot be removed at night, as sunglasses can be.

Seat belts and mounting points

1.130 It is important that seat belt mounting points should be an integral part of the basic body frame of the car. We attended one accident in which the load on the belt caused the welds at the top of the centre post to fail, allowing the post, mounting point and belt to come forward. It is therefore necessary that the manufacturer should make the mounting points sufficiently strong.

1.131 We regret the reluctance of most Australian manufacturers to fit seat belts as original equipment in all cars. Legislation to this end was passed by a former government of this state, but has not been proclaimed. Proclamation of this bill would be the most effective single action that the government could take to reduce the frequency and severity of injuries and fatalities in road traffic accidents. There is evidence from Wisconsin, U.S.A., that because legislation ensures that many more cars have belts in them, twice as many people will be wearing belts than would be the case without legislation.

Door locks

1.132 8.6 per cent of all car doors (including cars which struck pedestrians) in this survey came open in the accident. There is now abundant evidence that ejection greatly increases the risk of serious to fatal injury (see para. 11.56). Over the years, therefore, improvements have been made to door locks to prevent their coming open. The earliest of these was some form of longitudinal restraint to prevent the two halves of the lock separating from each other. We found that 5.5 per cent of locks with longitudinal restraint came open in the accident, whereas 11.1 per cent of those without longitudinal restraint came open. For Holden cars, which are by far the most frequent make on our roads, the lock failed in 8.9 per cent of doors without longitudinal restraint in their locks and in 4.8 per cent of doors with improved locks. This result is in close agreement with a similar analysis based on General Motors cars in the U.S.A. For the Volkswagen 1200 sedan, which has only two doors, 11.0 per cent of doors came open in the accident.

1.133 We emphasize the extreme importance of this feature of the detail design of the passenger car, for an effective doorlock is a safety feature which is built into the car and is operating all the time. It is not dependent for its efficiency on the common sense and continued co-operation of the occupant, as is the case with the seat belt. If the doorlocks of all new cars can be improved to the point where it is no longer the lock but the door itself which fails, many lives will be saved and much suffering avoided.

Roadworthiness

1.134 Generally in this report we are more concerned with the 'crashworthiness' of vehicles than with their roadworthiness, for estimation of the latter is complicated by the often extensive collision damage. Also we lacked the authority and the time to conduct detailed 'autopsies' on the vehicles involved. We encountered only two cases — both single vehicle accidents — in which deficient roadworthiness was of more than minor causal importance, and it is therefore possible that a programme of compulsory inspection of vehicles might do little to reduce metropolitan traffic accidents. More information, derived from a detailed inspection of a properly chosen sample of some hundreds of vehicles involved in accidents, is required before an authoritative statement could be made on the likely benefits that would accrue from such a programme, and at what cost.

Cost of repair

1.135 In the second year of this survey we tried to find out the actual cost of repair for each vehicle, and we present the cost of repair for 86 passenger cars. This sample was small, and was in no way properly representative, but some useful findings emerged. Thus there was a wide range of repair costs for the same degree of damage; for moderate damage the cost of repair varied between limits of £15 and £450, mainly as a result of similar variations in the market value of the vehicles concerned. We tried to minimize the effect of variations of this kind by dividing the cost of repair by the current market value of the vehicle, with some allowance for the general condition of each vehicle. For minor damage the value of this index averaged 0.05; for moderate damage it averaged 0.24; for severe damage 0.62 and for very severe damage it was 1.00 (i.e. a complete 'write off').

TABLE 1.1

INDICES OF REPAIR VERSUS MEDIAN VALVES OF OVERALL DAMAGE INDEX

Overall Damage Index		(Cost of Repair/Market Value) x 20
Scale	Median values	
Minor	1.5	1.0
Moderate	5.0	4.8
Severe	11.0	12.4
Extremely severe	22.5	20.0

1.136 These indices of repair are approximately in the ratios 1:5:12:20 from minor through to extremely severe, and we were gratified to find that they are in good agreement with the median values for each range of our overall damage index (see para. 3.47), as TABLE 1.1 shows. We thus obtained another indication that our simple vehicle damage scale was realistic and useful.

Time taken to complete repairs

1.137 This is subject to extraneous circumstances far more than is the cost. We obtained a few figures on this aspect for a total of 41 cars. Minor damage averaged 2 days to repair, moderate damage averaged more than 2 weeks, severe damage 3½ weeks and extremely severe damage (one case) required more than two months.

Car accidents: environment

1.138 We estimated as accurately as we could the travelling speeds (before evasive action) and the impact speeds of all vehicles involved in our accidents; and also the speeds of vehicles which rolled over without impact, and of motor-cycles at the moment when the rider fell. Although the ranges of speeds were considerable the means were quite low: a travelling speed of 27.0 m.p.h. and 20.5 m.p.h. at impact. However, the mean speeds for the 17 fatal accidents were higher: 36 m.p.h. and 31 m.p.h. Thus — if our estimates are accurate — most accidents occur at speeds well within the official speed limit of 35 m.p.h. Although the estimation of the speed of a vehicle after the event is most difficult, and the statements of drivers and witnesses are unreliable, other clues are useful, particularly skid marks due to braking. Our final estimates of speeds were generally much higher than those of the drivers concerned, but even so our mean values are low when compared to the speeds of traffic streams on many metropolitan roads, and we conclude that even slow speeds can still be dangerous in a metropolitan area — particularly at intersections.

1.139 We therefore made a special study of critical speeds* at intersections, by returning to 34 intersections at which we had attended accidents. With a radar speedmeter we recorded the approach and crossing speeds for 451 vehicles. We also measured the relevant sight distances, and were able to establish a minimum stopping distance from a given speed on the particular surface. We then calculated the critical speeds at these intersections.

1.140 Details of the calculation are given in para. 10.10 to 10.20. The results were surprising and disturbing, for in no case was the critical speed greater than 37 m.p.h., and in one case it was less than 11 m.p.h. The actual speeds of the 451 vehicles we observed varied between 50 and 0 m.p.h., and of them 363 (81 per cent) were exceeding the critical speed. Thus only 19 per cent of these drivers could hope to avoid all vehicles approaching from the right at these intersections. It is very easy in Adelaide to drive dangerously fast without exceeding the official limit of 35 m.p.h.

1.141 This study also suggested that the 'give way to the vehicle on the right' rule may be unsatisfactory in this city, for at the speeds at which vehicles are actually driven only one driver in seven could hope to obey the rule in every case. This important matter needs much further impartial and careful study, for perhaps a major and minor road system of determining right of way might be more in line with present driver behaviour. As a starting point, many more observations should be made at a larger and carefully representative sample of intersections.

1.142 We also made a special study of accidents at one particular signalized intersection (Gepps Cross), because we attended more accidents there (6) than at any other place. In fact a total of 433 accidents were reported from this intersection during the 4-year period 1961-64, and the property damage from the 143 accidents in 1964 alone has been estimated

*The maximum approach speed which will at any point enable the driver to avoid a collision, either by continuing on with undiminished speed or by stopping, is taken to be the meaning of the term 'critical speed'. The present application considers only the possibility of a collision with a vehicle approaching the intersection at a steady speed from the right of the case vehicle. It is also restricted to two roads which intersect at right angles.

This same assumption applies wherever the term 'critical speed' is used in this report.

at £A15,000. We found that the phasing of the lights allowed a conflict of two traffic streams, each of which had a green light, and the alignment of their paths is such that there is often a third car which obscures the other two cars from each other. Over these four years this particular feature of the phasing of the lights accounted for one quarter of the 433 accidents — 110 in all — but these included half of the personal injury accidents and half the total property damage. It is indeed unfortunate that this state of affairs was allowed to persist for so long.

1.143 Considerable emphasis is often placed on the relationship between skidding and accidents, especially skidding due to braking. It is well known that the effective braking force is less when the wheel is locked and sliding than when it is braked just short of locking. Although brakes which automatically achieve this latter end are standard on large commercial aircraft they are not found on cars, and few drivers are capable of the necessary degree of control to brake in this way during a 'panic stop'. Most will brake so hard that they will skid. We found that of the 623 vehicles for which this information was recorded 180 skidded when braking. All were on bitumen roads.

1.144 We therefore made a special study of skidding on this type of surface, recognizing that the term 'bitumen surface' includes surfaces varying from the machine-made 'hot mix' to the poorly maintained macadam-based surface found in many suburban side streets. We found by performing locked-wheel skids in our own vehicle at accident scenes that there can be great variations in the skid resistance of a clean dry bitumen surface. Our tests gave stopping distances, from 30 m.p.h., varying from 11 to 22 yd. A stopping distance of 22 yd from 30 m.p.h. on clean dry bitumen (at 80 F) is most surprising. The poor skid resistance of the particular surface on which this latter stopping distance was found is apparently due to the large aggregate being coated with bitumen which is melted by the heat generated by the tyre sliding over it. The resulting skid mark is a molten tar mark and not an abraded rubber mark, and the vehicle in fact slides on molten tar. We understand this surface is a base course for the final layer of hot mix, and because there is often a delay of some months before the final layer is applied, we suggest that signs should be displayed to warn motorists of the slippery surface.

1.145 The white paint used for road markings has a much lower skid resistance than that of a bitumen road surface, and it can initiate a skid in much the same way as a patch of oil may do so. The skid may then continue on the bitumen surface. Similarly, the skid resistance of a dry road surface will be reduced if it is covered with a layer of loose material. Although only 16 of our 623 vehicles were on such a surface, ten of them skidded on the loose material. Some of these cases could have been avoided if the regular road maintenance had included removing the loose material with a street sweeping machine.

1.146 Exactly one eighth of our accidents occurred on wet roads. Seventy-five vehicles were travelling on wet roads at the time of their accidents, but only 10 of these were recorded as having skidded. In 16 cases we were unable to determine whether skidding had occurred. Considering only verified cases, we found just as many instances of skidding on loose material as on wet roads. It must be remembered that the Adelaide rainfall is only some 21 in. annually, mostly in short sharp falls.

1.147 Temperature effects on skidding are not critical in Adelaide. Ice formation on the road surface is unknown, and indeed the softening of road tars in midsummer may be more of a problem. However, we did not investigate accidents during the hottest months.

1.148 The condition of the tyres of the vehicle is often considered to be related to the risk of skidding, and we therefore carefully examined tyres of vehicles involved in our accidents, classifying them into two classes, either 'good' or 'worn'. We regarded a tyre as good if it had a well-defined tread pattern with the tread at least 1/10 in. deep, and if even one tyre could not be classed as good we placed that vehicle in the 'worn' class. More vehicles with good tyres (94) skidded than did those with worn tyres (67), even on wet roads, though on wet roads the numbers were very small (7 and 3). However, we do not know how many of the vehicles were braking, nor can we assume that other conditions such as the skid resistance of the surfaces on which the accidents occurred were similar. Indeed, we have already shown that the skid resistance of even dry clean bitumen can vary by as much as 100 per cent. For vehicles which did not skid, there were almost equal numbers with good tyres as with worn tyres. We found no evidence therefore that worn tyres played a major role in the causation of our metropolitan accidents.

1.149 Skid marks on the road convey much more information than merely to indicate that the vehicle has skidded. Assuming that the coefficient of friction between a skidding tyre and a uniform road surface is independent of both the weight and speed of the vehicle, it was possible, by relating the length of the test skids in our own vehicle to those of vehicles involved in accidents, to calculate the speed lost by that vehicle in the skid. This was particularly valuable in pedestrian accidents where little energy is lost by the vehicle in the actual collision. Skidding in collisions between vehicles usually permitted only an estimate of the difference between travelling and impact speeds.

1.150 Skid marks often define very clearly the position of the wheels on impact, and under certain conditions the angle of deflection of the marks may help determine the momentum of each vehicle on impact. Skid marks also often clearly show the path of a car after the impact, and if the marks for the front and rear wheels are separate — as they are when the vehicle is sliding sideways or spinning — it is possible to determine the position of the car at any point along the skid marks, if the track and wheelbase of the car are known. In this way it is often possible to determine the exact behaviour of a car at the moment when an occupant was ejected.

1.151 Accidents at intersections are very common in Adelaide, where the rectangular layout is such that there are very many intersections between wide straight roads. Thus for car-to-car collisions 70.5 per cent occurred at intersections, 5.5 per cent within the 20 yd. after an intersection, 2.2 per cent within the 20 yd. before an intersection and 21.8 per cent not at intersections. 17 car accidents occurred at intersections controlled by stop signs, and 25 at traffic lights, i.e. 42 of the total of 129 accidents at intersections. Three cases occurring at stop signs were of no special significance, for they involved stationary vehicles which were struck by other cars which had been involved in previous collisions. However, nine vehicles that had stopped, as required, at a stop sign were struck by vehicles approaching on the intersecting road — five from the right and four from the left. In this kind of collision a third vehicle may create a 'blind spot' for the driver moving off from the stop sign, and sometimes drivers seem not to appreciate that if they move off suddenly an approaching car may not be able to stop in time.

1.152 In 11 accidents of these 25 we are certain that one vehicle did not stop at the stop sign, and one of these resulted in the death of a passenger in the offending car. In two more cases we suspect but cannot be sure that the driver did not obey the sign.

1.153 In some instances stop signs and other warning signs are difficult to see, either because they are obscured by foliage, or by poles and the like which have been placed in front of them by some other public agency. We also found some unnecessary signs.

1.154 Thirty-seven of the total 408 accidents were at traffic lights. There were two main groups: in one group (16 cases) both vehicles were proceeding straight across the intersection, and in the other (15 cases) one vehicle was turning right. Other kinds of accident were few. The commonest feature of the first group was a collision during or at the end of the amber phase of the lights. An all-red phase seems to be the only way to minimize this type of happening, and a judgement would have to be made in some way between the benefit resulting from a diminution in accidents and the cost of a diminution in traffic flow; or to put it crudely, how many accidents are tolerable for a given vehicle flow?

1.155 There were two cases in which a driver mistook a green 'turn left' arrow for the green light for 'straight ahead', but only one case of the afternoon sun shining directly into the traffic lights making it difficult to decide which light was illuminated.

1.156 In the second group a vehicle turned right across the path of another vehicle approaching from the other direction. This is the typical motor-cycle accident, and five of these 15 accidents involved a motor-cycle. In some cases the layout of the intersection and/or the mode of operation of the lights seemed to be confusing. We mention some specific instances.

Car accidents: occupants

1.157 There were 1,029 car occupants seated in the 542 cars involved in our survey, i.e. 1.9 persons per car. There were 228 occupants of cars which collided with pedestrians, pedal cycles and motor-cycles, and of these 221 were not injured at all, one of the remainder received severe injuries, and none was killed. Of the 801 occupants of cars which collided with cars, trucks, fixed objects or rolled over, 63 per cent were injured (minor 42 per cent, moderate 16 per cent, severe 4 per cent, very severe and fatal 1 per cent). There were only two deaths in car occupants: one was a 13-year-old boy who was thrown against a tree from the tray of a truck when it rolled over on a bend, and the other was a 27-year-old woman occupying the left front seat of a Morris Minor which was struck on its left front door by a large car.

1.158 Regional injuries were: head and neck 70 per cent, thorax 19 per cent, abdomen 4 per cent, spine and pelvis 2 per cent, upper limb 31 per cent and lower limb 52 per cent. Most of the limb injuries were minor, as were about two thirds of the head injuries. However, 26 per cent of head injuries were of moderate to fatal degree, as were 6 per cent of thoracic injuries, 1 per cent of abdominal injuries, 2 per cent of injuries to the spine and pelvis, 4 per cent of upper limb injuries and 3 per cent of lower limb injuries, so that head injuries made up almost half of the injuries that warranted admission to hospital or caused death.

1.159 75 per cent of those with head injuries had soft tissue injuries of the face, and 5 per cent had fractures of the face. About half (120/265) of the soft tissue facial injuries were lacerations, and many of these victims were women, to whom the cosmetic effects are especially important. 34 per cent were concussed, and 19 percent had lacerations of the scalp. There were two skull fractures (0.06 per cent).

1.160 Certain structures inside the car cause characteristic lacerations: thus sunvisor hinges cause a 'U' shaped laceration of the scalp at or above the hairline, and the rear vision mirror, which is usually struck by the forehead, nose and upper cheek, produces a series of small lacerations as the glass shatters. When a car occupant strikes a tempered glass windscreen with force sufficient to break it, he usually receives small shallow lacerations. If his head then travels downwards he receives lacerations to the lower surface of the chin. On the other hand, impact with a laminated glass windscreen produces severe lacerations when the glass is penetrated by the head. In all, there were 48 cases when the occupant's head struck the windscreen (43 tempered, 5 laminated).

1.161 There were 15 neck injuries. Of these eight were soft tissue strains, five of which were due to impacts from the rear of the car. There were two injuries of the spine. In one of these (previously described) a 35-year old man driving a Volkswagen struck another car head on, the steering column was driven up in front of him almost 10 in., and he suffered a fracture-dislocation of the cervical spine with transection of the spinal cord and consequent permanent quadriplegia, when his head struck the header area.

1.162 The commonest thoracic injuries were superficial abrasions and bruises (67 per cent). 41 per cent of injuries to the thorax were skeletal injuries, of which more than half were fractures of the ribs, and in five of these 25 cases there was evidence of damage to the underlying lung.

1.163 There were three internal abdominal injuries and two of these victims died. One had lacerations of the spleen and left kidney, and the other a laceration of the left kidney and avulsion of the left renal artery from the aorta. In the third case there was contusion of the left kidney. There were six cases with fractures of the pelvis and two of fractures of lumbar transverse processes.

1.164 In the upper limb superficial injuries predominated, but there were 15 fractures. Only one of these resulted from a blow (from the tray of a truck) on the protruding elbow of a driver. Superficial injuries also predominated in the lower limb, usually abrasions and bruises from striking the lower edge of the instrument panel or the edge of the parcel shelf. However there were 13 fractures in 11 persons (hip 1, femur 3, patella 4, tibia 3, foot 2).

1.165 Proceeding to analyse the cause of injury to car occupants, we found that for **all** injuries the instrument panel caused most injuries, followed in order of frequency by the door and frame, the windscreen and frame, the header area, the steering wheel and column, ejection, and the front seat. However, if only injuries of moderate or greater severity are considered, the order of causation changes markedly, for the door was easily the most important cause of moderate or greater injury (51 injuries), followed by the windscreen (24 injuries), the instrument panel (18 injuries), the header area (17 injuries), ejection (16 injuries), and the steering column (11 injuries).

1.166 The direction of impact has a considerable bearing on what areas of the car interior cause injury to each part of the body, and the seated position of the occupant also influences injury production. Thus in front impacts passengers are injured more often than drivers, in impacts on the right side drivers are injured more often than passengers, and in impacts on the left side front seat passengers are injured more often than drivers. The occupant's body in fact strikes those parts of the interior of the car which lie closest to it in the direction of the impact. In frontal impacts the heads of both driver and front seat passenger strike the header area, but the driver also strikes the steering wheel and therefore does not strike the windscreen as often as the front seat passenger. The driver's chest strikes the steering wheel, the passenger's chest strikes the instrument panel. The legs of both strike the instrument panel.

1.167 In impacts from the right side the driver is injured in all body areas by the door, but the front seat passenger strikes the header area and the instrument panel with his head and thorax, and the steering wheel with his upper limbs, while his lower limbs also strike the instrument panel.

1.168 In impacts from the left side the front seat passenger is injured in all body areas by the door, and ejection becomes a cause of injury for the head and both upper and lower limbs. Drivers are thrown to the left and forwards, usually clear of the steering wheel, to strike their heads on the left side of the windscreen and the header area. They may also strike the left door. The instrument panel is still the main cause of injury to the lower limbs.

1.169 Rear seat passengers in frontal impacts strike their knees on the front seat, and possibly their heads on the top of the back of the front seat. In side impacts they strike the doors rather as do front seat occupants.

1.170 The degree of injury also varies according to seated position. Thus front seat passengers are injured significantly more often than drivers, and rear seat passengers less often than either of the other two classes. Because almost two thirds of front seat passengers are women, and the commonest injuries are to the head and legs, women are exposed to the risk of injury more than men are, and the injuries they receive may well be more serious, both abolutely and also cosmetically.

1.171 There is, as expected, a significant correlation between injury severity and vehicle damage. The regression lines have the same slope, but the line for front seat passengers is above that for drivers, which in turn is above that for rear seat passengers.

Ejection

1.172 Thirty-five of the 1,029 car occupants in all the accidents in our series were ejected (3.4 per cent). The proportion of moderate and worse injuries was significantly greater in those ejected (16 of 34 cases) than in those not ejected (155 of 987 cases). Only one of the 34 persons ejected was not injured at all, while almost half had moderate or worse injuries. (In one person ejected the degree of injury was not recorded.) Those ejected received severe to fatal injuries more than four times as often as those not ejected.

1.173 In our series ejection was associated with spinning of the car rather than with rollover, and often occurred when the car stopped suddenly. The impact on the side of the car which sets it spinning also springs open the doors on the opposite side of the car, through which the ejection takes place.

Seat belts

1.174 Fifty-eight of the 1029 car occupants (5.6 per cent) had seat belts available and 24 were actually wearing them. In accidents not involving pedestrians, pedal cyclists or motor-cyclists we found that half of those wearing belts were injured, but so were half of those not wearing belts. However there were fewer moderate and greater injuries in those wearing belts. The frequencies are too small to allow any definite statistical statement to be made from our data about the efficiency of belts in injury prevention during the period covered by this survey. We have some evidence that the proportion of cars fitted with visible belts (enabling spot counts to be made from the roadside) increased from 3 per cent at the beginning of 1963 to almost 15 per cent at the end of 1964, and that about 60 per cent of occupants with belts available were wearing them. In a few individual accidents, seat belts undoubtedly reduced the severity of injury.

Alcohol

1.175 Although we could not perform clinical tests, we made a personal assessment of those participants who showed signs of recent ingestion of alcohol. This almost certainly resulted in a considerable underestimate, but 5.5 per cent of drivers involved in collisions with motor-cycles, pedal cycles and pedestrians showed evidence of alcohol, as did 15.2 per cent of other drivers in our sample. Thus, of all drivers, 12.5 per cent showed evidence of alcohol. In single vehicle accidents 16 of the 43 drivers (37 per cent) showed evidence of alcohol. The percentage for pedestrians was 16 per cent, but for pedal cyclists and motor-cyclists it was 4 per cent.

1.176 More than half of the car occupants did not require any medical treatment. Three hundred and fifty-three of them attended a hospital, and 203 were allowed to leave after treatment in the casualty department. One hundred and fifty persons (14.6 per cent) were admitted; of these two died in hospital and the others stayed an average of 4.8 days.

Pre-existing disease

1.177 Two car drivers collapsed at the wheel and died soon afterwards. Both had previously unsuspected coronary artery disease at necropsy. Thus fewer than 0.5 per cent of drivers had pre-existing disease which might conceivably have been detected at a routine medical examination. This low figure should be noted by those who urge a routine medical examination of all drivers before a licence to drive is granted.

Car accidents: further statistical studies

1.178 Twenty variates from the data on car-to-car collisions were selected for detailed correlation analysis. Seven of these were aspects of body injury, and were therefore related. All the others except age and sex were aspects of vehicle damage in one way or another; and age and sex themselves vary with seated position in a non-random way. It is important therefore to realize that the variates were not mutually independent, for this materially reduced the usefulness of the analysis.

1.179 Simple linear correlation matrices were calculated for all occupants and for drivers, front seat passengers and rear seat passengers respectively. Conservative tests of significance were used, to minimize the appearance of nonsense correlations. Many interesting and suggestive correlations were found: these are set out in detail in Appendix A of the report.

1.180 Multiple regressions were then calculated of various factors on those variates expressing degree of injury, both overall and regional. Again many suggestive findings emerged, which are set out in detail in Appendix A. A factor analysis was also performed on the data, but it was found, as was expected, that this did not give such useful information as did the more conventional multiple regression. Most factors were bipolar and difficult to identify, except the first factor which seemed to give some measure of the general severity of the accident.

1.181 We concluded that our understanding in quantitative terms of what happens in collisions between two cars is not yet sufficiently advanced to enable us to select independent variates; and until we are able to do this there appears to be little point in these more advanced and elaborate analyses.

RECOMMENDATIONS

1.182 These recommendations have been derived from our assessment of the whole body of our data. Undoubtedly there will be omissions, because we have by no means made an exhaustive analysis. In effect, in preparing this report we have gathered and examined what seem to us to be the obvious nuggets lying mostly on the surface, but have not dug very deeply except in a few places. Realizing this, we have tried in the body of the report to set out the facts as fully as we could, so that others with more experience or with different interests may mine them for themselves. Therefore these recommendations do not represent all that can be wrung from this study. The reader is referred to the report itself for other matters which need action or merit further study.

1.183 The study has shown that the designers and constructors of roads and vehicles, administrators and the road users themselves can all contribute to a reduction in the incidence of road accidents and of the severity of injuries, either through action, or in some cases through further research and development.

1.184 The following recommendations are addressed to the groups most directly concerned with the particular aspect of the problem, though often several groups are concerned. In many cases it is not clear to us who would be responsible for taking the action recommended.

PEDESTRIANS

1.185 There is a clear and urgent need for greater protective measures for pedestrians in Adelaide. Because a good proportion of pedestrians are struck when 'stranded in the middle', we believe that the efficacy of a system of median strips deserves further detailed study. A median will act as a pedestrian refuge without interrupting vehicle flow, and at the same time lightens the pedestrian's task in that he has to penetrate a traffic stream proceeding only in one direction. In other places a pedestrian crossing may be thought more suitable. But however it is to be done, we strongly recommend prompt and energetic measures to protect our pedestrians.

1.186 Pedestrians should be warned that it is quite likely that drivers will not see them at night. They must therefore wait for safe gaps in the traffic, and they must not expect drivers to manoeuvre around them.

1.187 Drivers however need to know that pedestrians are likely to behave as if they expect to be seen by drivers, even in circumstances when this is quite difficult.

1.188 Pedestrians should be warned again of the dangers of crossing roads near but not at intersections. If they do cross in such places they should be particularly wary of the vehicle approaching from across the intersection.

1.189 It is likely that the severity of injuries received by pedestrians could be reduced by appropriate redesign of the frontal shapes of cars. We believe that vehicle designers should bear the pedestrian in mind, as well as the car occupant, when considering the safety features of their vehicles.

PEDAL CYCLISTS

1.190 Educational programmes directed at car drivers should include the advice to be especially watchful for pedal cyclists between 4 p.m. and 6 p.m., when half the cyclists' accidents occur, and to be aware that a youthful rider may make a sudden 'U' turn in front of the car.

1.191 Similarly, pedal cyclists should be warned of the danger of sudden 'U' turns, and they should also be warned that drivers are likely not to notice them at intersections.

1.192 Because one third of pedal cycle accidents occur at night, and often involve cyclists riding steadily along at the side of the road, cycles should carry lights which are larger and brighter than those commonly used at present.

1.193 Head injuries are common in pedal cyclists struck by cars, and there is a case for urging them to wear protective helmets of suitable design.

1.194 Pedal cyclists are very vulnerable to serious injury, and many of them are children in whom such injuries are particularly distressing. We believe that there is a case for a serious study of the practicability of removing pedal cyclists from the roadway altogether, on to the footpath if special cycle tracks are not possible. Pedestrians might suffer some inconvenience if this were done, but young lives would be saved.

MOTOR-CYCLISTS

1.195 Because almost two thirds of motor-cycle accidents occur at intersections, educational programmes directed at motor cyclists should warn them to take special care at such places, and should indicate that many motor-cycle accidents involve collisions with cars that are changing direction.

1.196 Programmes aimed at drivers should emphasise the risk to motor cyclists when car drivers pull out from the kerb or start a 'U' turn. Unless the driver looks carefully to his rear before attempting these manoeuvres he may not notice an approaching motor cyclist. In one half of all collisions between a motor cycle and a car, the car was turning right. Drivers need to ensure that the road is clear of motor cycles, as well as other large vehicles, before turning right.

Helmets

1.197 In most of the head impacts suffered by motor cyclists in this survey, greater forces were developed on the head than the present helmets are designed to withstand. Moreover only a minority of impacts occur on the crown of the helmet where there is protective padding, and most impacts are on the lower sides where there is no padding. The efficiency of the helmet at present specified by Standard E33-1959 — and required by law to be worn by all motor cyclists in Victoria — is not as great as it could be. Official consideration should be given to requiring that all helmets sold for use by motor cyclists meet British Standard B.S. 1869:1960 — Protective Helmets for Racing Motor Cyclists —

which specifies an enveloping helmet covering the forehead, ears and occiput, a strong webbing suspension and a complete lining with energy-absorbing material.

TRUCKS

Doorlatches

1.198 Truck occupants may be ejected through the doors, and their injuries thereby aggravated. Trucks should therefore be fitted with doorlatches designed to prevent unlatching in an accident, just as for cars.

Crash barriers

1.199 A study should be made of the benefits and costs that would result from requiring the installation of crash barriers of suitable design below the tray at the rear and at the sides of trucks.

CARS

Seat belts

1.200 Few car occupants in our survey wore belts, but the benefits of seat belts were confirmed. The case for requiring belts as original fittings of cars is strong.

Injury-producing structures in cars

1.201 Our findings, which we believe are important, on the injury-producing potential of the internal components of cars, are set out in para 11.26 to 11.38. We believe they should be carefully studied by vehicle manufacturers, for here is a body of facts which will be of undoubted value in designing for safety. We hope also that these findings will be studied by those authorities concerned with design standards of vehicles and vehicle components.

Windshield injuries

1.202 Further investigation of the injury-producing potential of laminated and tempered glass windshields appears to be worthwhile. This might be approached by a comparison of injury data from this series (in which tempered glass windshields greatly predominate) with matched examples from the Cornell data (which contains entirely laminated windshields).

Trailers

1.203 The strength and condition of safety chains, and their methods of attachment both to the trailer and to the towing vehicle, should be specified to prevent accidents caused by trailers breaking loose.

HIGHWAY ENGINEERING

Utility poles

1.204 A cost-benefit analysis of collisions with utility poles would be worthwhile, to determine whether these poles — at least in places where pedestrians are few — should be so constructed as to minimise the damage to a vehicle (and to its occupants) on striking the pole.

Speed at intersections

1.205 The relation between actual speed at intersections and a safe speed of approach (which we call the 'critical speed') is recommended for special study. An examination of 38 intersections showed that 84 per cent of drivers were exceeding this critical speed. If this speed is confirmed as being impractically low the validity of the 'give way to the right' rule is called in question. We estimate that a single team working with a radar speed meter could get very valuable information in two months.

1.206 Our methods for calculating these critical approach speeds at intersections differ from those commonly employed by traffic engineers. In addition to an 'on the spot' study of actual approach speeds at a carefully chosen, adequately large and representative sample of intersections, we suggest that there is a need for the re-examination of the general case — the whole question of how to calculate a 'safe approach speed' for an intersection. This should obviously be incorporated into the 'on the spot' study.

Accident records at light-controlled intersections

1.207 Better methods are needed for checking the 'before and after' accident records at complex intersections at which lights have been installed. In one particular instance we found that a most unsatisfactory situation had been allowed to persist for some years.

Slippery bitumen surfaces

1.208 The poor skid resistance of certain base course bitumen surfaces should be recognized. If it is not practicable to cover the base course with the final course promptly, signs should be displayed to warn drivers of the slippery surface.

GENERAL

Collision theory

1.209 An analysis in greater depth should be made of the engineering data obtained in this survey, to bring the material into better order and to try to make some progress towards the understanding in quantitative terms of what happens in collisions between cars, and to advance the rather rudimentary existing 'collision theory'.

Alcohol

1.210 There is a need for accurate information about the customary distribution of alcohol levels in the driving population, and studies should be set up to obtain it — if possible in two capital cities to provide a cross-check. It cannot be doubted, from the data available from our police forces and our pathologists, that Australia has a drinking driver problem. What is not known accurately is the size of the problem, and it is important to obtain this information as a baseline for studying secular trends, and particularly the effects of changes in legislation against driving while under the influence of alcohol.

Continuing surveillance

1.211 A mobile unit concerned with the analysis of individual accidents or groups of accidents, and not concerned in any way with enforcement, should be a permanent feature of the highway scene in each capital city. Traffic accidents are a serious endemic disease which needs continuing surveillance. Such a unit — among other things — would help to study particular 'black spots' where accidents are frequent, so that remedial measures can be taken without delay.

Country accidents

1.212 There is still a serious gap in knowledge created by the lack of good information about rural accidents. Further thought should therefore be given to setting up a detailed study in the country.

SPECIAL REPORT NO. 1

The Special Report No. 1 is the first of a new series of publications produced by the Australian Road Research Board. This report is entitled "Traffic Accidents in Metropolitan Adelaide", and a preliminary report on the same subject has been published in the journal 'Australian Road Research', Vol. 2, No. 5, 1965. The price is $Aust.12.00 per copy, (surface mail postage free). Special reports will be published irregularly.

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