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Commonwealth Department of Transport

THE EFFECTIVENESS OF AUSTRALIAN DESIGN RULE 22 FOR HEAD RESTRAINTS

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THE EFFECTIVENESS OF AUSTRALIAN DESIGN RULE 22 FOR HEAD RESTRAINTS

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Abstract As introduction, the report describes Australian Design Rules 22 and 22A requiring head restraints to be fitted to driver and front left seats of all new cars in Australia from 1972 models onwards. The effective heights of these restraints are discussed, as well as the nature of whiplash injuries which they are designed to prevent. Other studies of head restraint effectiveness are reviewed.

Data on 1974-75 claims to the Motor Accidents Board in Victoria for injury compensation are then analysed to evaluate the effectiveness of ADR 22. Potential benefit groups (front outboard seat occupants in rear end impacts) and disbenefit groups (rear seat occupants in front end impacts) are considered, as well as other occupants and crash circumstances as a control for crash severity differences.

The report concludes that there is weak evidence that ADR 22 is effective in reducing whiplash injuries sustained in rear end impacts. The benefit is almost entirely confined to female occupants of front left seats. There is no evidence of disbenefits in terms of head or facial injuries to rear seat occupants. However there is evidence of disbenefits in terms of whiplash and major intracranial injuries to drivers involved in front end impacts in ADR 22 cars compared with pre-ADR 22 cars.

The absence of information on crash severity and seat belt wearing from the analysed data limits the above conclusions to being suggestive, not definitive.

NOTE:

This report is disseminated in the interest of information exchange.

The views expressed are those of the author(s) and do not necessarily represent those of the Commonwealth Government.

THE EFFECTIVENESS OF AUSTRALIAN DESIGN RULE 22 FOR HEAD RESTRAINTS

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INTRODUCTION

BACKGROUND

Following a submission by Mr V. Arnold, Chairman, and Mr A. Clarke, General Manager, Motor Accidents Board (MAB), Victoria to the House of Representatives Standing Committee on Road Safety in August 1975 a meeting of Victorian (Motor Accidents Board and Road Safety and Traffic Authority) and Commonwealth (Department of Transport) officers was held to discuss uses of MAB data for road safety research purposes. The Department of Transport commissioned M.H. Cameron, Consultant Statistician, to design a study using MAB data to evaluate the effect of Australian Design Rules 22 and 22A (Head Restraints) on whiplash injuries in rear end impacts. The MAB data were considered particularly suitable for this study because whiplash injuries are more likely to be reported to an injury compensation scheme than to the Police.

The Department of Transport submitted the study design to the Road Safety and Traffic Authority who accepted it with minor amendments regarding an extension of the analysis to consider possible disbenefits of head restraints in terms of facial injuries to rear passengers in frontal impacts. The amended study design was accepted by the Motor Accidents Board, who supplied a magnetic tape file of claims related to accidents during the financial year 1974-75. The file was analysed using the computer facilities of the Road Safety and Traffic Authority by J.P. Wessels, Computer Systems Consultant of M.H. Cameron and Associates, while under contract to the Department of Transport. He was directed by M.H. Cameron, consultant to both the Road Safety and Traffic Authority and the Department of Transport.

This report contains the results of that analysis.

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AUSTRALIAN DESIGN RULES 22 AND 22A

Australian Design Rule (ADR) for Motor Vehicle Safety No.22 required manufacturers to fit head restraints to the front outboard seating positions of passenger cars and derivatives manufactured on or after 1 January 1972. Manufacturers were permitted to fit either fixed (integral with the seat) or adjustable head restraints. To overcome problems of improper adjustment, ADR No.22A extended the original rule by specifying a mimimum height for head restraints. It applied to vehicles manufactured on or after 1 January 1975. Most manufacturers satisfied ADR 22A by fitting fixed restraints.

HEIGHT OF HEAD RESTRAINTS

ADR 22 required that head restraints be capable of presenting an impact surface between 23 and 27.5 inches (584 to 699mm) above the 'H' point, the simulated position of the hip of a 50th percentile adult male. ADR 22A requires that the upper boundary of the impact surface be not less than 700mm above the H point. The static test method for both rules specifies the application of a force at a point 635mm above the H point.

In an anthropometric study of 120 Australian adults, Herbert and Corben (1977) measured the height of the ear hole above the H point. They claimed that 'the mass centre (of the head) is usually considered to be located mid-way between the ear holes of human subjects, although eye height is sometimes proposed'. They estimated the height of the ear hole of a 95th percentile adult male to be 693mm, with a population high limit (upper 95 per cent confidence limit) of 700mm on this estimate. Thus it would appear that the top edge of head restraints installed under both design rules should be at least capable of being positioned at or above the height of the ear hole of 95 per cent of the adult male population and presumably a higher percentage of adult females.

Field data suggest that the proportion of ADR 22 head restraints which were correctly positioned was considerably lower. The Office of Road Safety of the Department of Transport made available results from surveys of the height and adjustment of head restraints satisfying ADR 22 conducted in Sydney, Melbourne and Adelaide late in 1972 by the traffic authority in each State. Of 3000 drivers of passenger cars and derivatives observed in Sydney, 9 per cent had integral (fixed) head restraints, 12 per cent had adjustable, and 2 per cent had the accessory (unapproved) type. A head restraint was recorded as 'too low' if the top of the restraint was below the bottom of the ear hole of the occupant of that seat. An adjustable restraint

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was recorded as 'down' if it was set at its lowest position. Front left passengers were also observed in Melbourne and Adelaide.

Only 73 per cent of front outboard seat occupants were observed with satisfactory height head restraints in Melbourne and Adelaide (Table I). Sydney data were not included in the table because they pertain to drivers only and were not available for integral restraints nor by sex and seating position. The table shows that integral restraints were more likely to be satisfactory (83 per cent), due to the low proportion of adjustable restraints which were satisfactory when set at the down position (45 per cent). However, adjustable restraints when set somewhere above this position were satisfactory for 93 per cent of occupants. The table also shows that in general female occupants more frequently had satisfactory height restraints, especially those with the integral type or adjustable restraints set at the down position.

The above results can be contrasted with U.S. experience with Federal Motor Vehicle Safety Standard (FMVSS) No. 202 on which ADR 22 was based. FMVSS 202 made head restraints mandatory equipment for passenger cars sold in the U.S. on and after 1 January 1969. In roadside observations of 4983 drivers in Los Angeles and Washington, O'Neill et al (1972) found that only 16 per cent of male drivers and 29 per cent of female drivers had their adjustable head restraints properly positioned behind their heads. The criteria used are not given in the reference. Garrett and Morris (1972) found that only 18 per cent of American occupants in rear impacts had their adjustable head restraints in the up position, in comparison with the Australian 42 per cent implicit in Table I. They also found that 73 per cent of head-restraint-equipped U.S. cars had adjustable restraints, in comparison with 53 per cent of like Australian cars (implicit in Table I also). Thus, in comparison with U.S. cars satisfying FMVSS 202, Australian cars meeting ADR 22 were less likely to have adjustable head restraints, were more likely to be driven with such restraints in an up position, and possibly more likely to have such restraints satisfactorily positioned behind the heads of drivers and front left passengers.

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Table I: Number of occupants observed with head restraints available and percentage with satisfactory height restraints, in Adelaide (N=1689) and Melbourne (N=416).

TYPE OF HEAD RESTRAINT AND POSITION	DRIVERS		FRONT LEFT PASSENGERS		DRIVERS AND FRONT LEFT PASSENGERS		
	Male	Female	Male	Female	Male	Female	Both
ADJUSTABLE							
1. Down position							
(a) No. of occupants	447	79	58	63	505	142	647
(b) Percent with satisfactory restraints	37.1	72.2	46.6	60.3	38.2	66.9	44.5
2. Up position							
(a) No. of occupants	341	61	25	33	366	94	460
(b) Percent with satisfactory restraints	92.7	91.8	92.0	100.0	92.6	94.7	93.0
3. Down or up position							
(a) No. of occupants	788	140	83	96	871	236	1107
(b) Percent with satisfactory restraints	61.2	80.7	60.2	74.0	61.1	78.0	64.7
INTEGRAL							
(a) No. of occupants	687	129	63	119	750	248	998
(b) Percent with satisfactory restraints	79.3	93.0	79.4	92.4	79.3	92.7	82.7
ALL TYPES							
(a) No. of occupants	1475	269	146	215	1521	484	2105
(b) Percent with satisfactory restraints	69.6	86.6	68.5	84.2	69.5	85.5	73.2

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NATURE OF WHIPLASH INJURIES

'Whiplash' injuries are poorly defined. Objective clinical evidence of injury does not exist in a typical case, precluding a strict definition of the injury (States et al, 1972). Huelke and O'Day (1975) summarised various descriptions of the injury, namely:

- cervical sprain syndrome,
- flexion-torsion neck injury,
- hyperextension/hyperflexion injury,
- cervical hyperextension

It appears that whiplash is a term reserved for minor or moderate neck injuries on the Abbreviated Injury Scale (Huelke and O'Day, 1975) and that it is any minor fracture, dislocation, sprain, or complaint of pain associated with hyperextension or hyperflexion of the neck.

The symptoms of whiplash injury are often delayed hours or days so that the injury is not evident at the scene of the accident and hence may not be reported to Police accident investigators (States et al, 1972). Thus Police accident reports, especially those based on an injury criterion for data collection, would probably not adequately represent the extent of whiplash injuries. Injury reports based on follow-up interviews with occupants in rear impacts (e.g., States and Balcerak, 1973; McLean, 1973) or on insurance claims (e.g. O'Neill et al, 1972) should more accurately represent the incidence of whiplash injuries.

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Several studies have indicated that women are more susceptible to whiplash injury during rear-end collisions than men (Kihlberg, 1969; States et al, 1972; O'Neill et al, 1972). States et al suggested that this difference between the sexes may be because the ratio of head mass to neck circumference is greater among females than for males. It was also suggested that the following factors affect predisposition to whiplash injury:

- sex
- age
- body build (sitting height)
- cervical spine arthritis
- seating position in vehicle
- position at moment of impact
- seat back failure
- vehicle crushability at rear

Cameron and Nelson (1977) identified seat belt wearing as a further factor. They analysed a file of detailed injury reports on vehicle occupant casualties killed or treated at hospital during 1971-73 in Victoria to determine the effect on injuries of seat belts as actually worn under compulsory wearing legislation. In rear end impacts, it was found that drivers and front left passengers more frequently sustained whiplash injury when wearing seat belts (predominantly lap/sash static type) than like occupants not wearing belts.

OTHER STUDIES OF HEAD RESTRAINT EFFECTIVENESS

There have been a number of studies aimed at evaluating head restraints installed under FMVSS 202, and two detailed reviews of these studies (Griffin, 1973; Comptroller General of the United States, 1976). Table II summarises the studies.

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All but the study by Fell (1972) concluded that head restraints had at least some small effect in reducing whiplash injuries. The data analysed by Fell (1972) and Garrett and Morris (1972) pertain to severe injury-producing accidents. It is possible that the effect of head restraints is less easily measurable in such data because an occupant who avoids a whiplash injury may not appear in the data file at all if he sustains no other injury.

Some of the studies indicated that head restraints may have been more effective for women than men. For example, O'Neill et al (1972) estimated that head restraints reduced the frequency of whiplash injuries in male drivers in rear-end impacts by 10 per cent, compared with a reduction of 22 per cent for women drivers.

Fell (1972) also considered possible disbenefits of head restraints in terms of facial injuries to rear occupants in frontal impacts. He concluded that injuries associated with contacts with head restraints were of comparable or lesser severity than those associated with contacts with the seat back or side interior. However, Griffin (1973) pointed out that if adjustable head restraints had more commonly been in an up position than was the case, then the steel bar supporting the head padding of such restraints may have presented more of a hazard to rear seat occupants.

In March 1974 an amendment to FMVSS 202 was proposed requiring head restraints to be of a certain minimum height (as per ADR 22A), but as of January 1976 this amendment had not been implemented (Comptroller General of the United States 1976) and it is understood that this remains the current situation. Huelke and O'Day (1975) recommended laboratory and field studies on neck injury mechanisms with high-back seats before concluding that fixed head restraints reduce the frequency of whiplash injury. They quoted O'Neill et al (1972) who found that, at least in one vehicle type, the incidence of whiplash injury was greater in the high-back than low-back seats.

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Table II: Summary of U.S. studies to evaluate the effect of head restraints on whiplash injuries (revised table from report by Comptroller General of the United States, 1976).

Date of report	Researchers, type of data, and location	Accident period included in sample	Sample size: Rear Impacted Cars	Sample size: Occupants	General conclusion
January 1972	Garrett and Morris				
	ACIR (Note a) files--31 States. Trilevel accident study files--western New York State.	1953-71 (only accidents involving 1960-71 model cars)	961	1,342	A decrease (unspecified) in the frequency of non-dangerous cervical injury
March 1972	O'Neill et al				
	Insurance claim files -- Los Angeles	Jan.-Sept. 1970 (only accidents involving 1966-70 model cars)	5,663	5,663 drivers	18% effective for drivers
December 1972	Fell				
	MDAI (Note b) files--various	1968-72	200	353	No apparent reduction in injuries
June 1973	States and Balcerak				
	Police accident reports supplemented by telephone interviews and mail questionnaires--Rochester, N.Y.	Jan.-Apr. 1972	769	906	14% effective
1973	McLean				
	Police accident reports in North Carolina supplemented by additional data and telephone interviews with occupants	Apr.-Aug. 1971	563	750	Appear to reduce the frequency and severity of injury in more severe rear end impacts
December 1973	Joksch				
	State of Texas accident records	1971-72	Not stated		Between 10 and 30%, most likely 15 to 20% effective

Table II: (Cont.d)

Note a) The ACIR (Automotive Crash Injury Research) file of about 85,000 injury-producing motor vehicle accidents was developed from a study conducted by the Cornell Aeronautical Laboratory, Inc. (Now Calspan, Inc.), in 31 participating States between 1953 and 1969. The trilevel files have been developed from a study in an eight-county area of western New York since 1969.

Note b) Multidisciplinary Accident Investigations, a major detailed accident and injury data file sponsored by the National Highway Traffic Safety Administration and the Motor Vehicle Manufacturers Association, covering a small number of accidents. Teams of specialists - including medical, legal, and engineering disciplines - make in-depth studies of selected accidents to obtain precrash, crash, and postcrash accident data on the occupant, the vehicle, and the environment.

Mackay (1975) commented that head restraints were not used in sufficient frequency in Europe to allow any statistical field studies of their value up to that time. However, Volvo (1973) found that in rear-end impacts to their own current-model cars (74 per cent with head restraints fitted) in Sweden in 1972, 16 per cent (20 out of 126) of occupants with head restraints had whiplash injuries compared with 35 per cent (16 out of 45) of occupants without head restraints. The net effectiveness (55 per cent reduction in whiplash frequency) was significant at the 5 per cent level.

DATA FOR THIS STUDY

The data on which this analysis was based were supplied by the Motor Accidents Board (MAB) in the form of a magnetic tape file covering 38088 claims for compensation related to accidents during the financial year 1974-75. The file was translated to be compatible with computer facilities used by the Road Safety and Traffic Authority and at the same time the fields shown in Appendix A were extracted.

Wessels (1978) gives details of the codes for each of the extracted fields as well as frequency distributions of each of the variables used in the analysis (see next chapter). Almost 14500 claims had information missing on one or more of the following variables : year of manufacture, date of birth, claimant type, type of accident, and point of impact. The bulk of these appeared to be claims which had been denied. Such claims were excluded from further consideration because the analysis required that all of the above missing fields should contain valid data (see next chapter).

Up to five injuries per claimant had been coded according to the 8th Revision of the International Classification of Diseases (ICD). When the present study was first designed, whiplash injuries were defined as:

- sprains and strains of other and unspecified parts of back (847)
  - : 847.0 Neck
  - : 847.8 Other
  - : 847.9 Unspecified
- other, multiple, and ill-defined dislocations (839)
  - : 839.0 Cervical vertebra, simple
  - : 839.1 " " compound.

However, it was established in a preliminary study (Wessels 1978) that in the MAB data the fourth digit (the decimal point subcategory) was very infrequently used. Hence, it was not possible to distinguish between decimal sub-categories and these were combined to form a three digit injury code.

The following largely non-whiplash injuries, were thus included with, and counted as, whiplash injuries:

- 839.5 Other location, simple

Coccyx	Spine, except cervical
Pelvis	Sternum
Sacro-iliac (joint)	Trachea
Sacrum	Vertebra, except cervical

- 839.6 Other location, compound

- 839.7 Multiple and ill-defined, simple

Arm	Other ill-defined locations
Back	Unspecified location
Hand	Multiple locations, except fingers alone and toes alone.

- 839.8 Multiple and ill-defined, compound

- 839.9 Late effect, cervical vertebra or other.

However, according to a senior data coder at MAB, these injuries would have accounted for at most 20% of the injuries in category 839. Unfortunately, there was insufficient time to test this claim by, say, checking a sample of the data. The other category used to code whiplash injuries, 847, contained only whiplash injuries. Since April 1977 it has been the policy of the MAB to classify all whiplash injuries as 847; however, when the data used in the present study were collected, whiplash injuries were apparently somewhat indiscriminately coded as either 839 or 847. It was therefore necessary to combine 839 and 847 and treat them together as whiplash injuries.

When invited to comment on a draft of this report, MAB supplied details of their own investigation of the errors and omissions of data during the transfer of information from claim forms and medical accounts to computer files (Appendix A). The investigation related only to "in-coverage" claims (fatalities, and claims for at least $100 total cost) from accidents which occurred late in 1977, but it was considered that the error rates measured would be lower than those in 1974-75. Thus there may have been considerable errors and omissions in the data analysed here. The authors were conscious of this possibility when the study was designed and accordingly developed a study design to minimize the risk of invalid conclusions (see next chapter). The method used was to limit the analysis to internal comparisons of the injuries of groups of claimants in the same data set; there was no evidence that the error rates differed between the groups compared. However, the poor quality of the data, if this was the case, may have severely weakened the analysis and the resulting conclusions.

The lack of two key variables in the MAB supplied data also severely limited the effectiveness of the analysis and the strength of the conclusions which followed. These variables were seat belt wearing and impact severity. Cameron and Nelson (1977) showed that seat belt wearing had an effect on whiplash injuries. Thus belt wearing should be controlled in any comparison of injuries to occupants with and without head restraints. It is also possible that the effect of head restraints may be different for occupants wearing seat belts compared with those who do not. Furthermore, McLean (1973) showed that whiplash injuries are more frequent in severe rear-end impacts. McLean's results also indicated that head restraints may only be effective in severe rear-end impacts. On the question of impact severity, urban/rural location of accident (at least) should have been available, but this field was blank in all records of the data file supplied (Appendix A).

STUDY DESIGN

APPROACH

The basic approach was to compare the frequencies of whiplash (potential reduction) and head and facial injuries (potential increases) of vehicle occupants exposed to head restraints with those of similar occupants not exposed. "Exposed" was taken to mean front outboard seat occupants of head restraint-equipped vehicles involved in rear-end impacts, or rear seat occupants involved in frontal impacts while occupying vehicles with head restraints fitted to the front seats.

VEHICLES WITH HEAD RESTRAINTS

Sedans and station wagons (so-called "private" vehicles) were the largest definable group of vehicles in the MAB file to which ADR 22/22A was clearly applicable. Occupants of these cars manufactured in the years 1972 onwards were taken as potentially exposed to head restraints. Year of manufacture in the MAB file was obtained from Motor Registration Branch records as part of the procedure for ensuring claim eligibility.

Some manufacturers fitted head restraints prior to the mandated date (1 January 1972), as part of a change in model run. Appendix C indicates that this practice did not cause severe contamination (head restraint fitted) of pre-1972 cars and essentially did not extend back beyond 1971 models. Accordingly, pre-1972 cars were taken as having no head restraints for the bulk of the analysis. However, for some critical analyses, the contaminated 1971 models were excluded from the no head restraint group.

Consideration was also given to separating the ADR 22/22A cars into those with adjustable and those with fixed head restraints. However, the limited information on private vehicle type (make, body type, number of cylinders, and year of manufacture) in the MAB file prevented this. There were also insufficient 1975 cars in the file (1974-75 claims) to enable a separate evaluation of ADR 22A.

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OTHER RELEVANT AUSTRALIAN DESIGN RULES

A number of other ADRs aimed at reducing injuries came into effect at the same time or within a year of ADR 22:

2. Door Latches and Hinges (1 January 1971)
3. Seat Anchorages (1 January 1971)
4. Seat Belts - Rear Seats (1 January 1971)
8. (Windscreen) Safety Glass (1 July 1971)
10A. Steering Columns (1 January 1971)
10B. Steering Columns (1 January 1973)
11. (Padded) Sun Visors (1 January 1972)
14. (Breakaway) Rear Vision Mirrors (1 January 1972)
21. Instrument Panels (1 January 1973)

The effect of these design rules may have contaminated the effect of ADR 22. Most of these design rules were aimed at reducing injuries to front seat occupants in frontal impacts, or preventing ejection of occupants whose vehicles rolled-over or spun. Fortunately, such occupants and crash circumstances are not those for whom head restraints may have a benefit (or disbenefit, e.g. rear occupants in frontal impacts). However, such occupant-crash combinations could not be considered as control occupants either (see next section).

The two exceptions were ADR 3 (Seat Anchorages) and ADR 4 (Seat Belts - Rear Seats). The first design rule was intended, amongst other things, to make seat backs stronger and this could have affected whiplash injuries in rear impacts (States et al, 1972). However, it is understood that ADR 3 in general only formalised current practice and represented no real design change. ADR 4 required that cars manufactured as from 1 January 1971 should have, in addition to the front seats, seat belts fitted in the rear seats (lap/sash type in the outboard seating positions). While Boughton, Cameron and Milne (1978) have shown that the wearing rate of fitted belts in rear seats was low in December 1975 (26 to 48 per cent), the effect of head restraints on injuries to rear seat passengers involved in frontal impacts may have been contaminated by increased seat belt use in the ADR 22 cars.

CONTROL OCCUPANTS FOR IMPACT SEVERITY

Because impact severity could not be controlled in the analysis, it was decided to consider also the injuries of a control group of occupants in ADR 22 cars compared with those in pre-ADR22 cars. These control occupants and their crash circumstances were chosen such that neither ADR 22 nor any other ADR coming into effect at or about the same time (see previous section) would be relevant to their injuries. Then any differences in their injuries in ADR 22 cars compared with pre-ADR 22 cars would be a measure of differences in impact severity.

The control occupants chosen were:

- rear occupants in rear-end impacts, and
- occupants in side impacts to the passenger compartment.

Clearly the first of these was a potentially better control group because it related to the same crash circumstances (rear-end impacts) in which any potential benefit of head restraints was likely to appear. However, it was recognised that rear-end impacts were relatively rare crashes and rear seat occupancy was also relatively rare. (This fact prevented a more rigorous study design in which consideration of the injuries of front seat occupants in rear-end impacts is limited to those accompanied by rear seat passengers.) The availability of seat belts in the rear seats of ADR 22 cars due to ADR 4 (see previous section) compared with relatively few of the pre-ADR 22 cars may also have affected the injuries of rear seat passengers in rear-end impacts. Hence, side impacts to the passenger compartment were also considered, but it was recognised that any differences in injuries would measure only differences in the crash severity environments (e.g., urban/rural) of ADR 22 cars compared with pre-ADR 22 cars.

It was not possible to define a group of control occupants for frontal impacts. Injuries to front seat occupants in frontal impacts were potentially affected by at least ADRs 8, 10A, 10B, 11, 14 and 21 (see previous section) which came into effect at or about the same time as ADR 22.

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ANALYSIS

CRITERION VARIABLES

The criterion variables were the separate proportions of (a) whiplash (b) head (c) facial injuries sustained by claimants in the financial year 1974-75. The proportions that these injuries represented of total injuries were calculated for the occupants of passenger cars and station wagons manufactured in (1) 1969-71 versus those manufactured in (2) 1972-74.

This choice of criterion variables was made necessary by the absence of information on uninjured occupants in the data file and the lack of such information from other sources. The criterion variables suffer by including the criterion injuries in both their numerator and denominator. Thus they would lack sensitivity to any change to the risk of sustaining one of the criterion injuries in crashes of a given severity. For example, if the proportion of all injuries which were whiplash was 0.5 (approximately correct for front outboard seat occupants in rear-end impacts - see Results chapter) and the risk of whiplash injury was reduced by 50 per cent, then we would expect to find the proportion of injuries which were whiplash reduced by only 33.3 per cent. The lack of sensitivity is less critical for injuries which represent only a small proportion of the total.

The criterion injuries were defined in terms of the 8th Revision of the International Classification of Diseases; Chapter NXVII, Accidents, Poisonings and Violence. This injury coding system is summarised in Appendix B. The definitions of the criterion injuries are given in Table III.

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CONTROL FOR SEAT BELT WEARING

To attempt to cope with the absence of seat belt wearing information in the MAB file, the pre-ADR 22 cars in the study were restricted to those manufactured in 1969 and later, since these vehicles should have had lap/sash seat belts fitted to the front outboard seating positions, under ADR 4. Consideration was given to relaxing the restriction on the pre-ADR 22 cars to those manufactured in 1965 and later, since under the Victorian seat belt retro-fitting legislation (effective from February 1974), lap/sash seat belts were required to be fitted to the front outboard seating positions of all cars manufactured between October 1964 and December 1968. However, Boughton and Cameron (1978) showed that this legislation had had only a small effect as at December 1975. It had not resulted in 100 per cent fitting to the front outboard seats.

Thus, all drivers and front left passengers (in both ADR 22 and pre-ADR 22 cars) in the study should have had lap/sash seat belts fitted to their seating positions and, of course, provided they were aged 8 or more, they were equally obliged to wear those belts under the compulsory seat belt wearing legislation.

CONTROLS FOR INJURY SUSCEPTIBILITY

States et al (1972) listed a number of human variables which they suggested may affect susceptibility to whiplash injury. Two were available in the MAB file:

- sex
- age (derived from birthdate and accident date).

An imbalance of either or both of these factors among occupants of ADR 22 cars compared with pre-ADR 22 cars could have invalidated the evaluation of the effect of head restraints. It was planned to consider the sex and age distributions of the occupants of each seating position in the two groups of cars and, if the distribution were significantly different, to control for the offending variable (e.g., sex) by partitioning the analysis according to the variable (e.g. treating male and female occupants separately).

Table III Definition of the criterion variables: (a) whiplash (b) head (c) facial injuries.

(a) Whiplash Injuries

. Whiplash (minor neck injury only)
- sprains and strains of other and unspecified parts of back: 847
- other, multiple, and ill-defined dislocations: 839.

. Major neck injury
- fracture and fracture dislocation of vertebral column without mention of spinal cord lesion: 805
- fracture and fracture dislocation of vertebral column with spinal cord lesion: 806.

(b) Head Injuries

. Skull fracture
- fracture of vault of skull: 800
- fracture of base of skull: 801
- other and unqualified skull fracture: 803.

. Concussion: 850.

. Major intracranial
- Cerebral laceration and contusion: 851
- Subarachnoid subdural and intradural haemorrhage, following injury (without mention of cerebral laceration or contusion): 852
- Other and unspecified intracranial haemorrhage following injury (without mention of cerebral laceration or contusion): 853
- Intracranial injury of other and unspecified nature: 854

(c) Facial Injuries

. Major facial
- Open wound of eye and orbit: 870
- Enucleation of eye: 871
- Open wound of ear: 872
- Fracture of face bones: 802
- Multiple fractures involving skull or face with other bones: 804
- Dislocation of the jaw: 830.

. Other and unspecified laceration of the head: 873.

. Minor facial
  - Superficial injury of face, neck and scalp: 910
  - Contusion of face, scalp, neck (except eye): 920
  - Contusion of eye and orbit: 921
  - Injury to optic nerve(s): 950
  - Injury to other cranial nerve(s): 951.

CRASH TYPES CONSIDERED

Crash types were defined in terms of a classification system for (1) point of impact and (2) Road User Movement (RUM) code. The former was developed by the Motor Accidents Board (MAB) and the latter by the Victorian Road Safety and Traffic Authority (RoSTA). These classification systems are described in Appendix D.

Injuries resulting from three different types of crash situations were considered:

(a) REAR END IMPACTS: accident type is rear end (RUM's 33, 35 37, 51, 52, 53) and point of impact is at rear (Code 5)

(b) SIDE IMPACTS: accident type is right angle collision (RUM 21) and point of impact is passenger cabin (Codes 3 & 7); and

(c) FRONT END IMPACTS: accident type is front end (RUM's 21, 22, 31, 33, 35, 36, 37, 51 to 57, 59, 61, 72, 74, 77, 82, 84, 85, 88, 89, 92, 97) point of impact is at front (Code 1).

SUBJECT GROUPS INVESTIGATED

(1) Front outboard occupants in crash type (a).
Purpose: (i) to investigate possible reduction in whiplash injuries and (ii) to investigate possible disbenefits in terms of facial and head injuries.

(2) Rear passenger in crash type (a). Purpose: (i) to investigate possible disbenefits in terms of facial and head injuries; and (ii) as a control group for impact severity.

(3) Front outboard occupants in crash type (b).
Purpose: as a control group for impact severity.

(4) Rear Passengers in crash type (c). Purpose: to investigate possible disbenefits of facial and head injuries.

STATISTICAL TEST METHODS

The statistical significance of the changes in frequency of the target injuries were tested by the 2 x 2 Chi-square test of independence. For each type of crash, the frequency of each specific injury type was always compared with the total number of all injuries for that crash situation.

In the case of whiplash injuries in rear end impacts a one directional, i.e. a one-tailed statistical test, was used. That is, it was assumed that head restraints would not have a negative effect on the incidence of whiplash injuries in rear end impacts. In all other cases a two-tailed Chi-square test of significance was used.

The statistical significance of the possible effect of the controlling variables sex and age (3 levels) was tested using 2 x 2 and 3 x 2 Chi-square tests, respectively.

ACCIDENT PERIOD

The beginning and end of the accident period could have been arbitrarily chosen, as long as the data had been recorded in a consistent way throughout the period. It was understood that in the period from 12 February 1974 up to June 1974 the data coding systems were still being refined. After June 1974 the system stabilised, especially the coding of injury data. When the study was originally designed in 1975, it was thought that the financial year 1974-75 would be the best choice for the accident period. It is the data of this financial year which the MAB supplied to RoSTA and on which the study was based.

Unfortunately, this choice of accident period excluded the possibility of evaluating ADR 22A, which was instituted on 1 January 1975, separately. The data included too few injured occupants of vehicles manufactured after this date: 15, 4, 41, respectively, for rear end, right angle side and front end impacts. It was decided to exclude from the present study the vehicles manufactured after 1 January 1975.

RESULTS

NUMBER OF INJURED OCCUPANTS (SUMMARY)

The number of MAB claimants in 1974-75 occupying passenger cars and station wagons manufactured in 1969-74 involved in rear end, front end and right angle side impacts, are given in Tables IV, V and VI, respectively.

Table IV Number of injured occupants by sex and seating position in rear end impacts.

	Driver	Centre Front	Left Front	Rear	Unknown	Total
Male	353	8	63	54	1	479
Female	286	18	252	122	2	680
Total	639	26	315	176	3	1159

Table V Number of injured occupants by sex and seating position in front end impacts.

	Driver	Centre Front	Left Front	Rear	Unknown	Total
Male	848	23	269	182	12	1334
Female	364	41	499	258	6	1168
Total	1212	64	768	440	18	2502

Table VI Number of injured occupants by sex end seating position in right angle side impacts (nearside and offside combined)

	Driver	Centre Front	Left Front	Rear	Unknown	Total
Male	152	-	43	43	4	242
Female	105	10	112	76	-	303
Total	257	10	155	119	4	545

As can be seen from Table VII, approximately twice as many persons were injured in vehicles impacted in the front than those impacted in the rear. The number of injured occupants in right angle offside and nearside impacts combined were again approximately half as many as those in rear impacts. The pattern of the distribution of the number of injured persons across the different seat positions were consistent across the four types of impacts.

Table VII Frequency percentage distribution of injured persons by seating position and type of impact for occupants of passenger cars and station wagons manufactured in 1969-74.

Type of Impact	Seating Position					
	Driver	Centre Front	Left Front	Rear	Unknown	All seats Combined
Rear end	15.2	0.6	7.5	4.2	0.1	27.6
Front end	28.8	1.5	18.3	10.5	0.4	59.5
Right angle offside	2.5	0.1	1.2	1.0	0.0	4.8
Right angle nearside	3.6	0.2	2.5	1.8	0.1	8.2
All impacts combined	50.1	2.3	29.5	17.5	0.6	(N=4206)

REAR END IMPACTS

The detailed frequencies of the criterion injuries in rear end impacts are given in Appendix E. In Table VIII results for male and female occupants are combined.

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Table VIII REAR END IMPACTS:

Criterion injuries as a percentage of all injuries (column percentages) for occupants of private vehicles manufactured in (1) 1969-71 versus those manufactured in (2) 1972-74.

	Drivers *(N=639)		Front Centre (N=26)		Front Left (N=315)		Rear (N=176)		Unknown (N=3)		Total (N=1161)	
	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
Whiplash	48.7	47.8	16.7	36.4	48.0	39.9	29.8	24.4	-	-	44.3	41.
Major neck injury	0.3	-	-	-	-	-	-	-	-	-	0.1	-
Head Injuries**	11.5	11.5	8.3	27.3	13.2	10.4	23.4	16.7	-	-	13.9	12.:
Total all other injuries	39.5	40.7	75.0	36.4	38.7	49.7	46.8	58.9	100.0	100.0	41.7	46.(
Total injuries	390	339	24	11	204	163	124	90	1	2	743	605

* N = number of injured occupants.

** Head, facial and skull injuries.

Table IX REAR END IMPACTS:

Whiplash injuries (major and minor combined) as a percentage of all injuries.

	Year of manufacture			
	1971	1969-70	1969-71	1972-74
Drivers	48.2%	49.4%	49.0%	47.8%
Front Left passengers	46.4%	48.9%	48.0%	39.9%

1. Whiplash Injuries

The reduction in the proportion of whiplash injuries (major and minor combined) for drivers, from 49% to 47.8%, was not significant. For front left passengers the reduction in whiplash injuries from 48% to 39.9% approached statistical significance ($p < 0.1$ with a one tailed Chi-square test).

2. Whiplash Injuries when Vehicles Manufactured in 1971 were Excluded

A small proportion of vehicles manufactured in 1971 were fitted with head restraints. When vehicles manufactured in 1971 were excluded, there were larger reductions in the percentage of whiplash injuries. The proportion of whiplash injuries for occupants of vehicles manufactured in 1969-70 was higher than those of vehicles manufactured in 1971 for both the front outboard seats (Table IX).

3. Head Injuries to Front Seat Occupants

As can be seen from Table VIII there was no overall head injury disbenefit due to the fitting of head restraints either for drivers or front left passengers.

An increase in concussion from 2.0% to 3.0% and skull fracture from 0% to 0.2% for the occupants of the two outboard front seats combined, was not statistically significant (Table E7, Appendix E). There was a decrease for every other type of head injury for occupants of these two seat positions combined.

The increase in the proportion of head injuries for front centre passengers (Table VIII) was not statistically significant. It should be noted that there were so few centre front passengers that the test of significance may not be meaningful.

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4. Facial Injuries to Rear Seat Passengers

There was a decrease in the proportion of total head injuries for rear seat passengers. Only one head region injury increased: Minor facial injuries, from 5.6% to 7.8%; this change was not significant. When major and minor facial injuries were combined, the increase in facial injuries was reduced: 7.2% to 7.8% (Table B6, Appendix E).

5. Rear Seat Passengers as a Control for Impact Severity

The difference in the proportion of whiplash injuries for rear seat passengers in rear end impacts (Table VIII), was not statistically significant. This indicated that the severity of impact in rear end accidents for early and late model vehicles were comparable.

FRONT END IMPACTS

The detailed frequencies of the criterion injuries in front end impacts are given in Appendix F. In Table X results for male and female occupants are combined.

1. Whiplash Injuries

There was an increase in the proportion of whiplash injuries (major and minor combined) for drivers from 8.2% to 12.4% and for front left passengers from 8.0% to 11.0%. The former result was statistically significant ($p < 0.01$), whilst the latter was not.

2. Head Injuries to Front Seat Occupants

The changes in overall head injuries were not significant: an increase for drivers and front centre passengers and a decrease for front left passengers.

For the types of head injuries most likely to be affected by head restraints: (1) concussion, (2) major intracranial injury and (3) skull fracture; the results were as follows:

Drivers: an increase in all three categories; however, only the change in (2) was significant ($p < 0.05$). (Entries 2a, 2b, 2c of Table F4).

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Front left passengers: a non-significant increase in (1), a non-significant decrease in (2), and (3) unchanged. (Entries 2a, 2b, 2c of Table F5).

3. Facial Injuries to Rear Seat Passengers

For rear seat passengers there was a decrease in every category of head-facial-skull injuries, except concussion (unchanged), and minor facial injury (a non-significant increase) (Table F6).

Table X. FRONT END IMPACTS:

Criterion injuries as a percentage of all injuries (column percentages) for occupants of private vehicles manufactured in (1) 1969-71 versus those manufactured in (2) 1972-74.

	Drivers (N=1216)		Front Centre (N=64)		Front Left (N=770)		Rear (N=440)		Unknown (N=18)		Total (N=2508)	
	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
Whiplash	7.9	12.1	3.4	12.9	7.4	9.6	3.1	5.5	-	-	6.7	10.1
Major neck injury	0.2	0.3	-	-	0.6	1.3	0.7	0.7	-	-	0.4	0.6
Head Injuries	23.5	24.4	22.4	22.6	25.3	19.3	33.8	26.5	33.3	33.3	25.4	23.3
Total all other injuries	68.3	63.2	74.1	64.5	66.7	69.7	62.5	67.3	66.7	66.7	67.5	65.9
Total injuries	807	783	58	31	538	456	293	272	6	12	1705	1554

Table XI. RIGHT ANGLE SIDE IMPACTS:

Target injuries as a percentage of all injuries (column percentages) for occupants of private vehicles manufactured in (1), 1969-71 versus those manufactured in (2), 1972-74.

	Drivers (N= 257)		Front Centre (N=10)		Front Left (N=155)		Rear (N=119)		Unknown (N=4)		Total (N=545)	
	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
Whiplash	10.2	10.3	-	-	4.9	3.0	6.3	2.5	33.3	-	7.7	6.2
Major neck injury	0.5	-	-	-	-	-	-	-	-	-	0.2	-
Head Injuries	21.4	15.4	16.7	25.0	15.6	17.2	25.0	32.9	66.7	50.0	20.6	20.3
Total all other injuries	67.9	74.4	83.3	75.0	79.5	79.8	68.8	64.6	-	50.0	71.4	73.5
Total injuries	196	156	12	4	122	99	80	79	3	2	413	340

RIGHT ANGLE SIDE IMPACTS

The detailed frequencies of the criterion injuries in right angle side impacts are given in Appendix G. In Table XI results for male and female occupants are combined.

Head Injuries

The increases in the proportions of head injuries for front left and rear passengers (Table XI) were not statistically significant. Also the decrease in head injuries for drivers was not statistically significant. There were too few head injuries for centre front occupants to carry out meaningful tests of statistical significance. For the combination of driver, front left, and rear seat occupants, the proportion of head injuries for early and late model vehicles was essentially equal : 20.4 and 20.7 per cent, respectively.

NEED FOR CONTROLLED ANALYSIS OF REAR END IMPACTS

1. Age of occupants

For the driver and front left seating positions, there was no association between the age of the injured occupants and the early and late model vehicle groups. However, for the rear seat passengers the older vehicles had a larger percentage of injured occupants under 16 years of age (57.7%) than the later model vehicles (36.9%). This difference was statistically significant ($p < 0.01$).

Even though age was not uniformly distributed for rear seat passengers the subsequent analysis was not controlled for age.

2. Sex of occupants

For all seat positions combined, there was a larger number of female than male injured occupants. However this distribution was not uniform for the different seat positions: males were more likely to be drivers, whilst females were more likely to be passengers (Table XIII).

Drivers of the later model cars were also more likely to be male than drivers of early model vehicles (Table XIV) and this result was statistically significant ($p < 0.01$). For front left passengers, there was no association between sex and year of manufacture. Finally, rear passengers were more likely to be females in late than early model vehicles ($p < 0.05$).

The interaction between sex of occupant, seat position and vehicle year of manufacture required that sex be controlled for in the subsequent analysis.

Table XII REAR END IMPACTS:

Number of injured occupants in each age group for (1) earlier model vehicles 1969-71 and (2) later model vehicles 1972-74. (Column percentages in brackets).

	Drivers		Front Left		Rear		Total	
	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
Less than 8 years	3* (0.9)	3* (1.0)	6 (3.3)	5 (3.7)	35 (33.7)	12 (16.4)	44 (7.1)	20 (3.9)
8 thru 16 years	-	-	14 (7.8)	7 (2.7)	25 (24.0)	15 (20.5)	39 (6.3)	22 (4.3)
17 thru 49 years	252 (74.3)	237 (79.0)	122 (67.8)	91 (66.9)	28 (26.9)	33 (45.2)	402 (64.5)	361 (70.9)
50 thru 99 years	84 (24.8)	59 (19.7)	36 (20.0)	33 (24.3)	13 (12.5)	13 (17.8)	133 (21.3)	105 (20.6)
Age Unknown	-	1 (0.3)	2 (1.1)	-	3 (2.9)	-	5 (0.8)	1 (0.2)
TOTAL	339	300	180	136	104	73	623	509

* These cases may be due to miscodings of claiment type and/or date of birth.

Table XIII REAR END IMPACTS: Sex distribution by seating position (column percentages)

	Drivers	Centre Front	Left Front	Rear	Unknown	Total
Male	55.2	30.8	20.0	30.7	33.3	41.3
Female	44.8	69.2	80.0	69.3	66.7	58.7
TOTAL	639	26	315	176	3	1159

TABLE XIV REAR END IMPACTS: Sex distribution by seating position for (1) earlier model vehicles 1969-71 and (2) later model vehicles 1972-74.

	Drivers		Front Left		Rear		Total	
	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
Male	50.1	61.0	19.6	20.6	36.5	22.2	39.1	44.7
Female	49.9	39.0	80.4	79.4	63.5	77.8	60.9	55.3
TOTAL*	339	300	179	136	104	72	622	508

* TOTAL = Total number of injured occupants.

CONTROLLED ANALYSIS OF REAR END IMPACTS

In Tables XV to XVII (below) the major and minor neck injuries of the tables of Appendix E were combined. There was only one major neck injury in rear end impact accidents (Table E1).

1. Whiplash Injuries

There was a reduction in the proportion of whiplash injuries for male drivers but not for female drivers (Table XV). Neither of these results was statistically significant.

Table XV REAR END IMPACTS : Criterion injuries as a percentage of all injuries (column percentages) for drivers of private vehicles.

	Male		Female	
	1969-71 (N=170)	1972-74 (N=183)	1969-71 (N=169)	1972-74 (N=117)
Whiplash	48.7	45.5	49.2	51.1
Head Injuries*	12.8	12.0	10.3	10.8
Total of all other injuries	38.5	42.5	40.5	38.1
Total injuries	195	200	195	139

For the front left seat there was a reduction for both male and female occupants in the proportion of whiplash injuries (Table XVI). The decrease in the proportion of whiplash injuries to females from 51.6% to 41.7% was statistically significant ($p < 0.05$).

Table XVI REAR END IMPACTS : Criterion injuries as a percentage of all injuries (column percentages) for front left passengers of private vehicles.

	Male		Female	
	1969-71 (N=35)	1972-74 (N=28)	1969-71 (N=144)	1972-74 (N=108)
Whiplash	34.9	32.3	51.6	41.7
Head injuries	18.6	16.1	11.8	9.1
Total of all other injuries	46.5	51.6	36.6	49.2
Total injuries	43	31	161	132

2. Head Injuries to Front Seat Occupants

As can be seen from Tables XV and XVI there was no overall head injury disbenefit due to the fitting of head restraints either for drivers or front left passengers. The small increase in head injuries for female drivers from 10.3% to 10.8%, was due to an increase in concussion from 4 to 5 or 2.1% to 3.6% of all injuries. This increase was not statistically significant.

3. Rear Seat Passengers as a Control for Impact Severity

The trend in whiplash injuries for rear passengers was an increase for male occupants and a decrease for female occupants (Table XVII); neither change was statistically significant. Thus it would seem reasonable to assume that the severity of impact in rear end accidents was comparable for early model vehicles (1969-71) and late model vehicles (1972-74).

Table XVII REAR END IMPACTS : Criterion injuries as a percentage of all injuries (column percentages) for rear passengers of private vehicles.

	Male		Female	
	1969-71 (N=38)	1972-74 (N=16)	1969-71 (N=66)	1972-74 (N=56)
Whiplash	23.9	25.0	33.3	24.3
Head Injuries	34.8	25.0	16.7	14.3
Total of all other injuries	41.3	50.0	50.0	61.4
Total injuries	46	20	78	70

DISCUSSION

The evidence for an effect of ADR 22 in terms of reducing whiplash injuries sustained in rear end impacts appears to be weak. There was no evidence for a reduction in whiplash injuries to drivers and only weak evidence of such a reduction when front left passengers of all types were considered. When the pre-ADR 22 group of cars was purified by excluding 1971 model vehicles (a small proportion of which were fitted with head restraints), the results were substantially unchanged.

However, drivers injured in rear end impacts to ADR 22 cars were more likely to be male compared with pre-ADR 22 cars. When sex of driver was controlled, there was still no evidence for a reduction in whiplash injuries to either sex. In contrast, among front left passengers (of whom 80% were female), the reduction in the proportion of whiplash injuries when ADR 22 cars were compared with pre-ADR 22 cars was statistically significant for female passengers but not for males. Thus, there was evidence for an effect of ADR 22 on whiplash injuries in rear end impacts among female front left passengers only. This finding seemed inconsistent with (a) the non-significant increase in the proportion of whiplash injuries to female drivers involved in rear end impacts (who exceeded in number the female front left passengers in rear end impacts) and (b) roadside survey results indicating that female drivers and front left passengers were approximately equally protected by their head restraints (Table I).

There was no evidence that ADR 22 cars were involved in more or less severe rear end impacts than pre-ADR 22 cars. The reduction in the proportion of whiplash injuries to rear seat occupants (to whose seats ADR 22 did not apply) of ADR 22 cars in rear end impacts compared with like occupants of pre-ADR 22 cars was not statistically significant. However, the rear seat occupants of the ADR 22 cars were more likely to be female and were older compared with the pre-ADR 22 cars. They were also more likely to have had a seat belt available. When sex of rear seat occupant was controlled, the above result was substantially unchanged.

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Furthermore, differences in the proportions of head injuries sustained by front outboard seat occupants involved in right angle side impacts to ADR 22 cars compared with pre-ADR 22 cars were not statistically significant. Hence, there was no evidence that pre- and post-ADR 22 cars were involved in crashes in different crash severity environments.

There was some evidence of disbenefits in cars with ADR 22, though not in the crash circumstances originally hypothesized. There was no evidence for an increase in head or facial injuries to rear seat passengers when ADR 22 cars were compared with pre-ADR 22 cars, neither for front end nor rear end impacts. Similarly, there was no evidence for an increase in head injuries to drivers and front left passengers involved in rear end impacts. However, there was evidence of disbenefits to drivers of ADR 22 cars involved in front end impacts. Such drivers sustained statistically significant greater proportions of whiplash and major intracranial injuries than like drivers of pre-ADR 22 cars. However, it was not possible to test directly whether these two groups of drivers were involved in crashes of equal severity.

Cameron (1979) observed a related result in a study of the effect of ADRs 10A and 10B for steering columns. These ADRs applied to cars manufactured in 1971 or later years. Thus there was considerable correlation between ADR 22 and ADR 10A/B in terms of date of implementation. Cameron found that the severity of head injury (skull or intracranial injury, but not facial injury) of non-ejected drivers who contacted steering assemblies in frontal impacts was greater than expected in ADR 10A/B cars, especially in small cars and for female and belted drivers (who tended to be one and the same group of drivers). There is no evidence that the increases in the frequency and/or severity of head injury to drivers were due to ADR 10A/B or ADR 22 or any other particular vehicle design change at the time.

Apart from the one or two unexpected results (see discussion in penultimate paragraph above), there was no evidence that the MAB supplied data were sufficiently lacking in quality to produce erroneous conclusions.

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The absence from the MAB data of information on (a) crash severity and (b) seat belt wearing has limited the conclusions from this study to being suggestive, not definitive. We have attempted to overcome the above deficiencies by (a) additionally considering changes in the injuries to 'control' occupants, as a proxy for differences in crash severity, and (b) limiting the study to occupants of cars with seat belts fitted in the front outboard seats (when first registered). While there was no evidence that ADR 22 cars were involved in crashes of different severity to pre-ADR 22 cars, we consider that the method of control occupants is a poor way of measuring such a difference. As far as seat belt wearing is concerned, we do not know whether limiting the study to cars with belts fitted was successful in controlling this variable, but the restriction on the data did have the unfortunate effect of eliminating a large amount of information on injuries in pre-ADR 22 cars.

The absence of crash severity information from any injury-based road accident data system may severely limit the inferences which can be derived from that system. If, at a given level of crash severity, a countermeasure (e.g. head restraints) is effective in reducing the probability of a particular injury (e.g. whiplash) and the injury frequently occurs alone in the crash circumstances (e.g. whiplash in rear end impacts), then car occupants successfully protected by the countermeasure may not appear among accident data which have personal injury as the criterion for selection. Thus, the proportion of injured occupants who sustained the particular injury would lack sensitivity to the effect of the countermeasure when injured occupants who had the countermeasure available are compared with those who did not. If, however, a measure of crash severity was available in the data, then car occupants sustaining the particular injury in the presence of the countermeasure (assumed effective) would have been involved in more severe crashes than like occupants without the countermeasure available.

CONCLUSIONS

1. There is weak evidence that ADR 22 is effective in reducing whiplash injuries sustained in rear end impacts. The effect appears to be almost entirely confined to benefitting only female occupants of front left passenger seats.

2. There is no evidence of disbenefits due to head restraints installed under ADR 22 in terms of head or facial injuries to rear seat passengers. However, there is evidence that drivers involved in front end impacts are more likely to sustain whiplash and major intracranial injuries in ADR 22 cars compared with pre-ADR 22 cars.

3. The absence from the MAB data of information on crash severity and seat belt wearing limits the above conclusions to being suggestive, not definitive.

RECOMMENDATIONS

It is suggested that consideration be given to implementing the following recommendations which have derived from this study.

1. Data on MAB claims in a more recent period should be analysed in a similar manner to this study to determine the effectiveness of ADR 22A (which applied to vehicles manufactured on and after 1 January 1975). ADR 22A now supercedes ADR 22 and specifies a minimum height for head restraints, which may alter their effectiveness. It was not possible to separately evaluate those ADR 22 head restraints which were not capable of being adjusted below a minimum height.

2. Data from the Royal Australasian College of Surgeons' Pattern of Injury Survey should be analysed to determine the role of seat belt wearing on the effectiveness of ADR 22. A matched file of reports on injuries and crash circumstances of car occupants who were killed or hospitalised in Victoria in the period June 1971 to May 1974 is available. These data relate to more severe injuries than the MAB data, but whiplash injuries were not uncommon (12%) among front outboard seat occupants involved in rear end impacts.

3. Procedures to collect information on seat belt wearing at the time of the crashes reported by MAB claimants should be investigated. Seat belt wearing is known to have a major effect on the probability and pattern of injury and its absence from the MAB data limits the inferences which can be derived from these data. It is acknowledged that, under compulsory seat belt wearing legislation, claimants for injury compensation from official bodies may not supply accurate information in this regard. The use of randomized response techniques (Warner, 1965), which would allow claimants to retain the privacy of information regarding seat belt use, could profitably be explored.

4. Procedures to collect information on crash severity of MAB claims should be investigated. The absence of crash severity information also limits inferences from MAB claims data.

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Realistically, appropriate measures of crash severity obtainable for all claims might range from vehicle damage value to crude measurements of vehicle deformation. Ideally, velocity change of the passenger compartment is the desired measure of crash severity. This latter measure is derived from accurate vehicle deformations and other parameters which are not easily measured by unskilled personnel. Such detailed crash severity measurements might be feasibly obtainable only for a sample of MAB claims defined, for example, geographically and by injury severity requiring immediate medical treatment.

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APPENDIX A

DATA EXTRACTED FROM MAB CLAIMS FILE FOR 1974-75

TABLE A1: Fields extracted from ICL-format version of MAB 1974-75 claims file for translation to CDC-format version.

	Field	Comment
1.	Claim number	
2.	Injury codes	Up to 5 injuries coded in ICD (8th Revision) system
3.	Date of accident	
4.	Location of accident	Blank in all records
5.	Closed claim indicator	
6.	Close reason	
7.	Driver code	Indicates whether valid driver.
8.	Owner code	Blank in all records
9.	Year of manufacture of vehicle	
10.	Vehicle type	Vehicle type (and no. of cylinders of private vehicles) and make
11.	Insurance class and district	
12.	Date of Birth	
13.	Sex	
14.	Injury codes	Duplicate of field 2 (not apparent at time of tape translation)
15.	Claimant type	Includes seating position
16.	Period licence held	
17.	Type of accident	RoSTA Road User Movement codes (RUM)
18.	Point of impact	
19.	Vehicle Registration no.	
20.	Police accident report no.	If accident was reported
21.	Blood alcohol level	Blank in all records
22.	Total amount paid to claimant	

MOTOR ACCIDENTS BOARD

Please address all correspondence to the
General Manager, Motor Accidents Board

Telephone enquiries to

Telephone extension No

9th Floor,
35 Spring Street, Melbourne
Box 2/GPO Melbourne 3001
Telephone 653 1111
Telegrams and Cables "Motaccord"

4th October, 1978.

Mr. M.H. Cameron,
M.H. Cameron and Associates,
17 Myrtle Grove,
BLACKBURN Vic. 3130

Dear Max,

Enclosed are details of errors and omissions rectified by the Statistical Section for "in-coverage" claims edited in the period 1st February, 1978 - 30th April, 1978. Because of the lag between accident date and edit date, the claims examined in this period related primarily to accidents occurring in the October-December quarter, 1977.

Error details were extracted for this period rather than for the working-up April-June quarter, 1977 (as had been indicated) because of improved error recording practices in the later period.

Yours faithfully,

D.E. Kearsley,
SENIOR STATISTICAL OFFICER.

Enc.

The following table gives details of the omissions and errors rectified for in-coverage claims relating to the accident period 1st October, 1977 - 30th December, 1977.

Data Item	Percentage of Claims in Error
Sex	12.9
Date of Birth	11.9
Marital Status	9.5
Occupation Code	24.5
Employment Code	10.7
Licence Status	8.7
Claimant Type	9.0
Injury Code	59.0
Period Licence Held	7.2
Accident Day	9.8
Accident Time	6.5
Accident Date	0.7
Accident Municipality	15.8
Impact Code	18.5
Road User Code	33.3
Registration Number	0.6

APPENDIX B

INJURY CODES USED BY MAB IN 1974-75

TABLE B1: Injury codes used by MAB in 1974-75

Code	Injury
	Fractures
800	Vault of skull
801	Base of skull
802	Face bones
803	Other and unqualified skull fractures
804	Multiple fractures involving skull or face with other bones
805	Fracture or fracture dislocation of vertebral column without mention of spinal cord lesion
806	Fracture and fracture dislocation of vertebral column with spinal cord lesion
807	Rib(s), sternum, and larynx
808	Pelvis
809	Multiple and ill-defined fractures of trunk
810	Clavacle (collar-bone)
811	Scapula (sholder blade)
812	Humerus (shoulder)
813	Radius and ulna (forearm)
814	Carpal bone(s) (wrist)
815	Metacarpal bone(s) (hand)
816	Fracture of one or more phalanges of hand (thumb, finger (s))
817	Multiple fractures of hand bones.
818	Other, multiple, and ill-defined fractures of upper limb
819	Multiple fractures of both upper limbs, and upper limb with rib(s) and sternum
820	Neck of femur (hip)
821	Fracture of other and unspecified parts of femur (upper leg)
822	Patella (knee-cap)
823	Tibia and Fibula (lower leg)
824	Ankle
825	Fracture of one or more tarsal and metatarsal bones (foot excepting toes)
826	Fracture of one or more phalanges of foot (toe(s))
827	Other, multiple, and ill-defined fractures of lower limb
828	Multiple fractures involving both lower limbs, lower with upper limb, and lower limb(s) with rib(s) and sternum
829	Unspecified bones

Code	Injury
	Dislocation
830	Jaw
831	Shoulder
832	Elbow
833	Wrist
834	Finger
835	Hip
836	Knee
837	Ankle
838	Foot
839	Multiple and ill-defined dislocations
	Sprains and Strains
840	Shoulder and upper arm
841	Elbow and forearm
842	Wrist and hand
843	Hip and thigh
844	Knee and leg
845	Ankle and foot
846	Sacro-iliac region
847	Other and unspecified parts of back
848	Other and ill-defined sprains and strains
	Intracranial Injury
850	Concussion
851	Cerebral laceration and contusion
852	Subarachnoid subdural and extra-dural haemorrhage, following injury (without mention of cerebral laceration and contusion)
853	Other and unspecified intracranial haemorrhage following injury (without mention of cerebral laceration or contusion)
854	Intracranial injury of other and specified nature
	Internal Injury of Chest, Abdomen, and Pelvis
860	Traumatic pneumothorax and haemothorax
861	Injury to heart and lung
862	Injury to other and unspecified intrathoracic organs
863	Injury to gastro-intestinal tract
864	Injury to liver
865	Injury to spleen
866	Injury to kidney
867	Injury to pelvic organs
868	Injury to other and unspecified intra-abdominal organs

TABLE B1: (Cont'd)

Code	Injury
869	Internal injury, unspecified or involving intrathoracic and intra-abdominal organs
	Laceration and Open Wound
870	Open wound of eye and orbit
871	Enucleation of eye
872	Open wound of ear
873	Other and unspecified laceration of head
874	Neck
875	Chest (wall)
876	Back
877	Buttock
878	Genital organs (external) including traumatic amputation
879	Other and unspecified open wound of head, neck and trunk
	Laceration and Open Wound of Upper Limb
880	Shoulder and upper arm
881	Elbow, forearm, and wrist
882	Hand except finger(s)
883	Finger(s) or Thumb
884	Multiple and unspecified open wound of upper limb
885	Traumatic amputation of thumb (complete or partial)
886	Traumatic amputation of other finger(s) (partial or complete)
887	Traumatic amputation of arm and hand (complete and partial)
	Laceration and Open Wound of Lower Limb
890	Open wound of hip and thigh
891	Open wound of knee, leg (except thigh) and ankle
892	Open wound of foot except toe(s)
893	Open wound of toe(s)
894	Multiple and unspecified open wound of lower limb
895	Traumatic amputation of toe(s)
896	Traumatic amputation of foot (feet), partial or complete
897	Traumatic amputation of leg(s), complete or partial
	Laceration and Open Wound of Multiple Location
900	Multiple open wounds of both upper limbs
901	Multiple open wounds of both lower limbs
902	Multiple open wounds of upper with lower limb(s)
903	Multiple open wounds of both hands
904	Multiple open wounds of head with limb(s)
905	Multiple open wounds of trunk with limb(s)
906	Multiple open wounds of face with limb(s)
907	Multiple open wounds of other and unspecified location
	Superficial Injury
910	Superficial injury of face, neck, and scalp
911	Superficial injury of trunk
912	Superficial injury of shoulder and upper arm
913	Superficial injury of elbow, forearm, and wrist
914	Superficial injury of hand(s) except finger(s)
915	Superficial injury of finger(s)
916	Superficial injury of hip, thigh, leg, and ankle
917	Superficial injury of foot and toe(s)
918	Superficial injury of other, multiple or unspecified sites
	Contusion and Crushing with Intact Skin Surface
920	Contusion of face, scalp, neck (except eye)
921	Contusion of eye and orbit
922	Contusion of trunk
923	Contusion of shoulder and upper arm
924	Contusion of elbow, forearm, and wrist
925	Contusion of hand(s) except finger(s)
926	Contusion of finger(s)
927	Contusion of hip, thigh, leg, and ankle
928	Contusion of foot and toe(s)
929	Contusion of other, multiple, and unspecified sites

TABLE B1: (Cont'd)

Code	Injury
	Effects of Foreign Body entering through Orifice
930	Foreign body in eye or adnexa
931	Foreign body in ear
932	Foreigh body in nose
933	Foreign body in pharynx and larynx
934	Foreign body in bronchus and lung
935	Foreign body in mouth, oesophagus, stomach
936	Foreign body in intestine and colon
937	Foreign body in anus and rectum
938	Foreign body in digestive system, unspecified
939	Foreign body in genito-urinary tract
	Burn
940	Burn confined to eye
941	Burn confined to face, head, and neck
942	Burn confined to trunk
943	Burn confined to upper limb except wrist and hand
944	Burn confined to wrist(s) and hand(s)
945	Burn confined to lower limb(s)
946	Burn involving face, head, and neck with limb(s)
947	Burn involving trunk with limb(s)
948	Burn involving face, head, and neck with trunk and limb(s)
949	Burn involving other and unspecified parts
	Injury to nerves and spinal cord
950	Injury to optic nerve(s)
951	Injury to other cranial nerve(s)
952	Injury to nerve(s) in upper arm
953	Injury to nerve(s) in forearm
954	Injury to nerve(s) in wrist and hand
955	Injury to nerve(s) in thigh
956	Injury to nerve(s) in lower leg
957	Injury to nerves in ankle and foot
958	Spinal cord lesion without evidence of spinal bone injury
959	Other nerve injury including nerve injury in several parts
	Effects of other external causes
001	Drowning and non-fatal submersion
007	Asphyxiation and strangulation
008	Electrocution and non-fatal effects of electric current
995	Shock

APPENDIX C

DATES OF INTRODUCTION OF HEAD RESTRAINTS IN AUSTRALIAN VEHICLES

DATES OF INTRODUCTION OF HEAD RESTRAINTS IN AUSTRALIAN VEHICLES

The manufacturers of the more popular vehicles were contacted to establish whether head restraints were fitted to their vehicles prior to 1 January 1972. A summary of this information is given below. However, it should be kept in mind that this information was often supplied by telephone and may not be entirely accurate or comprehensive.

Ford:

Not prior to 1 January 1972.

General Motors:

Introduced as a production option on HQ Holden and LC Torana in July 1971; compulsorily fitted 1 January 1972.

Toyota:

Corolla (K-20 series) had fixed head restraints which complied with ADR 22 when introduced circa 1970 (Imported seats). Celica introduced with Corolla seats circa 1971. These complied with ADR 22.

Chrysler:

Standard adjustable head restraints on 1969 VF 'V.I.P.' Sedan and 1969-70 A82 Colt Fastback, 1970 A51 Galant.

Fixed head restraints as of 1972 GB Galant Range.

Mazda:

Some doubt as to models which were phased out prior to 1972.

Datsun:

No data were obtained.

Volkswagen:

Not prior to 1 January 1972.

Leyland:

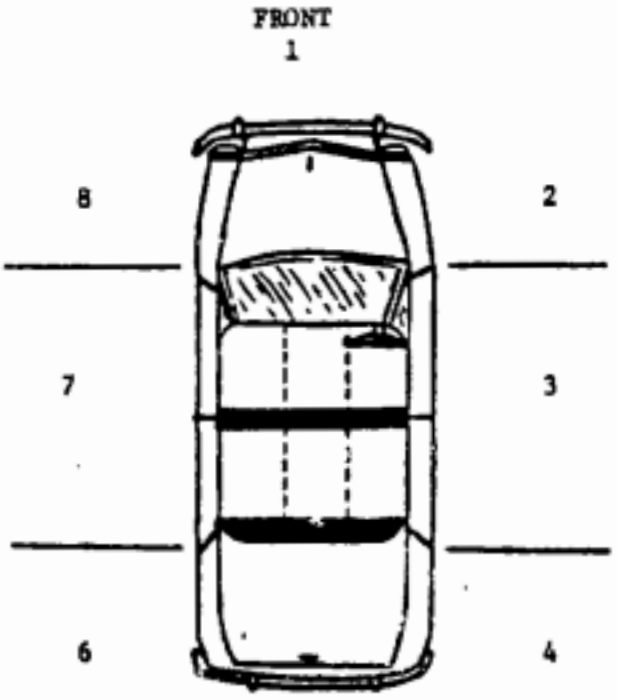
Optional on Tasman, Kimberley just prior to January 1972.

The eight manufacturers listed above accounted for approximately 80% of the vehicles in this study.

APPENDIX D

POINT OF IMPACT AND ROAD USER MOVEMENT (RUM) CODES

POINT OF IMPACT



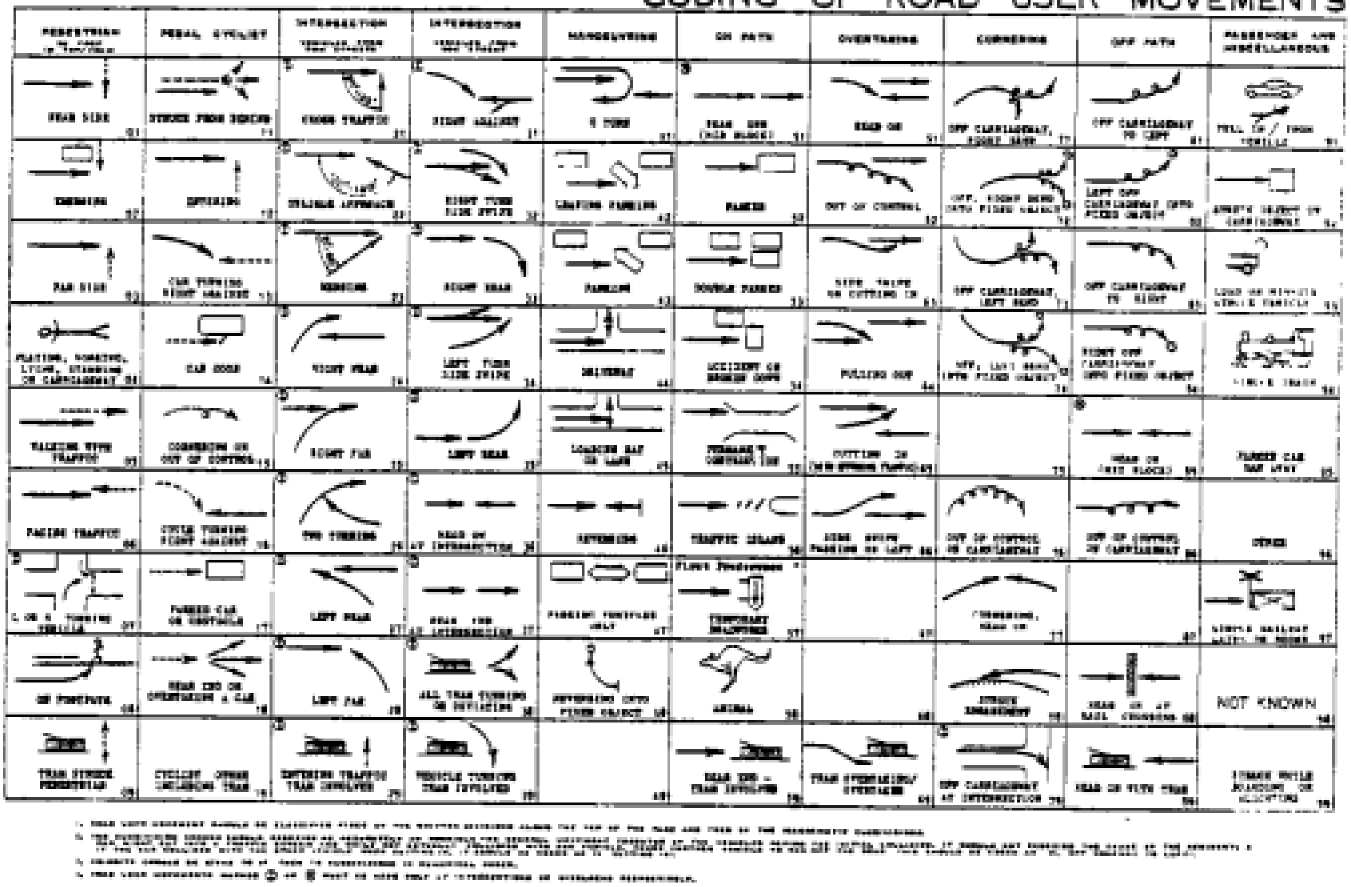
	CODE
Front of Vehicle	1
O/s Forward of Cabin	2
O/s Passenger Doors	3
O/s Rear of Cabin	4
Rear of Vehicle	5
N/s Rear of Cabin	6
N/s Passenger Doors	7
N/s Forward of Cabin	8
Roof (Roll over)	9
No impact	0

Note (1) In the case of a collision between a motor vehicle and a pedal cycle, the point of impact on the motor vehicle is required.

(2) If the point of impact is not known, the field should be left blank (this includes cases for which it is not known whether a collision occurred).

ROAD SAFETY AND TRAFFIC AUTHORITY

CODING OF ROAD USER MOVEMENTS



DATE OF ISSUE : JULY 1972 106407

APPENDIX E

DETAILED INJURIES IN REAR END IMPACTS

TABLE E1 Drivers in rear end impacts

INJURY (ICD)	Male		Female	
	1969-71 (N = 170)*	1972-73 (N = 183)	1969-71 (N = 169)	1972-73 (N = 117)
850	60	47	64	31
347	34	44	32	40
1. Whiplash	94 (48.2)	91 (45.5)	96 (49.2)	71 (51.1)
2. Major Neck Injury (805 or 806)	1 (0.5)	-	-	-
3a. Concussion (850)	5	8	4	5
3b. Major Intracranial (851, 852, 853, 854)	1	1	4	3
3c. Skull Fracture (800, 801, 803)	-	1	-	-
3d. Minor facial (910, 920, 921, 950, 951)	10	5	6	5
3e. Major facial (870, 871, 872, 802, 804, 830)	1	2	2	-
3f. Other and Unspecified head lacerations (873)	8	7	4	2
3. Total Head-facial-skull injuries	25 (12.8)	24 (12.0)	20 (10.3)	15 (10.8)
4. Total all other injuries	75 (38.5)	85 (42.5)	79 (40.5)	53 (38.1)
TOTAL (All injuries)	195	200	195	139

* Capital N specifies the number of occupants. The other figure in brackets are column percentages.

TABLE E2 Front left passengers in rear end impacts

INJURY CODE	Male		Female	
	1963-71 (N=35)	1972-74 (N=28)	1963-71 (N=144)	1972-74 (N=108)
830	11	7	48	38
847	4	3	35	17
1. Whiplash	15 (34.9)	10 (32.3)	83 (51.6)	55 (41.7)
2. Major Neck Injury (805 or 806)	-	-	-	-
3a. Concussion (850)	2	-	1	2
3b. Major Intracranial (851, 852, 853,854)	-	1	5	3
3c. Skull Fracture (800,801, 803)	-	-	-	-
3d. Minor facial (910,920,921,950, 951)	3	2	5	3
3e. Major facial (870,871,872,802, 804,850)	-	-	2	-
3f. Other and Unspecified head lacerations (873)	3	2	6	4
3. Total Head-facial-skull injuries	8 (18.6)	5 (16.1)	19 (11.8)	12 (9.1)
4. Total all other injuries	20 (46.5)	16 (51.6)	59 (36.6)	65 (49.2)
TOTAL (All injuries)	43	31	161	132

* Capital N specifies the number of occupants. The other figure in brackets are column percentages.

TABLE E3 Rear passengers in rear end impacts

INJURY CODE	Male		Female	
	1969-71 (N= 38)	1972-74 (N= 16)	1969-71 (N= 66)	1972-74 (N= 56)
839	6	2	11	7
847	5	3	15	10
1. Whiplash	11 (23.9)	5 (25.0)	26 (33.3)	17 (24.3)
2. Major Neck Injury (805 or 806)	-	-	-	-
3a. Concussion (850)	1	1	2	1
3b. Major Intracranial (851, 852, 853,854)	2	-	3	1
3c. Skull Fracture (800,801, 803)	2	-	1	-
3d. Minor facial (910,920,921,950, 951)	2	3	5	4
3e. Major facial (870,871,872,802, 804,830)	2	-	-	-
3f. Other and Unspecified head lacerations (873)	7	1	2	4
3. Total Head-facial-skull injuries	16 (34.8)	5 (25.0)	13 (16.7)	10 (14.3)
4. Total all other injuries	19 (41.3)	10 (50.0)	39 (50.0)	43 (61.4)
TOTAL (All injuries)	46	20	78	70

* Capital N specifies the number of occupants. The other figure in brackets are column percentages.

TABLE E4 Drivers (Male and Female combined) in rear end impacts

INJURY TYPE	1969-71 (N=339)	1972-74 (N=300)	Row Total (N=639)
1. Whiplash (Ø)	191 (49.0)	162 (47.8)	353 (48.4)
2a. Concussion	9 (2.3)	13 (3.8)	22 (3.0)
2b. Major Intracranial	5 (1.3)	4 (1.2)	9 (1.2)
2c. Skull Fracture	-	1 (0.3)	1 (0.1)
2d. Minor Facial	16 (4.1)	10 (2.9)	26 (3.6)
2e. Major Facial	3 (0.8)	2 (0.6)	5 (0.7)
2f. Other and Unspecified head laceration	12 (3.1)	9 (2.7)	21 (2.9)
2. Total Head - facial - skull injuries	45 (11.5)	39 (11.5)	84 (11.5)
3. Total all other injuries	154 (39.5)	138 (40.7)	292 (40.1)
TOTAL (All injuries)	390	339	729

(Ø) N.S. at p = .05

TABLE E5 Front left passengers (Male and Female combined) in rear end impacts

INJURY TYPE	1969-71 (N= 179)	1972-74 (N= 136)	Row Total (N= 315)
1. Whiplash (*)	98 (48.0)	65 (39.9)	163 (44.4)
2a. Concussion	3	2	5
2b. Major Intracranial	5	4	9
2c. Skull Fracture	-	-	-
2d. Minor Facial	8	5	13
2e. Major Facial	2	-	2
2f. Other and Unspecified head laceration	9	6	15
2. Total Head - facial - skull injuries	27 (13.2)	17 (10.4)	44 (12.0)
3. Total all other injuries	79 (38.7)	81 (49.7)	160 (43.6)
TOTAL (All injuries)	204	163	367

(*) This result is approaching statistical significance $p < .1$; one-tailed x^2 test

TABLE E6 Rear passengers (Male and Female combined) in rear end impacts

INJURY TYPE	1969-71 (N= 104)	1972-74 (N= 72)	Row Total (N= 176)
1. Whiplash	37 (29.8)	22 (24.4)	59 (27.6)
2a. Concussion	3 (2.4)	2 (2.2)	5 (2.3)
2b. Major Intracranial	5 (4.0)	1 (1.1)	6 (2.8)
2c. Skull Fracture	3 (2.4)	-	3 (1.4)
2d. Minor Facial	7 (5.6)	7 (7.8)	14 (6.5)
2e. Major Facial	2 (1.6)	-	2 (0.9)
2f. Other and Unspecified head laceration	9 (7.3)	5 (5.6)	14 (6.5)
2. Total Head - Facial - skull injuries	29 (23.4)	15 (16.7)	44 (20.6)
3. Total all other injuries	58 (46.8)	53 (58.9)	111 (51.9)
TOTAL (All injuries)	124	90	214

TABLE E7 Outboard front seats (Male and Female combined) in rear end impacts

INJURY TYPE	1969-71 (N= 518)	1972-74 (N= 436)	Row Total (N= 954)
1. Whiplash (Ø)	289 (48.7)	227 (45.2)	516 (47.1)
2a. Concussion (Ø)	12 (2.0)	15 (3.0)	27 (2.5)
2b. Major Intracranial	10 (1.7)	8 (1.6)	18 (1.6)
2c. Skull Fracture	-	1 (.2)	1 (.1)
2d. Minor Facial	24 (4.0)	15 (3.0)	39 (3.6)
2e. Major Facial	5 (.8)	2 (0.4)	7 (0.6)
2f. Other and Unspecified head laceration	21 (3.5)	15 (3.0)	36 (3.3)
2. Total Head - facial - skull injuries	72 (12.1)	56 (11.2)	128 (11.7)
3. Total all other injuries	233 (39.2)	219 (43.6)	452 (41.2)
TOTAL (All injuries)	594	502	1096

(Ø) N.S. at p = 105

TABLE ES Injuries for occupants of vehicles manufactured in the two year period 1969-70.

INJURY CODE	Drivers		Front Left Passengers		Rear Passengers	
	Male (N=102)	Female (N=116)	Male (N=23)	Female (N=98)	Male (N=29)	Female (N=49)
839	39 (33.3)	44 (32.4)	8 (28.6)	34 (31.8)	5 (14.7)	9 (15.8)
847	19 (16.2)	23 (16.9)	3 (10.7)	21 (19.6)	4 (11.8)	12 (21.1)
1. Whiplash	58 (49.6)	67 (49.3)	11 (39.3)	55 (51.4)	9 (26.5)	21 (36.8)
2. Major Neck Injury (805 or 806)	-	-	-	-	-	-
3a. Concussion (850)	2	3	2	1	1	2
3b. Major Intracranial (851, 852, 853,854)	-	3	-	4	-	2
3c. Skull Fracture (800, 801, 803)	-	-	-	-	2	1
3d. Minor facial (910,920,921,950,951)	6	3	1	4	2	4
3e. Major facial (870,871,872,802,804, 830)	-	2	-	1	2	-
3f. Other & Unspecified head lacerations (873)	5	1	3	3	5	2
3. Total Head-facial-skull injuries	13 (11.1)	12 (8.8)	6 (21.4)	13 (12.2)	12 (35.3)	11 (19.3)
4. Total all other injuries	46 (39.3)	57 (41.9)	11 (39.3)	39 (36.4)	13 (38.2)	25 (43.9)
TOTAL (All injuries)	117	136	28	107	34	57

* Capital N specifies the number of occupants. The other figures in brackets are column percentages.

APPENDIX F

DETAILED INJURIES IN FRONT END IMPACTS

TABLE F1 Drivers in front end impacts

INJURY CODE	Male 1969-71 (N=432)	Male 1972-74 (N=416)	Female 1969-71 (N=183)	Female 1972-74 (N= 181)
869	22	37	13	22
847	21	22	8	14
1. Whiplash	43 (7.7)	59 (10.7)	21 (8.5)	36 (15.5)
2. Major Neck Injury (805 or 806)	1 (0.2)	2 (0.4)	1 (0.4)	-
3a. Concussion (850)	16	26	10	12
3b. Major Intracranial (851, 852, 853,854)	12	26	4	4
3c. Skull Fracture (800,801, 803)	2	5	-	1
3d. Minor facial (910,920,921,950, 951)	30	25	5	4
3e. Major facial (870,871,872,802, 804,830)	25	22	3	3
3f. Other and Unspecified head lacerations (873)	63	49	20	14
3. Total Head-facial-skull injuries	148 (26.4)	153 (27.8)	42 (17.1)	38 (16.3)
4. Total all other injuries	369 (65.8)	336 (61.1)	182 (74.0)	159 (68.2)
TOTAL (All injuries)	561	550	246	233

* Capital N specifies the number of occupents. The other figure in brackets are column percentages.

TABLE F2 Front left passengers in front end impacts

INJURY CODE	Male		Female	
	1969-71 (N=148)	1972-74 (N=121)	1969-71 (N=256)	1972-74 (N= 243)
859	6	9	14	16
847	1	4	19	15
1. Whiplash	7 (3.6)	13 (9.0)	33 (9.6)	31 (9.9)
2. Major Neck Injury (805 or 806)	2 (1.0)	1 (0.7)	1 (0.3)	5 (1.6)
3a. Concussion (850)	10	6	14	6
3b. Major Intracranial (851, 852, 853,854)	11	4	11	9
3c. Skull Fracture (800,801, 803)	3	2	2	2
3d. Minor facial (910,920,921,950, 951)	8	7	16	15
3e. Major facial (870,871,872,802, 804,830)	8	3	4	2
3f. Other and Unspecified head lacerations (873)	24	18	25	14
3. Total Head-facial-skull injuries	64 (33.0)	40 (27.8)	72 (20.9)	48 (15.4)
4. Total all other injuries	121 (62.4)	90 (62.5)	238 (69.2)	228 (73.1)
TOTAL (All injuries)	194	144	344	312

* Capital N specifies the number of occupants. The other figure in brackets are column percentages.

TABLE F3 Rear passengers in front end impacts

INJURY CODE	Male		Female	
	1969-71 (N=103)*	1972-74 (N= 79)	1969-71 (N=129)	1972-74 (N=129)
839	3	-	4	9
847	-	1	2	5
1. Whiplash	3 (2.4)	1 (1.0)	6 (3.6)	14 (8.4)
2. Major Neck Injury (805 or 806)	-	2 (1.9)	2 (1.2)	-
3a. Concussion (850)	8	2	7	12
3b. Major Intracranial (851, 852, 853,854)	2	2	4	2
3c. Skull Fracture (800,801, 803)	3	-	2	1
3d. Minor facial (910,920,921,950, 951)	11	7	8	15
3e. Major facial (870,871,872,802, 804,830)	4	2	7	4
3f. Other and Unspecified head lacerations (873)	21	15	22	10
3. Total Head-facial-skull injuries	49 (38.6)	28 (26.7)	50 (30.1)	44 (26.3)
4. Total all other injuries	75 (59.1)	74 (70.5)	108 (65.1)	109 (65.3)
TOTAL (All injuries)	127	105	166	167

* Capital N specifies the number of occupants. The other figure in brackets are column percentages.

TABLE F4 Drivers (Male and Female combined) in front end impacts

INJURY TYPE	1969-71 (N=615)	1972-74 (N=597)	Row Total (N=1212)
1. Whiplash (**)	66 (8.2)	97 (12.4)	163 (10.3)
2a. Concussion (Ø)	26 (3.2)	38 (4.9)	64 (4.0)
2b. Major Intracranial (*)	16 (2.0)	30 (3.8)	46 (2.9)
2c. Skull Fracture (Ø)	2 (0.2)	6 (.8)	8 (.5)
2d. Minor Facial	35 (4.3)	29 (3.7)	64 (4.0)
2e. Major Facial	28 (3.5)	25 (3.2)	53 (3.3)
2f. Other and Unspecified head laceration	83 (10.3)	63 (8.0)	146 (9.2)
2. Total Head - facial - skull injuries	190 (23.5)	191 (24.4)	381 (24.0)
3. Total all other injuries	551 (68.3)	495 (63.2)	1046 (65.8)
TOTAL (All injuries)	807	783	1590

(*) $p < .05$

(**) $p < .01$

(Ø) N.S. at $p = .05$

TABLE F5 Front left passengers (Male and female combined) in front end impacts

INJURY TYPE	1969-71 (N=404)	1972-74 (N=364)	Row Total (N=768)
1. Whiplash (Ø)	43 (8.0)	50 (11.0)	93 (9.4)
2a. Concussion (Ø)	24 (4.5)	12 (2.6)	36 (3.6)
2b. Major Intracranial	22 (4.1)	13 (2.9)	35 (3.5)
2c. Skull Fracture	5 (.9)	4 (.9)	9 (.9)
2d. Minor Facial	24 (4.5)	22 (4.8)	46 (4.6)
2e. Major Facial	12 (2.2)	5 (1.1)	17 (1.7)
2f. Other and Unspecified head laceration	49 (9.1)	32 (7.0)	81 (8.1)
2. Total Head - facial - skull injuries	136 (25.3)	88 (19.3)	224 (22.5)
3. Total all other injuries	359 (66.7)	318 (69.7)	677 (68.1)
TOTAL (All injuries)	538	456	994

(Ø) N.S. at p = .05

TABLE F6 Rear passengers (Male and Female combined) in front end impacts

INJURY TYPE	1969-71 (N= 232)	1972-74 (N= 208)	Row Total (N= 440)
1. Whiplash (Ø)	11 (3.8)	17 (6.3)	28 (5.0)
2a. Concussion	15 (5.1)	14 (5.1)	29 (5.1)
2b. Major Intracranial	6 (2.0)	4 (1.5)	10 (1.8)
2c. Skull Fracture	5 (1.7)	1 (.4)	6 (1.1)
2d. Minor Facial (Ø)	19 (6.5)	22 (8.1)	41 (7.3)
2e. Major Facial	11 (3.8)	6 (2.2)	17 (3.0)
2f. Other and Unspecified head laceration	43 (14.7)	25 (9.2)	68 (12.0)
2. Total Head - facial - skull injuries	99 (33.8)	72 (26.5)	171 (30.3)
3. Total all other injuries	183 (62.5)	183 (67.3)	366 (64.8)
TOTAL (All injuries)	293	272	565

(Ø) N.S. at p = .05

TABLE F7 Outboard front seats (Male and female combined) in front end impacts

INJURY TYPE	1969-71 (N= 1019)	1972-74 (N= 961)	Row Total (N= 1980)
1. Whiplash (*)	109 (8.1)	147 (11.9)	256 (9.9)
2a. Concussion	50 (3.7)	50 (4.0)	100 (3.9)
2b. Major Intracranial	38 (2.8)	43 (3.5)	81 (3.1)
2c. Skull Fracture	7 (.5)	10 (.8)	17 (.7)
2d. Minor Facial	59 (4.4)	51 (4.1)	110 (4.3)
2e. Major Facial	40 (3.0)	30 (2.4)	70 (2.7)
2f. Other and Unspecified head laceration	132 (9.8)	95 (7.7)	227 (8.8)
2. Total Head - facial - skull injuries (Ø)	326 (24.2)	279 (22.5)	605 (23.4)
3. Total all other injuries	910 (67.7)	813 (65.6)	1723 (66.7)
TOTAL (All injuries)	1345	1239	2584

(*) $p < .01$

(Ø) N.S. at $p = .05$

APPENDIX G

DETAILED INJURIES IN RIGHT ANGLE SIDE IMPACTS

TABLE G1 Drivers in right angle side impacts.

INJURY CODE	Male		Female	
	1969-71 (N= 88)	1972-74 (N= 64)	1969-71 (N= 55)	1972-74 (N= 50)
839	3	4	7	5
847	4	1	6	6
1. Whiplash	7 (5.8)	5 (6.0)	13 (17.3)	11 (15.1)
2. Major Neck Injury (805 or 806)	1 (0.8)	-	-	-
3a. Concussion (850)	7	3	-	3
3b. Major Intracranial (851, 852, 853,854)	2	1	1	1
3c. Skull Fracture (800,801, 803)	-	-	-	-
3d. Minor facial (910,920,921,950, 951)	8	1	1	2
3e. Major facial (870,871,872,802, 804,830)	1	-	1	3
3f. Other and Unspecified head lacerations (873)	12	7	9	3
3. Total Head-facial-skull injuries	30 (24.8)	12 (14.5)	12 (16.0)	12 (16.4)
4. Total all other injuries	83 (68.6)	66 (79.5)	50 (66.7)	50 (68.5)
TOTAL (All injuries)	121	83	75	73

* Capital N specifies the number of occupants. The other figure in brackets are column percentages.

TABLE G2 Front left passengers in right angle side impacts

INJURY CODE	Male		Female	
	1964-71 (N. 26)	1972-74 (N= 17)	1964-71 (N= 62)	1972-74 (N= 50)
839	1	-	2	1
847	-	-	3	2
1. Whiplash	1 (2.9)	-	5 (5.7)	3 (3.8)
2. Major Neck Injury (805 or 806)	-	-	-	-
3a. Concussion (850)	2	3	1	2
3b. Major Intracranial (851, 852, 853,854)	-	1	1	-
3c. Skull Fracture (800,801, 803)	-	-	-	-
3d. Minor facial (910,920,921,950, 951)	1	1	3	1
3e. Major facial (870,871,872,802, 804,830)	1	1	-	-
3f. Other and Unspecified head lacerations (873)	7	1	3	7
3. Total Head-facial-skull injuries	11 (31.4)	7 (33.3)	8 (9.2)	10 (12.8)
4. Total all other injuries	23 (65.7)	14 (66.7)	74 (85.1)	65 (83.3)
TOTAL (All injuries)	35	21	87	78

* Capital N specifies the number of occupants. The other figure in brackets are column percentages.

TABLE G3 Rear passengers in right angle side impacts

Injury Type	Male		Female	
	1966-71 (N=29)	1972-77 (N=14)	1966-71 (N= 34)	1972-77 (N= 42)
599	2	-	1	2
847	1	-	1	-
1. Whiplash	3 (8.8)	-	2 (4.3)	2 (3.2)
2. Major Neck Injury (805 or 806)	-	-	-	-
3a. Concussion (850)	-	2	4	2
3b. Major Intracranial (851, 852, 853,854)	1	1	1	1
3c. Skull Fracture (800,801, 803)	-	-	-	-
3d. Minor facial (910,920,921,950, 951)	4	3	-	6
3e. Major facial (870,871,872,802, 804,830)	1	-	1	1
3f. Other and Unspecified head lacerations (873)	4	3	4	7
3. Total Head-facial-skull injuries	10 (29.4)	9 (52.9)	10 (21.7)	17 (27.4)
4. Total all other injuries	21 (61.8)	8 (47.1)	34 (73.9)	43 (69.4)
TOTAL (All injuries)	34	17	46	62

* Capital N specifies the number of occupants. The other figure in brackets are column percentages.