DEPARTMENT OF TRANSPORT

OFFICE OF ROAD SAFETY

THE EFFECT OF SEAT BELTS ON MINOR AND SEVERE INJURIES MEASURED ON THE ABBREVIATED INJURY SCALE

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Abstract

Following the implementation of compulsory seat belt wearing legislation in Victoria in December 1970, the Royal Australasian College of Surgeons established a survey to collect detailed injury and crash data from car accidents in that State. An analysis of the effect of seat belt wearing on severe injuries sustained by car occupants during the first two years of the survey was reported by Cameron and Nelson (1977). Minor injuries were ignored in that analysis. Further work extended the file to cover 8537 occupants injured during the first three years of the survey and the injuries (including minor injuries) were coded on the Abbreviated Injury Scale. This report examines the effect of seat belt wearing on both minor and severe injuries. Some comparisons of injury severity distributions in the Victorian data and in data collected by North American MDAI teams are also made.

The report concludes that the wearing of static three-point lap/sash belts by front outboard seat occupants of cars and car derivatives is associated with:

(a) reduced likelihood of severe-to-fatal injury to the head-face, thorax, lower torso and lower extremities when injured and not ejected in crashes in built-up areas and, for some body regions, in open road crashes,

(continued)

NOTE:

Report to
Office of Road Safety
Commonwealth Department of Transport

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Abstract (continued)

(b) increased likelihood of minor injury to the thorax and lower torso when injured and not ejected in crashes in all locations and of minor injury to the neck (ie, whiplash) when injured and not ejected in crashes in built-up areas.

There are suggestions that the increased likelihoods of the minor injuries are not artefacts of the injury criterion for inclusion, nor of the reduced likelihood of severe injury to the trunk when seat belts are worn, but are due to the wearing of the seat belt.

The absence of crash severity information in the survey data prevented a definitive evaluation of the effect of seat belt wearing alone on the injuries of car occupant casualties.

Reference M.H. Cameron and P.G. Nelson. "Injury patterns with and without seat belts", Proceedings, Sixth International Conference of the International Association for Accident and Traffic Medicine, Melbourne, 1977.

THE EFFECT OF SEAT BELTS ON MINOR AND SEVERE INJURIES MEASURED ON THE ABBREVIATED INJURY SCALE

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INTRODUCTION

To assess the effect of seat belt wearing on the injury pattern of injured car occupants, Cameron and Nelson (1977) analysed a matched file of 6526 trauma and crash reports collected during the first two years of the Royal Australasian College of Surgeons' Pattern of Injury Survey. From June 1971, the survey collected details of injuries of Victorian road users treated at hospital or killed. These details, recorded on a Road Trauma Report (RTR) form, were matched with information on the crash circumstances of car occupants provided by ambulance officers. Unfortunately, the ambulance officer return was incomplete and biased toward rural crashes (Nelson 1974).

Cameron and Nelson found that the number of injuries recorded on the RTR form was too great for individual study. They concentrated on a particular subset of the injuries recorded, chosen as being those injuries commonly occurring among fatally-injured vehicle occupants. This selection method had the disadvantage of missing uncommon severe injuries. A more objective method of selecting severe injuries, say based on the Abbreviated Injury Scale (Joint Committee on Injury Scaling, 1976), was not available in the matched file at the time. Nor was it possible to select minor injuries in the absence of an objective injury scale. This meant that the effect of seat belt wearing on minor injuries could not be fully considered.

seat belt wearing on both minor and severe injuries measured on the Abbreviated Injury Scale (AIS). The addition of a further year's data has extended the file to cover 8537 injured occupants of cars and car derivatives. Each injury, including soft/surface tissue injuries, has been assigned an AIS score (Table I) and grouped into six body regions defined by Huelke et al (1977). The highest AIS score was calculated for each region, and the maximum AIS score (MAIS) over all regions found for each injured occupant. The AIS scoring and the body regions used are described in greater detail later.

TABLE I : Abbreviated Injury Scale

AIS CODE	
0	No injury
1	Minor
2	Moderate
3	Severe (not life-threatening)
4	Serious (life-threatening, survival probable)
5	Critical (survival uncertain)
6	Maximum (currently untreatable)

DATA

INTRODUCTION

The data collected during the first two years of the Royal Australasian College of Surgeons' (RACS) Pattern of Injury Survey have been described elsewhere (Nelson 1974; Cameron and Nelson 1977). A third year's data were collected in the same way and incorporated in the matched file analysed here (Cameron 1977). It remains to describe the assignment of AIS scores to injuries recorded on the RTR form, the grouping of injuries into body regions, considerations of the completeness of recording of minor injuries, and the description of crash location.

ASSIGNMENT OF AIS SCORES

The AIS score assigned to each injury on the RTR form is shown in Appendix A. These scores were based on Nelson (1974, Appendix F) who in turn based his assignment on the original nine-point AIS system (States 1969). Nelson did not make use of scores 6 to 9 of the original AIS scale, which relate to various degrees of fatal consequences of the injury. The 1976 version of AIS (Joint Committee on Injury Scaling, 1976) used a six-point scale where a score of 6 was reserved for currently untreatable (necessarily fatal) injuries (Table I). Only one injury on the RTR form was considered to be an AIS=6 injury, namely the joint occurrence of primary severe brain damage and secondary intracranial compression. Further details are given in Cameron (1977).

BODY REGIONS

Injuries recorded on the RTR form were grouped into six body regions based on those used by Huelke _et al_ (1977), shown in Table II. Huelke _et al_ referred to the "head-face" region as "head" only. All soft tissue injuries recorded in the Head and Neck section of the RTR form were assigned to the head-face region, in order to leave whiplash injuries (also AIS=1) uncontaminated in the neck region.

TABLE II: Structures of the Body Regions (after Huelke *et al* 1977)

Head-Face:	Includes brain, calvarium and oral-facial structures.
Neck:	Includes the cervical spine and musculature, anterior throat structures and cervical blood vessels and nerves.
Thorax:	Includes all of the structures of the internal thoracic area from the base of the neck to the respiratory diaphragm, the ribs, vertebrae, sternum and overlying musculature and skin.
Lower Torso:	Includes the abdominal wall musculature, the lumbar spine and associated musculature, the abdominal organs, the respiratory diaphragm, the bony pelvis, the pelvic organs as well as the skin over the iliac areas, the buttocks and side portions of the pelvis overlying the hip articulation.
Upper Extremities:	Includes the shoulder girdle and joints, and all structures of the arm, elbow, forearm, wrist, hands and fingers.
Lower Extremities:	Includes all structures of the thigh, knee, leg, ankle, foot and toes.

In each body region the AIS score corresponding to the most severe injury was found. The maximum AIS score (MAIS) over all regions was also calculated for each injured occupant. MAIS is not the same as the more commonly used overall AIS (OAIS) which is a clinical judgement of the AIS of a single injury which by itself would be equivalent in terms of overall severity to the cumulative effect of multiple injuries (Joint Committee on Injury Scaling, 1976).

RECORDING OF MINOR INJURIES

Nelson (1974) compared a sample of RTR forms with corresponding hospital histories and found a substantial omission of injuries, possibly mainly minor injuries. To establish whether minor injuries were seriously under-recorded in comparison with similar crash injury data files, a comparison of RACS data with data collected by North American in-depth accident investigation teams was made (Appendix B).

Except for the head-face region, there was some evidence of under-recording of minor injuries (AIS=1) in the RACS data. However, it was concluded that sufficient minor injuries were recorded in the RACS data to make worthwhile an evaluation of the effect of seat belt wearing on these injuries.

CRASH LOCATION

Cameron and Nelson (1977) attempted to control for crash severity differences by the use of crash location (metropolitan Melbourne versus non-metropolitan). To some extent this choice of the crash location was historical (Nelson 1974) and also because the variable described crash location with very little missing data (Table III). Another descriptor of crash location was also provided by ambulance officers, namely open road versus built-up area. Although this variable has a higher level of missing data in the matched file, it was considered to represent a better indicator of vehicle speed and hence crash severity. Accordingly, it was chosen as the control for crash severity in the analysis reported here.

Occupant casualties in crashes in built-up areas were spread over both metropolitan and non-metropolitan areas (Table III). The strong association between the two crash location variables may explain some of the apparent contradictions between the detailed results presented here and those given by Cameron and Nelson (1977) when controlling for crash location. The most important of these apparent contradictions relates to the association between neck injury and seat belt wearing. This is discussed further with the relevant results from this study.

TABLE III : Number of occupant casualties in the RACS matched file, described by two descriptors of crash location

	Open Road	Built-up Area	Unknown	TOTAL
Metropolitan Melbourne	152	3483	108	3743
Non-metropolitan (rest of Victoria)	2780	1956	38	4774
Unknown	3	10	7	20
TOTAL	2935	5449	153	8537

ANALYSIS

ANALYSIS OF RACS FILE

For comparison of the results with Cameron and Nelson (1977), the analysis was restricted to non-ejected front outboard seat occupant casualties in the RACS matched file. Since the period in which the crashes occurred (June 1971 to May 1974) was before the effective date of Australian Design Rule 4B requiring inertia reel seat belts to be fitted to the front outboard seats of new vehicles, the restrained occupant casualties considered were almost exclusively wearing static three-point lap/sash belts.

The analysis was further restricted to occupant casualties of known age 16 years or older so that the results could be compared with those of Huelke et al (1977). Such occupants represent about 93 per cent of the non-ejected front outboard seat occupant casualties in the matched file (Cameron and Nelson 1977).

When comparing injured seat belt wearers and non-wearers, Cameron and Nelson found important differences of seating position, crash location (metropolitan Melbourne versus non-metropolitan), impact direction, vehicle size, ejection from vehicle, and occupant age and sex. Since each of these variables was potentially related to crash severity (as experienced by the occupant) or injury susceptibility, they attempted to control for these differences by initially restricting the analysis to non-ejected front outboard occupants and then sub-setting the data by each of the remaining variables in turn. In general, the controlled analyses confirmed the differences in injury patterns found for all wearers compared with all non-wearers, as far as the severe injuries were concerned. The absence of crash severity information in the Survey data prevented a definitive evaluation of the effect of seat belt wearing on severe injuries of occupant casualties, but the consistent results from controlled analyses caused the authors to suggest that the observed injury differences were substantially due to seat belt wearing alone.

The consistent results also suggest that controlled analyses may not be necessary during any subsequent comparison of the injuries of seat belt wearing and non-wearing occupant casualties in the same data file. This was taken as being the case during this study of the effect of seat belt wearing on minor and severe injuries, except that crash location (open road versus built-up area) was retained as a controlling variable both because of its likely association with crash severity and the known rural bias of the data file (Nelson 1974).

RESULTS FROM NORTH AMERICAN STUDIES

Huelke et al (1977) analysed the injuries of 5103 occupants in frontal collisions and 994 occupants in roll-overs investigated by North American in-depth accident investigation teams (see Appendix B). They separately considered the 765 non-ejected occupants in roll-overs. Most of the restrained occupants wore lap only belts, but 215 of the occupants in frontal collisions and 57 of the non-ejected occupants in roll-overs wore lap/shoulder belts. Thus measures of the difference in injury pattern of unrestrained and lap/shoulder belted occupants were available for comparison with the results based on the RACS matched file. However the RACS results include occupants in all crash types, about 42% of which involved frontal impacts or the vehicle overturning.

RESULTS

INTRODUCTION

The following sections describe differences in AIS distributions when unrestrained front outboard seat occupant casualties aged 16 years or older are compared with restrained occupant casualties of the same seats and age-group. RACS results for non-ejected occupants in crashes on the open road and in built-up areas separately are also compared with Huelke's results for occupants in frontal crashes and non-ejected occupants in rollovers. AIS distributions for the whole body are first considered, using Maximum AIS (MAIS) for the RACS results and Overall AIS (OAIS) for Huelke's results, and then the individual body regions.

WHOLE BODY

There was a statistically significant ($p < 0.001$) difference in the frequency distributions of MAIS when unrestrained occupants in the RACS file who were involved in crashes in built-up areas were compared with restrained occupants in like crashes (Table C1 in Appendix C). Restrained occupants were less likely to have sustained injuries with maximum AIS greater than one and were more likely to have no injury (MAIS=0). There was no significant difference in the distribution of MAIS between belted and unbelted occupants involved in open road crashes (Appendix Table C1).

About 11 per cent of the occupants included in Table C1 had a maximum AIS of zero. This does not necessarily imply that they were uninjured, only that they failed to score a tick in one of the AIS boxes on the RTR form shown in Appendix A. They may have sustained more minor injuries recorded in the General section of the RTR. In contrast, Huelke's data relate to severe injury accidents but may include uninjured occupants involved in crashes resulting in injury.

Table IV summarizes the differences in MAIS distribution of unrestrained compared with restrained occupants in terms of a measure of 'belt effectiveness', defined in the footnote to the table. Belt effectiveness is the percentage change in the frequency of each AIS level (or group of levels) when seat belt wearers are compared with non-wearers. A negative sign implies that seat belt wearing was associated with a reduction in the proportion of occupant casualties sustaining injuries of the given level of severity.

TABLE IV : Belt effectiveness+ of front outboard seat occupant casualties aged 16 years or older in (a) RACS matched file (non-ejectees only) and (b) results given by Huelke et al (1977)

WHOLE BODY

	RACS (non-ejectees): Maximum AIS		Huelke (CPIR data): Overall AIS	
	Open Road Crashes	Built-up Area Crashes	Frontal Crashes	Rollovers (non-ejectees)
AIS				
0	+26.8	+36.9	+48.4	+20.6
1	+10.2	+ 8.5	+ 6.2	+43.9
2	-23.7	-16.1	- 3.1	-38.2
3+	- 7.7	-32.4	-58.0	-70.4
No. not belted	812	1970	3950	566
No. belted (lap/sash belt)	919	1831	215	57

-1) x 10

The belt effectiveness measures were not tested separately for statistical significance; overall tests were made by the Chi-square values in Table C1. Also shown in Table IV is the belt effectiveness of lap/shoulder belts in the results given by Huelke et al (1977); however here injury severity is measured by OAIS described earlier.

BODY REGIONS

Appendix Tables C2 to C7 compare the AIS frequency distributions of unrestrained and restrained occupants in the RACS file for each of the six body regions in turn. In the following cases there were statistically significant differences (maximum significance level $p=0.1$):

(a) head-face injury in open road crashes and in built-up area crashes ($p < 0.001$ in both cases),

(b) neck injury in built-up area crashes ($p < 0.1$),

(c) thorax injury in open road crashes ($p < 0.1$) and in built-up area crashes ($p < 0.01$),

(d) lower torso injury in built-up area crashes ($p < 0.001$), and

(e) lower extremity injury in built-up area crashes ($p < 0.01$)

The detailed results are summarized in terms of belt effectiveness (defined earlier) in Tables V to X. In all of the significant cases above, except neck injury in built-up area crashes, restrained casualties were less likely to have sustained severe-to-fatal injury ($AIS \geq 3$) in the particular body region compared with unrestrained occupant casualties, confirming the results of Cameron and Nelson (1977). In the case of neck injury in built-up area crashes, restrained casualties were more likely to have sustained minor-to-severe injury compared with unrestrained occupant casualties, partially confirming the findings of Cameron and Nelson for this body region. They found increases in the frequency of whiplash injury (AIS=1) among belted occupants involved in crashes in both metropolitan Melbourne and the rest of Victoria, as well as increases in the frequency of more severe neck injuries in non-metropolitan areas. The disparity in the results may be due to the different crash location variables used in the two studies.

.../

Turning now to minor injuries (AIS=1), the frequency of their occurrence appeared unchanged or slightly reduced in the head-face and extremities regions, when seat belt wearers were compared with non-wearers. However, the wearing of seat belts was associated with substantial increases in the frequency of:

(a) AIS 1 injuries in the thorax region, for both open road and built-up area crashes,

(b) AIS 1 injuries in the lower torso region, for both open road and built-up area crashes, and

(c) AIS 1 (whiplash) injuries in the neck region, for built-up area crashes only (as discussed earlier).

TABLE V : Belt effectiveness in the head-face region of front outboard seat occupant casualties aged 16 years or older in (a) RACS matched file (non-ejectees only) and (b) results given by Huelke *et al* (1977)

HEAD-FACE Region

	RACS (non-ejectees)		Huelke (CPIR data)	
	Open Road Crashes	Built-up Area Crashes	Frontal Crashes	Rollovers (non-ejectee
AIS				
0	+35.2	+45.5	+71.3	+12.9
1	- 6.4	-13.2	-29.5	+15.7
2	-39.4	-41.5	-35.4	-26.7
3+	- 9.5	-51.1	-74.7	-81.4
No. not belted	812	1970	3950	569
No. belted (lap/sash belt)	919	1831	215	57

TABLE VI : Belt effectiveness in the neck region of front outboard seat occupant casualties aged 16 years or older in (a) RACS matched file (non-ejectees only) and (b) results given by Huelke *et al* (1977)

NECK Region

	RACS (non-ejectees)		Huelke (CPIR data)	
	Open Road Crashes	Built-up Area Crashes	Frontal Crashes	Rollovers (non-ejectees)
AIS				
0	-1.0	-1.4	-14.9	-5.5
1	-18.4	+51.6	+113.1	+90.1
2+	+89.3	+25.5	+27.6	-100.0
No. not belted	812	1970	3950	570
No. belted (lap/sash belt)	919	1831	215	57

TABLE VII : Belt effectiveness in the thorax region of front outboard seat occupant casualties aged 16 years or older in (a) RACS matched file (non-ejectees only) and (b) results given by Huelke et al (1977)

THORAX Region

			Huelke (CPIR data)	
	Open Road Crashes	Built-up Area Crashes	Frontal Crashes	Rollovers (non-ejectees)
AIS				
0	-4.2	-3.0	-2.5	+18.3
1	+34.8	+23.8	+36.8	-30.1
2	-6.0	+28.8	-56.3	-12.5
3+	-13.2	-36.6	-36.3	-64.7
No. not belted	812	1970	3950	569
No. belted (lap/sash belt)	919	1831	215	57

TABLE VIII : Belt effectiveness in the lower torso region of front outboard seat occupant casualties aged 16 years or older in (a) RACS matched file (non-ejectees only) and (b) results given by Huelke *et al* (1977)

LOWER TORSO Region

	RACS (non-ejectees)		Huelke (CPIR data)	
	Open Road Crashes	Built-up Area Crashes	Frontal Crashes	Rollovers (non-ejectees)
AIS				
0	- 2.3	- 1.7	-10.1	- 1.4
1	+49.5	+73.4	+113.5	+ 43.0
2	-29.3	-13.9	+ 16.7	-100.0
3+	- 9.0	-36.4	- 55.8	- 40.4
No. not belted	812	1970	3950	570
No. belted (lap/sash belt)	919	1831	215	57

TABLE IX : Belt effectiveness in the upper extremities of front outboard seat occupant casualties aged 16 years or older in (a) RACS matched file (non-ejectees only) and (b) results given by Huelke *et al* (1977)

UPPER EXTREMITIES

	RACS (non-ejectees)		Huelke (CPIR data)	
	Open Road Crashes	Built-up Area Crashes	Frontal Crashes	Rollovers (non-ejectees)
AIS				
0	+ 0.1	+ 1.2	-11.5	+ 0.6
1	- 1.9	+ 2.7	+32.1	+14.1
2	-20.9	-10.0	+18.6	-36.9
3+	+16.1	-33.9	-79.2	-53.8
No. not belted	812	1970	3950	570
No. belted (lap/sash belt)	919	1831	215	57

TABLE X : Belt effectiveness in the lower extremities of front outboard seat occupant casualties aged 16 years or older in (a) RACS matched file (non-ejectees only) and (b) results given by Huelke *et al* (1977)

LOWER EXTREMITIES

	RACS (non-ejectees)		Huelke (CPIR data)	
	Open Road Crashes	Built-up Area Crashes	Frontal Crashes	Rollovers (non-ejectees)
AIS				
0	+ 2.3	+ 6.6	+20.4	+ 21.9
1	- 5.5	- 7.1	-13.0	- 15.1
2	+62.0	- 3.7	-21.7	-100.0
3+	- 2.6	-34.7	-81.3	- 66.0
No. not belted	812	1970	3950	570
No. belted (lap/sash belt)	919	1831	215	57

DISCUSSION

There is evidence that seat belt wearing by front outboard seat occupants was associated with reduced likelihood of sustaining severe-to-fatal injury to the head-face, thorax, lower torso and lower extremities when injured and not ejected in crashes in built-up areas and, for some body regions, in open road crashes. However, car occupants must have been injured (and treated at hospital, at least) to appear in the RACS matched file on which this evidence was based and it must be emphasised that nothing can be said about the likelihood of severe injury *ab initio* for car occupants in crashes.

There is also evidence that seat belt wearing by front outboard seat occupants was associated with increased likelihood of sustaining minor injury to the thorax and lower torso when injured and not ejected in crashes in all locations and minor injury to the neck (i.e., whiplash) when injured and not ejected in crashes in built-up areas. It is not known whether the increase in minor injury to the trunk was an artefact of the reduction in severe injury in the same body region when seat belts were worn, since seat belt wearers must have been injured somewhere to ultimately appear in the RACS matched file. However, in contrast, the reductions in severe injury to the head-face region and in the lower extremities were not accompanied by increases in minor injuries when belts were worn. These findings suggested that the increased likelihood of minor injury to the trunk, the body region contacted by a lap/sash belt, among injured belt wearers was in fact due to the presence of the seat belt.

The increase in likelihood of minor injury to the neck may also have been an artefact of the need for seat belt wearers to have been injured to appear in the RACS matched file. However, whiplash injury *per se* is not an injury requiring immediate treatment at hospital and it is likely that such injuries were accompanied by more severe injury. This suggests that the increased likelihood of minor injury to the neck among injured belt wearers was in fact due to the wearing of the seat belt.

In general, the results of Huelke *et al* (1977) for lap/shoulder belt effectiveness were in agreement with the RACS results when allowance was made for the relatively small number of lap/shoulder belted occupants in Huelke's data. Huelke *et al* also found evidence of increases in the likelihood of minor injury to the neck and lower torso in both frontal crashes and roll-overs, and to the thorax in frontal crashes (the type of crash in which lap/shoulder belted occupants would be expected to have had significant contact with the upper torso part of their belts).

CONCLUSIONS

1. The wearing of static three-point lap/sash belts by front outboard seat occupants of cars and car derivatives is associated with:

   (a) reduced likelihood of severe-to-fatal injury to the head-face, thorax, lower torso and lower extremities when injured and not ejected in crashes in built-up areas and, for some body regions, in open road crashes,

   (b) increased likelihood of minor injury to the thorax and lower torso when injured and not ejected in crashes in all locations and of minor injury to the neck (i.e. whiplash) when injured and not ejected in crashes in built-up areas.

2. There are suggestions that the increased likelihoods of the minor injuries are not artefacts of the injury criterion for inclusion, nor of the reduced likelihood of severe injury to the trunk when seat belts are worn, but are due to the wearing of the seat belt.

The absence of crash severity information in the RACS data prevented a definitive evaluation of the effect of seat belt wearing on the injuries of car occupant casualties. However, this and an earlier study (Cameron and Nelson 1977) suggest that the observed differences in injury, when seat belt wearers are compared with non-wearers, are substantially due to seat belt wearing alone.

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APPENDIX A

ASSIGNMENT OF AIS SCORES

ROAD TRAUMA REPORT

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

Vehicle Registration No. ☐ Seat Belt Worn ☐ Yes ☐ No

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

Locality of Accident..

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

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

CAR OCCUPANT ☐
PEDESTRIAN ☐
CYCLIST ☐

SOURCE OF INFORMATION ☐ 1. CASUALTY ☐ 2. WARD ☐ 3. CORONER

[Please place tick in relevant box (✓)]

A. GENERAL

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

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

BLOOD LOSS YES ☐ NO ☐
1. <500 Ml. ☐
2. >500 Ml. ☐

VOMIT YES ☐ NO ☐
1. Inhaled ☐
2. Not Inhaled ☐

SHOCK YES ☐ NO ☐
1. Moderate ☐
2. Severe ☐

CONTINUING HAEMORRHAGE YES ☐ NO ☐
1. Head and Neck ☐ *
2. Trunk ☐ *
3. Intraabdominal AIS = 1 ☐
4. Intrathoracic 1 ☐
5. Limbs ☐ *

(* See body region)

FACIAL BONE FRACTURE YES ☐ NO ☐
1. Malar AIS = 3 ☐
2. Middle $\frac{1}{3}$ 3 ☐
3. Mandible 3 ☐
4. Nasal 2 ☐

CERVICAL SPINE FRACTURE YES ☐ NO ☐
1. Body Stable 3 ☐
2. Body Unstable 5 ☐
3. Accessory Process 3 ☐

NON SPECIFIC (WHIPLASH) 1 ☐ NO ☐

SPINAL CORD DAMAGE YES ☐ NO ☐
1. Transient 2 ☐
2. Paraplegia – Arms 4 ☐) both
3. Paraplegia – Legs 4 ☐) 5

EYE DAMAGE YES ☐ NO ☐
1. Major 3 ☐
2. Minor 2 ☐

BRAIN DAMAGE YES ☐ NO ☐
1. Concussion 2 ☐
2. Primary Severe Brain Damage 5 ☐) both
3. Secondary Intracranial Compression 5 ☐) 6

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

B. HEAD AND NECK YES ☐ NO ☐
1. Major ☐
2. Minor ☐

SOFT TISSUE YES ☐ NO ☐
1. Laceration AIS = 1 ☐
2. Abrasion 1 ☐
3. Bruising 1 ☐
4. Penetrating 1 ☐
5. Loss of Tissue 1 ☐

(+1 AIS if continuing haemorrhage)

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

C. CHEST YES ☐ NO ☐
1. Major ☐
2. Minor ☐

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

(+1 AIS if continuing haemorrhage)

FRACTURE YES ☐ NO ☐
1. Ribs ☐
   - Minor 2 ☐
   - Flail 4 ☐
2. Clavicle 2 ☐
3. Sternum 2 ☐
4. Scapula 2 ☐

SEE BACK PAGE FOR INSTRUCTIONS

[Please place tick in relevant box (✓)]

CHEST (Cont.)

PNEUMOTHORAX YES ☐ NO ☐

AIS =

	AIS	
1. Right – Open	3	☐
2. Right – Closed	4	☐
3. Right – Tension	4	☐
4. Left – Open	4	☐
5. Left – Closed	3	☐
6. Left – Tension	4	☐

HAEMOTHORAX YES ☐ NO ☐

1. Right	3	☐
2. Left	3	☐

LUNG DAMAGE YES ☐ NO ☐

1. Right	3	☐
2. Left	3	☐

AORTA DAMAGE YES ☐ NO ☐

1. Major	5	☐
2. Minor	4	☐

TRACHEA DAMAGE YES ☐ NO ☐

1. Major	5	☐
2. Minor	4	☐

OESOPHAGUS DAMAGE YES ☐ NO ☐

1. Major	5	☐
2. Minor	4	☐

HEART DAMAGE YES ☐ NO ☐

1. Major	5	☐
2. Minor	4	☐

MAJOR VEIN DAMAGE YES ☐ NO ☐

1. Major	5	☐
2. Minor	4	☐

TREATMENT YES ☐ NO ☐

1. Operative – Major
2. Operative – Minor
3. Conservative ☐

D. ABDOMEN AND PELVIS YES ☐ NO ☐

1. Major ☐
2. Minor ☐

SURFACE TISSUES YES ☐ NO ☐

AIS =

1. Laceration	1	☐
2. Abrasion	1	☐
3. Bruising	1	☐
4. Penetrating	1	☐
5. Loss of Tissue	1	☐

(+1 AIS if continuing haemorrhage)

DAMAGED INTERNAL ORGANS YES ☐ NO ☐

1. Spleen	4	☐
2. Liver	4	☐
3. Bladder – Intraperitoneal	4	☐
4. Bladder – Extraperitoneal	3	☐
5. Urethra Membranous	3	☐
6. Urethra Extramembranous	3	☐
7. Ureter – Right	3	☐
8. Ureter – Left	3	☐
9. Pancreas	5	☐
10. Kidney – Right	4	☐

DAMAGED INTERNAL ORGANS (Cont.)

AIS =

11. Kidney – Left	4	☐ NO ☐
12. Duodenum	5	☐
13. Diaphragm	3	☐
14. Bowel – Large	5	☐
15. Bowel – Small	4	☐
16. Mesentery	3	☐
17. Major Vessel	5	☐
18. Stomach	4	☐
19. Other	2	☐

TREATMENT YES ☐ NO ☐

1. Operative – Major ☐
2. Operative – Minor ☐
3. Conservative ☐

E. SPINE AND PELVIC BONES YES ☐ NO ☐

1. Major ☐
2. Minor ☐

FRACTURE SPINE YES ☐ NO ☐

BODY YES ☐ NO ☐

1. Thoracic ☐
2. Lumbar ☐
3. Sacral ☐

Stable YES ☐ NO ☐

AIS =

1. Thoracic	3	☐
2. Lumbar	3	☐
3. Sacral	3	☐

Unstable YES ☐ NO ☐

1. Thoracic	4	☐
2. Lumbar	4	☐
3. Sacral	4	☐

ACCESSORY PROCESS YES ☐ NO ☐

1. Thoracic	3	☐
2. Lumbar	3	☐
3. Sacral	3	☐

FRACTURE PELVIS YES ☐ NO ☐

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

SPINAL CORD DAMAGE YES ☐ NO ☐

1. Transient	2	☐
2. Paraplegia	4	☐
3. Cauda Equina	4	☐

TREATMENT YES ☐ NO ☐

1. Operative – Major ☐
2. Operative – Minor ☐
3. Conservative ☐

(Please place tick in relevant box (✓))

F. EXTREMITIES

UPPER LIMBS YES☐ NO☐

1. Major ☐
2. Minor ☐

SURFACE TISSUE YES☐ NO☐

	AIS	L.	R.
1. Laceration	1	☐	☐
2. Abrasion	1	☐	☐
3. Bruising	1	☐	☐
4. Penetrating	1	☐	☐
5. Loss of Tissue	1	☐	☐

(+1 AIS if continuing haemorrhage)

FRACTURES YES☐ NO☐

	AIS	L.	R.
1. Arm	3	☐	☐
2. Forearm	3	☐	☐
3. Wrist	3	☐	☐
4. Fingers	1	☐	☐

DISLOCATION YES☐ NO☐

	AIS	L.	R.
1. Acromioclavicular	2	☐	☐
2. Shoulder	3	☐	☐
3. Elbow	3	☐	☐
4. Wrist	3	☐	☐
5. Fingers	1	☐	☐

NERVE INJURY YES☐ NO☐

L. R. 3 ☐ ☐

MAJOR VESSEL INJURY YES☐ NO☐

L. R. 3 ☐ ☐

TREATMENT YES☐ NO☐

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

LOWER LIMBS YES☐ NO☐

1. Major ☐
2. Minor ☐

SURFACE TISSUE YES☐ NO☐

	AIS	L.	R.
1. Laceration	1	☐	☐
2. Abrasion	1	☐	☐
3. Bruising	1	☐	☐
4. Penetrating	1	☐	☐
5. Loss of Tissue	1	☐	☐

(+1 AIS if continuing haemorrhage)

FRACTURES YES☐ NO☐

	AIS	L.	R.
1. Thigh	3	☐	☐
2. Knee/Patella	3	☐	☐
3. Leg	3	☐	☐
4. Ankle	3	☐	☐
5. Foot	2	☐	☐

DISLOCATION YES☐ NO☐

	AIS	L.	R.
1. Hip	3	☐	☐
2. Knee	3	☐	☐
3. Ankle	3	☐	☐
4. Toes	1	☐	☐

NERVE INJURY YES☐ NO☐

L. R. 3 ☐ ☐

MAJOR VESSEL INJURY YES☐ NO☐

L. R. 3 ☐ ☐

TREATMENT YES☐ NO☐

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

G. DISPOSAL

TREATED IN CASUALTY YES☐ NO☐

1. Observation ☐
2. Minor treatment ☐

WARD ADMISSION YES☐ NO☐

1. Operative treatment in Theatre ☐
2. Conservative ☐

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

DIED FROM INJURIES YES☐ NO☐

1. In Hospital ☐
2. Not Admitted to Hospital ☐

MAJOR CAUSE OF DEATH (Specify)

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

SECONDARY OR CONTRIBUTING CAUSE (Specify)

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

DIED FROM UNRELATED CAUSE YES☐ NO☐

APPENDIX B

RECORDING OF MINOR INJURIES IN THE RACS DATA

RECORDING OF MINOR INJURIES IN THE RACS DATA

Because Nelson (1974) reported a substantial number of omissions of injuries, possibly mainly minor injuries, a comparison was made with another source of similar injury data to establish whether the RACS data were deficient with respect to minor injuries.

Huelke et al (1977) reported an analysis of injuries recorded on the Collision Performance and Injury Report (CPIR) form by 39 in-depth multidisciplinary accident investigation teams throughout North America. These teams are more likely to have found and recorded minor injuries than the coroners and hospital personnel who completed RTR forms in the RACS survey. The CPIR data are biased towards the more severe collisions and the more serious casualties, something like the RACS matched file which covered only collisions attended by ambulance and, of course, injuries treated at hospitals or resulting in death. Huelke et al also reported an analysis of the Restraint System Effectiveness Study file. These data were not considered for comparison because they are based on tow-away crashes and the data include many more cases of no injury than the CPIR file.

Huelke et al restricted their attention to front outboard seat occupants aged 16 years or older, and from the CPIR file analysed the injuries of:

(a) 5103 occupants in frontal collisions (3950 not wearing seat belts), and

(b) 994 occupants in roll-overs (approximately 760 not wearing seat belts).

Injuries were grouped into six body regions and assigned an AIS score in a like manner to the RACS data, except that where a (not necessarily fatal) injury was sustained by a person who ultimately died, a score of 6 (i.e. died) was assigned irrespective of the severity of the injury. In the RACS data, an AIS score of 6 was reserved for necessarily fatal injuries only.

Since 77% of Huelke's data related to unrestrained occupants, the comparison with the RACS data was restricted to the injuries of occupants without belts (Table B1). The RACS data in Table B1 relate to unrestrained front outboard seat occupants aged 16 years or older, but were not restricted to particular crash types like the CPIR data. About 42% of the RACS occupants were involved in frontal impacts or in crashes in which the vehicle overturned.

In general there was good agreement between the injury severity distributions of the two files when allowance was made for the different methods of treating injuries associated with fatalities. However, except for the head-face region, there appeared to have been some under-recording of minor injuries (AIS=1) in the RACS data. In the case of the neck region, this may have been due to a deliberate policy to assign all soft tissue injuries recorded in the Head and Neck section of the RTR form to the head-face region only.

Notwithstanding the above findings, it was concluded that sufficient minor injuries were recorded in the RACS data to make worthwhile an evaluation of the effect of seat belt wearing on these injuries.

TABLE B1 : Comparison of injury severity distributions on unrestrained occupants in the CPIR file (Huelke et al 1977) and in the RACS matched file. Front outboard seat occupants aged 15 years or older only.

BODY REGION	AIS Score 0 %	1 %	2 %	3-5 %	Died(6) %
1. HEAD-FACE					
CPIR file					
Frontal	33.4	44.8	14.4	4.8	2.7
Rollover	36.6	31.7	12.8	8.6	10.4
RACS file	30.8	43.2	14.4	10.7	1.0
2. NECK					
CPIR file					
Frontal	86.4	10.7	0.9	1.1	0.9
Rollover	82.0	10.5	2.2	2.0	3.3
RACS file	95.8	2.4	0.1	1.7	-
3. THORAX					
CPIR file					
Frontal	71.1	17.7	3.2	5.0	3.0
Rollover	61.7	17.2	4.6	11.4	5.1
RACS file	72.0	13.8	4.5	9.6	-
4. LOWER TORSO					
CPIR file					
Frontal	84.9	9.6	1.2	3.6	0.7
Rollover	70.3	13.4	2.7	10.3	3.3
RACS file	85.8	5.5	0.3	8.3	-
5. UPPER EXTREMITIES					
CPIR file					
Frontal	66.2	27.1	4.3	2.4	-
Rollover	47.9	35.1	11.3	5.8	-
RACS file	68.3	22.5	3.9	5.3	-
6. LOWER EXTREMITIES					
CPIR file					
Frontal	50.6	38.5	6.0	4.8	-
Rollover	52.9	35.1	5.5	6.5	-
RACS file	62.1	28.2	0.9	8.7	-

TABLE B1 (Cont'd)

	AIS Score 0 %	1 %	2 %	3-5 %	Died (6) %
7. **WHOLE BODY**					
CPIR file (OAIS)					
Frontal	15.7	50.4	16.3	11.4	6.2
Rollover	7.7	40.6	15.9	17.2	18.8
RACS file (MAIS)	9.1	48.5	15.5	25.8	1.0

APPENDIX C

DETAILED RESULTS OF

INJURY FREQUENCIES

TABLE C1 : Injury frequencies of non-ejected front outboard seat occupant casualties aged 16 years or older in the RACS matched file, by belt use and crash location.

WHOLE BODY (Maximum AIS)

	Open Road Crashes			Built-up Area Crashes		
	Lap/sash Belt Use		Belt Effect* (%)	Lap/sash Belt Use		Belt Effect (%)
	Not Worn (N=812)	Worn (N=919)		Not Worn (N=1970)	Worn (N=1831)	
MAIS	%	%		%	%	
0	8.5	10.8	+26.8	10.1	13.8	+36.9
1	40.4	44.5	+10.2	55.8	60.6	+ 8.5
2	15.4	11.8	-23.7	15.9	13.4	-16.1
3	17.1	15.6	- 9.1	11.7	8.4	-28.4
4	6.0	5.3	-11.6	2.9	1.5	-47.1
5	11.0	10.0	- 8.7	3.3	2.3	-28.8
6	1.6	2.1	+29.1	0.3	0.1	-82.1
Total	100.0	100.0		100.0	100.0	
Chi-square Test	$x^2_6 = 10.2$ ($p > 0.1$)			$x^2_6 = 43.4$ ($p < 0.001$)		

* Belt Effect (%) $= \left(\frac{\text{Proportion of belted with AIS} = i}{\text{Proportion of unbelted with AIS} = i} - 1\right) \times 100$

Calculated from raw frequency data and any differences from calculations based on the percentages shown are due to rounding.

TABLE C2 : Injury frequencies in the head-face region of non-ejected front outboard seat occupant casualties aged 16 years or older in the RACS matched file, by belt use and crash location.

HEAD-FACE Region

	Open Road Crashes			Built-up Area Crashes		
	Lap/sash Belt Use		Belt Effect (%)	Lap/sash Belt Use		Belt Effect (%)
	Not Worn (N=812)	Worn (N=919)		Not Worn (N=1970)	Worn (N=1831)	
AIS	%	%		%	%	
0	28.3	38.3	+35.2	33.7	49.0	+45.5
1	41.4	38.7	- 6.4	45.2	39.3	-13.2
2	14.9	9.0	-39.4	14.4	8.4	-41.5
3	5.8	4.5	-22.9	3.4	1.9	-43.8
4	0.5	0.4	-11.6	0.5	0.1	-88.0
5	7.5	7.0	- 7.3	2.5	1.3	-50.5
6	1.6	2.1	+29.1	0.3	0.1	-82.1
Total	100.0	100.0		100.0	100.0	
Chi-square Test	$X^2_6 = 28.3$ ($p < 0.001$)			$X^2_6 = 116.6$ ($p < 0.001$)		

TABLE C3 : Injury frequencies in the neck region of non-ejected front outboard seat occupant casualties aged 16 years or older in the RACS matched file, by belt use and crash location.

NECK Region

	Open Road Crashes			Built-up Area Crashes		
	Lap/sash Belt Use		Belt Effect (%)	Lap/sash Belt Use		Belt Effect (%)
	Not Worn (N=812)	Worn (N=919)		Not Worn (N=1970)	Worn (N=1831)	
AIS	%	%		%	%	
0	95.1	94.1	- 1.0	96.9	95.5	- 1.4
1	3.2	2.6	-18.4	2.2	3.4	+51.6
2	0	0.4	n.c.	0.2	0.4	+151.0
3	0.4	1.1	+194.5	0.2	0.4	+88.3
4	0	0.1	n.c.	0	0	n.c.
5	1.4	1.6	+20.5	0.6	0.4	-31.5
Total	100.0	100.0		100.0	100.0	
Chi-square Test	$X^2_5 = 8.2$ ($p > 0.1$)			$X^2_4 = 8.3$ $p < 0.1$)		

n.c. Not calculable (zero in denominator)

TABLE C4 : Injury frequencies in the thorax region of non-ejected front outboard seat occupant casualties aged 16 years or older in the RACS matched file, by belt use and crash location.

THORAX Region

	Open Road Crashes			Built-up Area Crashes		
	Lap/sash Belt Use		Belt Effect (%)	Lap/sash Belt Use		Belt Effect (%)
	Not Worn (N=812)	Worn N= 919)		ot Worn N=1970)	Worn (N=1831)	
AIS	%	%		%	%	
0	65.8	63.0	- 4.2	78.5	76.1	- 3.0
1	14.3	19.3	+34.8	12.8	15.8	+23.8
2	5.8	5.4	- 6.0	3.9	5.0	+28.8
3	6.5	5.1	-21.6	2.3	1.0	-54.6
4	3.7	4.1	+11.9	1.6	1.2	-23.6
5	3.9	3.0	-22.7	1.0	0.8	-15.1
Total	100.0	100.0		100.0	100.0	
Chi-square	$X^2_5 = 9.6$ ($p < 0.1$)			$X^2_5 = 19.5$ ($p < 0.01$)		

TABLE C5 : Injury frequencies in the lower torso region of non-ejected front outboard seat occupant casualties aged 16 years or older in the RACS matched file, by belt use and crash location.

LOWER TORSO Region

	Open Road Crashes			Built-up Area Crashes		
	Lap/sash Belt Use		Belt Effect (%)	Lap/sash Belt Use		Belt Effect (%)
	Not Worn (N=812)	Worn (N=919)		Not Worn (N=1970)	Worn (N=1831)	
AIS	%	%		%	%	
0	80.7	78.8	- 2.3	91.0	89.5	- 1.7
1	6.4	9.6	+49.5	4.3	7.5	+73.4
2	0.6	0.4	-29.3	0.3	0.2	-13.9
3	3.1	2.3	-25.8	1.8	1.3	-26.2
4	8.9	8.3	- 6.7	2.6	1.3	-51.5
5	0.4	0.7	+76.7	0.1	0.3	+169.0
Total	100.0	100.0		100.0	100.0	
Chi-square Test	$X^2_5 = 7.7$ ($p > 0.1$)			$X^2_5 = 28.1$ ($p < 0.001$)		

TABLE C6 : Injury frequencies in the upper extremities of non-ejected front outboard seat occupant casualties aged 16 years or older in the RACS matched file, by belt use and crash location.

UPPER EXTREMITIES

	Open Road Crashes			Built-up Area Crashes		
			Belt Effect (%)	Lap/sash Belt Use		Belt Effect (%)
	Not Worn (N=812)	Worn (N=919)		Not Worn (N=1970)	Worn (N=1831)	
AIS	%	%		%	%	
0	64.8	64.9	+ 0.1	72.6	73.5	+ 1.2
1	22.3	21.9	- 1.9	21.3	21.9	+ 2.7
2	4.7	3.7	-20.9	2.5	2.2	-10.0
3	8.3	9.6	+16.1	3.6	2.3	-33.9
Total	100.0	100.0		100.0	100.0	
Chi-square Test	$X^2_3 = 1.9$ ($p > 0.5$)			$X^2_3 = 5.1$ ($p > 0.1$)		

TABLE C7 : Injury frequencies in the lower extremities of non-ejected front outboard seat occupant casualties aged 16 years or older in the RACS matched file, by belt use and crash location.

LOWER EXTREMITIES

	Open Road Crashes			Built-up Area Crashes		
	Lap/sash Belt Use		Belt Effect (%)	Lap/sash Belt Use		Belt Effect (%)
	Not Worn (N=812)	Worn (N=919)		Not Worn (N=1970)	Worn (N=1831)	
AIS	%	%		%	%	
0	59.4	60.7	+ 2.3	63.7	67.8	+ 6.6
1	26.6	25.1	- 5.5	29.4	27.4	- 7.1
2	0.7	1.2	+62.0	1.0	0.9	- 3.7
3	13.3	12.9	- 2.6	5.9	3.9	-34.7
Total	100.0	100.0		100.0	100.0	
Chi-square Test	$X^2_3 = 1.5$ ($p > 0.6$)			$X^2_3 = 12.1$ ($p < 0.01$)		