Australia's National Crash In-depth Study Progress Report
July 2001

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ABSTRACT

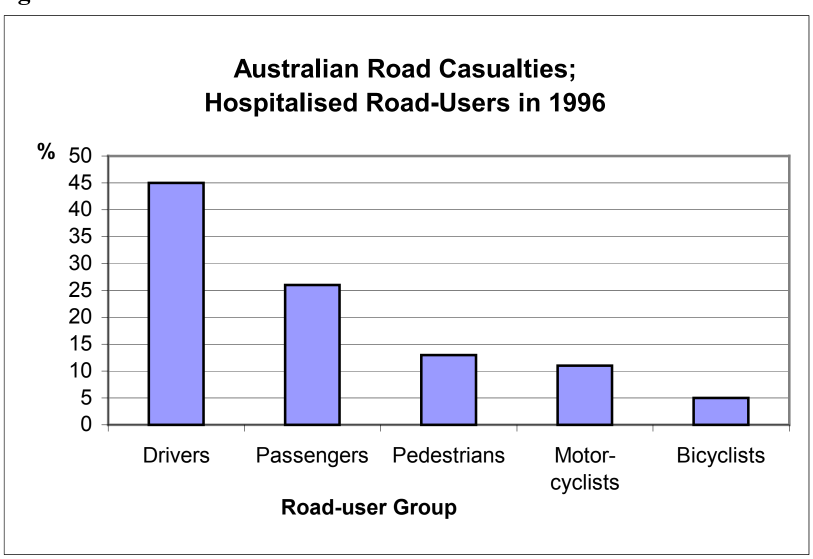
Australia's National Crash In-depth Study (ANCIS) is an ongoing retrospective study of real-world modern vehicle crash performance and occupant injuries undertaken in accordance with the format prescribed by the National Automotive Sampling System. The study primarily focuses on occupants of crashed vehicles who are hospitalised. Study method involves interviewing the patient and/or their relatives, perusal of the clinical records and an engineering assessment of the damaged vehicle. In addition, investigators visit the crash scene to assess various road and crash characteristics. Ten Victorian and three New South Wales hospitals are currently associated with the study. It is anticipated that the study will extend to other states Australia-wide and possibly New Zealand. Data have been collated from 91 cases investigated to date. Statistics and trends regarding various crash configurations such as frontal, side impact and rollovers have been compiled from this data. Injury patterns and scene data associated with these crashes will also be discussed. The study findings will assist in the identification of crash injury trends, emerging vehicle safety problems, as well as confirmation of successful safety developments. Furthermore, a greater understanding of injury biomechanics and possible counter-measures to these injuries may be gained. These data can be used for an in-depth evaluation of modern vehicle crash performance and injury outcomes.

Keywords: (Crash Investigation, Vehicle Safety, Crash Injuries).

INTRODUCTION

In 1996, drivers of vehicles comprised the highest percentage of hospitalised road-users on Australian roads (45%), followed by passengers (26%) according to Australian Transport Safety Bureau statistics as shown in Figure 1. This figure highlights the need for further research into the prevention of occupant injuries sustained as a result of motor vehicle crashes.

Figure 1:



In recent times, there has been a global expression of the need for quality in-depth data on the crash performance of modern vehicle designs. This has eventuated for a number of reasons including:

a) the development of new in-vehicle technology and a requirement for evaluation of field outcomes in comparison to laboratory performance;
b) the development of regulatory compliance testing in a number of countries including the introduction of frontal and side impact test requirements; this has lead to the need for an evaluation of the suitability of the compliance test conditions with respect to real-world crash conditions;
c) the emergence of New Car Assessment Programmes (NCAP) in a number of countries; and
d) a continual need for quality crash-injury data to improve the body of knowledge on human tolerance to impact and injury biomechanics and their relationship to injury criteria as assessed by anthropomorphic dummies in both the regulatory compliance and NCAP crash tests.

In April 2000, MUARC commenced an in-depth crash-injury study in Victoria, which is working towards expanding into a national study in the coming years. This study, known as Australia's National Crash In-depth Study (ANCIS) is designed to replicate an earlier study that was undertaken by MUARC between 1988 and 1992. Changes in the effectiveness of modern vehicle design can be evaluated and outstanding problems highlighted. This paper describes the study objectives, method and some of the preliminary results to date.

OBJECTIVES

The objectives of the study are as follows:

1) to undertake detailed in-depth inspections of a representative sample of modern passenger vehicle crashes across Australia. This will help to determine the patterns and severities of current crashes, the extent and severity of occupant injuries in these crashes, and the causes of and possible solutions to these injuries;

2) to provide annual analysis of this data to report on crash and injury trends as they develop and to identify emerging vehicle safety problems and issues that need to be addressed.

METHOD

A multi-disciplinary approach is used in the collation of data for ANCIS. Ten Victorian hospitals are associated with the study and recently the study extended to New South Wales, where a pilot study at three Sydney metropolitan Hospitals was undertaken. It is anticipated that the study will eventually include 11 hospitals in New South Wales, as well as other hospitals Australia-wide and possibly New Zealand.

The initial inclusion criteria that is applied during the hospital recruitment for each case specifies that:

1) the participant must be an injured occupant of a crashed vehicle and be a current in-patient at one of the study hospitals;
2) the vehicle must be a passenger car and no older than 10 years. This is due to the substantial improvements in vehicle design over this time period; and
3) informed consent must be gained from the participant and/or their next of kin.

The process that occurs in order to complete each case study is described below:

Sourcing potential cases

Research nurses source potential cases using one of the following methods as preferred by the participating hospital

a) Trauma data co-ordinator notifies research nurses of potential cases via e-mail;
b) Emergency clerical staff notify research nurses at least weekly of patients who have been admitted to the hospital as a result of a motor vehicle crash; or
c) Research nurses visit the hospital's Emergency Department and access a list of patients recently admitted to the hospital as a result of a motor vehicle crash, eliminating those who are injured pedestrians, motorcycle riders or bicyclists.

Patient Consent

The Unit Manager or the nurse caring for the patient is consulted by the research nurse regarding the suitability of the patient for the study, their ability to give informed consent and the timing of the approach. Informed consent is gained from the patient prior to participation. In the case of patients who are unable to give their own informed consent such as unconscious, confused or paediatric patients, consent is sought from the patient's next of kin. All information gathered by the research nurse is treated as confidential and any identifying information is removed before the case is entered into the database.

Consent for the study involves 3 components:

1) an interview (not essential)
2) examination of the patient's hospital records for accurate descriptions of documented injuries; and
3) examination of the vehicle in which the patient was travelling.

Interview and medical data collection

After informed consent is obtained, the research nurse carries out a brief structured interview with the injured person(s) during their hospital stay. Participants are asked questions about the car and the circumstances of the crash, their health status prior to the crash and their understanding of their injuries and how they were sustained. Also, any injuries sustained by other occupants in the car are ascertained if possible. Drivers are also questioned regarding their past driving experience and possible contributing factors to the crash. The participant's medical and radiological records are examined so as to gain accurate descriptions of their injuries. In the case of critically ill patients the interview is not performed, however, the next of kin may be able to provide some of the relevant details.

Vehicle inspection

All located vehicles involved in the crash are examined by an engineer (pending owner consent) in accordance with a standard proforma that is based on previous national and international studies. Information is recorded on approximately 300 aspects of each vehicle and both the interior and exterior are photographed extensively. The engineer performs the in-depth inspection of the crash-damaged vehicles at tow-truck storage yards, auction-houses and panel-beating shops.

Scene inspection

The crash scene is visited, inspected and photographed.

Case Analysis and Severity Measures

Injury severity: Injury coding allows for a standardised system for categorising injury type and severity and allows for analysis of data on a local and international level. The Abbreviated Injury Scale dictionary (1998 revision) is used to assign an appropriate six-digit code to each injury. The last digit of the AIS code classifies the injury on a threat-to-life scale from 1 to 6 as follows:

1=minor (e.g. bruise)
2=moderate (e.g. simple limb fracture)
3=serious (e.g. basilar skull fracture)
4=severe (e.g. major liver laceration)
5=critical (e.g. major aortic laceration)
6=maximum (e.g. decapitation)

The Maximum Abbreviated Injury Score (MAIS) is recorded for each participant, as well as the Injury Severity Score (ISS). The ISS is an indication of the overall severity of a person's injuries and is calculated by summing the squares of the highest AIS code in each of the three most severely injured body regions. Furthermore, all occupant injuries and their associated contact sources are classified and coded using the National Automotive Sampling System (NASS).

Crash Severity: Estimations of change of velocity (Delta-V) and Equivalent Barrier Speed (EBS) are calculated using the CRASH3 reconstruction package.

Collaboration: Sources of injury and injury mechanisms are determined collaboratively by all involved in the case analysis (i.e. the research nurse and the crash investigation engineers) using a 'best-evidence synthesis approach'.

Case History

A case history is produced for each case including details of the vehicle deformation, the crash circumstances, the crash severity, the injury descriptions and mechanisms. Key aspects of this information are also entered onto a summary sheet. No identifying information is recorded and analysis is only performed on aggregate crash data. Data analysis performed does not make any reference to vehicle make or model.

RESULTS

A total of 91 completed cases are held in the ANCIS database at present. The results presented below are an overview of these cases. It is stressed that the analysis is based on a small sample only and therefore interpretation analysis should be viewed with caution. The occupants in the sample are comprised of drivers (79%); front left seat passengers (17%) and rear left seat passengers (4%). There was a 95% seat belt usage rate confirmed during the vehicle inspection. The occupant characteristics are presented in Table 1.

Table 1: Occupant characteristics

Sex	Males 64% (n=58)	Females 36% (n=33)
Age	Mean=39 years	Range 4-87 years
Height	Mean=171cms	Range 120-201cm
Weight	Mean=75kg	Range 22-150kg
ISS	Mean=15	Range 0-75

It is acknowledged that in many crashes the vehicle sustains more than one single impact. The figures used in the impact classification table therefore reflect the impact that was thought to cause the most serious injury to the vehicle's occupants. The impact classification data related to the ANCIS cases to date are not necessarily representative of the impact classifications of all Victorian crashes involving hospitalised occupants.
This is illustrated when comparing the impact classifications of the ANCIS cases with those reported in the TAC[1] Claims File 2000 (Table 2). While frontal crashes are the most common type of crash in both samples, side-impact crashes and rollovers are over-represented in ANCIS crashes compared with all Victorian crashes involving hospitalised occupants.

Table 2: Distribution of impact classification for ANCIS cases and for a hospitalised sample in Victoria (TAC Claims File 2000)

Impact classification	% of ANCIS Crashes	% of Victorian hospitalised sample-vehicle occupants in cars 1991 and onwards (TAC database)
Frontal	48% (n=44)	68.7% (n=860)
Side	36% (n=33)	19.3% (n=241)
Rollover	10% (n=9)	4.6% (n=58)
Rear	6% (n=5)	7.4% (n=92)

Analysis of the data to date shows approximately half of the total ANCIS cases were involved in frontal collisions (48%) and approximately one quarter were involved in driver's side impact collisions (23%) (Table 3). The remaining cases were involved in passenger side, rollover and rear impacts. It has also been found that a side impact crash to the driver's side of the vehicle resulted in the highest mean ISS outcome to individual occupants, followed by a side impact crash to the passenger side, frontal crashes, rollovers and finally rear impacts (Table 3). These figures can be seen to reflect the more severe nature of side impacts.

Table 3: Impact classification with associated Mean Injury Severity Scores

Impact classification	**%**	**Mean ISS**
Frontal	48% (n=44)	14
Driver's side	23% (n=21)	20
Passenger's side	13% (n=12)	16
Rollover	10% (n=9)	14
Rear	6% (n=5)	11

Results to date also illustrate that in approximately one third of the total sample (34%), the object struck by the case vehicle was another car and another one third struck a tree or pole (33%). The remaining case vehicles struck other objects such as a truck/bus or rolled with or without a pre-impact (Table 4).

Table 4: Object struck by case vehicles

Object struck	**N**	**%**
Car	31	34%
Tree/pole	30	33%
Other	12	13%
Truck/bus	9	10%
Roll	6	7%
Roll with pre-impact	3	3%

Not surprisingly, the Equivalent Barrier Speed (EBS) and Delta-V were found to be higher in rural crashes than in urban crashes although these differences were not considerable. Higher Equivalent Barrier Speeds and Delta-V could be expected in rural areas compared with urban, as rural areas tend to have more open roads with higher speed limits.

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[1] TAC= Transport Accident Commission, a Victorian government-owned organisation whose role is to pay for treatment and benefits for people involved in transport accidents.

Also, the Mean ISS was higher in rural crashes (16.7) compared with urban crashes (14.3) but this is probably a function of slightly higher crash severities (Table 5).

Table 5: Equivalent Barrier Speed and Delta-V in Urban Vs Rural Crashes and associated Mean Injury Severity Scores

Urban	Rural
Equivalent Barrier Speed = 41.4km/hr (n=49)	Equivalent Barrier Speed = 44km/hr (n=22)
Delta-V= 42.4km/hr (n=31)	Delta-V= 47km/hr (n=14)
Mean Injury Severity Score = 14.3 (n=59)	Mean Injury Severity Score =16.7 (n=32)

Table 6 illustrates that when the object struck is a pole in both frontal and side impact crashes, the mean ISS is higher than when the object struck is another car. This is despite the fact that frontal impacts have a higher mean Delta-V and EBS in car-to-car crashes than car-to-pole crashes. This shows the severe nature of car-to-pole crashes and the need to discover ways of preventing or minimising injuries in these collisions.

Table 6: Mean Crash and Injury Severity by frontal and side impact crashes

Body region	FRONTAL		SIDE IMPACTS	
	Car-to-Car (n=18)	Car-to-Pole (n=18)	Car-to-Car (n=12)	Car-to-Pole (n=11)
Mean Delta-V	65 km/h	44 km/h	32 km/h	41 km/h
Mean EBS	45 km/h	44 km/h	26 km/h	41 km/h
Mean ISS	12	17	12	29

When considering all types of impacts the most commonly injured body region is the chest. Table 7 shows the breakdown of the percentage of occupants with MAIS 2+ injuries by the various impact types. This table also demonstrates that the head is the most commonly injured body region in car-to-pole impacts (29%) and rollovers (50%), while chest injuries feature more predominantly in other crash configurations. Lower limb injuries occur quite frequently in most crashes apart from rollovers.

Table 7: Percentage of occupants with MAIS 2+ injuries and impact types

Body region	All impacts (n=82)	Car-to-car (n=27)	Car-to-pole (n=28)	Car-to-truck / bus (n=9)	Other (n=10)	Rollover (n=8)
Head	17%	4%	29%	11%	0%	50%
Neck	6%	7%	7%	0%	10%	0%
Chest	35%	37%	21%	44%	80%	12.5%
Abdomen	6%	7%	7%	11%	0%	0%
Upper extremity	10%	7%	14%	0%	10%	12.5%
Lower extremity	20%	30%	21%	22%	0%	0%
Spine	6%	7%	0%	11%	0%	25%

It has also been found that the chest and lower extremities are regions of the body commonly injured in frontal and side impact crashes, whether this is car-to-car or car-to-pole. It is also interesting to note that in side impact crashes involving car-to-pole, head injuries of MAIS 2+ were recorded in 45% of cases whereas in car-to-car side impacts nil MAIS 2+ head injuries were recorded (Table 8). These findings need to be viewed with some caution due to the relatively low number of cases to date.

Table 8: Percentage of occupants with MAIS 2+ injuries in frontal and side impacts by car and pole as the objects struck

Body region	FRONTAL		SIDE IMPACTS	
	Car-to-Car (n=16)	Car-to-Pole (n=16)	Car-to-Car (n=10)	Car-to-Pole (n=11)
Head	6%	19%	0%	45%
Neck	6%	0%	0%	10%
Chest	25%	19%	60%	27%
Abdomen	13%	12%	0%	0%
Upper extremity	13%	25%	0%	0%
Lower extremity	31%	25%	30%	18%
Spine	6%	0%	10%	0%

Table 9 illustrates the time of day at which the ANCIS crashes occurred. When these figures are divided into day/night time (i.e. 6am to 6pm and 6pm to 6am respectively), it can be seen that slightly more crashes occurred during the day (54%) than at night (45%). Again it must be noted that findings are not conclusive at this stage.

Table 9: Time of Day of ANCIS Crashes

Time of Day	% of ANCIS Crashes
12am-6am	16%
6am-12pm	19%
12pm-6pm	35%
6pm-12am	29%

From scene data collated to date, it has been found that the large majority of crashes studied occurred on straight roads (70%) compared to curved roads (30%) (Table 10). It is also important to consider the presence/absence of an intersection at the crash site. Although many of the crashes occurred on straight roads, the presence of an intersection could be seen as a contributing factor. However, there have also been several cases where no discernable highway factor was evident on ‘straight’ sections of road.

Table 10:Type of Road Curvature on which ANCIS crashes occurred

Road Curvature	% of ANCIS crashes
Straight	70% (n=46)
Curved	30% (n=22)

DISCUSSION

This study is a preliminary account of a sample of hospitalised occupants in modern vehicle crashes involving vehicles that are ten years old or less. To date the study is mainly representative of the Victorian situation although there has been some preliminary work undertaken to commence data collection in both New South Wales and Queensland in order to obtain a more representative Australian perspective. Although a number of interesting findings have emerged from this study to date, it should be stressed that with only 91 full crash investigations completed to date, the findings should only be considered as preliminary.

Thus far, as may be expected, frontal impacts are under-represented and side impacts over-represented when the data are compared to all Victorian crashes involving hospitalised occupants (as reported by the TAC claims file 2000). It should be noted that the majority of side-impact damaged vehicles investigated in this study were manufactured before the introduction of the ADR 72 Regulation. Therefore, to date this study has not allowed any real insight into the effectiveness of this regulation. In future years, when more data are available, it may be possible to provide some indication of how successful the ADR72 Regulation has been by examining data collected as part of the ANCIS study. What is somewhat surprising is that to date, the preliminary data indicate that MAIS 2+ head injuries in car-to-car side impacts are not common. This will be closely monitored as the database increases in numbers. It is also interesting to observe that injury outcomes in pole crashes are worse for occupants in both frontal and side impact crashes. Whilst much of the regulatory compliance testing is designed to represent a car-to-car impact, the preliminary results from this study show that car-to-pole crashes are equally likely to occur in a sample of hospitalised occupants. This reinforces the need for pole impacts to be taken into consideration from a design consideration. In this respect, the data support the need for an additional test for head protection in pole impacts. Whilst vehicle design for such impacts may be shrouded in impracticalities, alternative road infrastructure design is another option that could be explored.

Rollover crashes represent a different set of challenges to the vehicle designer. Unlike frontal and side impact crashes, the occupant kinematics in a rollover are very difficult to predict, therefore it is not easy to develop countermeasures for these crashes. At present, some manufacturers have chosen to adopt ‘side-curtains’ as rollover protection devices and generally these serve to prevent ejection of the occupant (either totally or partially) from the vehicle. It will be interesting to evaluate the field performance of such devices and studies such as ANCIS can be of benefit in this respect.

It should be recognised that the mass data analysis used in ANCIS has both strengths and limitations in its approach. Some volatile evidence is lost at the scene by using a retrospective rather than at scene approach. However, it is important to note that this retrospective style of crash investigation can be performed at approximately one third of the cost of investigations carried out immediately post crash (Fildes et al, 1991). The method used is therefore considered optimal given the available resources and it is in line with international practices which allows provision for data-pooling. The accuracy of the crash reconstruction software (CRASH3) used also has its limitations, however it is the best system currently available for a retrospective approach. In addition, information cannot always be collected with regard to other occupants involved in the collision and deaths that occurred prior to arrival in hospital.

CONCLUSION

Real-world data collection such as that collated under the auspices of the ANCIS study is a valuable method of providing manufacturers and rule-making authorities with an informed perspective of the reality of crashes. Furthermore, the adoption of a scientific approach to vehicle safety and the accumulation of reliable and comprehensive databases have shown to be key elements in improving vehicle safety and reducing occupant injuries. It is anticipated that the data will become more representative of the serious crash population, as more cases become available in the years ahead.

ACKNOWLEDGEMENTS

The authors are very grateful for the generous provision of funding provided by the study sponsors. These include the Ford Motor Company of Australia, The Australian Transport Safety Bureau, Vic Roads, the NRMA, the RACV, the Transport Accident Commission, the Motor Accidents Authority, the Roads and Traffic Authority of NSW, Autoliv Australia and Toyota Motor Corporation. We also appreciate the support provided by staff at the participating hospitals throughout Victoria (The Alfred Hospital, Box Hill Hospital, Dandenong Hospital, Frankston Hospital, Geelong Hospital, Monash Medical Centre, Royal Children's Hospital, The Royal Melbourne Hospital, St.Vincent's Hospital and Western Hospital) as well as the three hospitals involved in the ANCIS pilot study in NSW (Liverpool Hospital, Prince of Wales Hospital and St.George Hospital).

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APPENDICES

Appendix I - Case Examples from ANCIS study

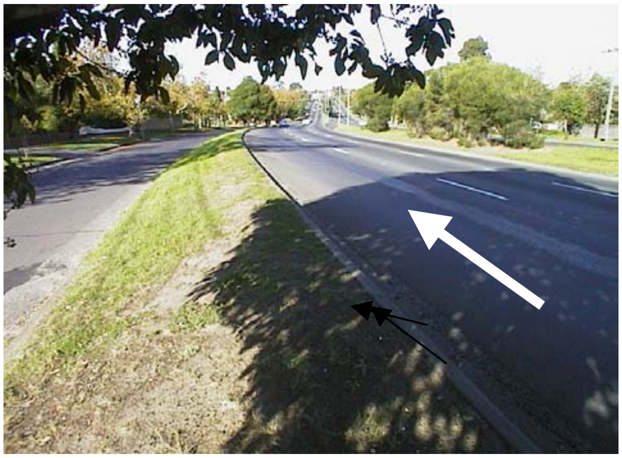
Example 1

Case 1

In this case, the driver and front seat occupant were travelling through an intersection when the vehicle in which they were travelling was struck in the driver's side at high speed (in the order of 60-80km/h). The vehicle was fitted with a number of advanced airbag systems including a thorax-bag, an inflatable tubular structure system (ITS) for head protection, a steering wheel airbag and a passenger facia airbag. The side airbag systems on the driver's side deployed as did both the steering wheel and facia airbag.
The injury outcomes were as follows;

	Driver	Passenger
Age	50 years	52 years
Sex	Male	Female
Weight	102kgs	60kgs
Height	191cms	160cms
MAIS	3	2
ISS	27	9
Belt use	Used	Used
Injury Details	Multiple rib #'s (door) Bilateral haemothorax (door) Multiple pelvic #'s (door and centre console) # occipital condyle (probably door) Multiple lower limb #'s (footwell)	Multiple rib #'s (door) Stable pelvis # (centre console)

Example 2



Case 2

In this case, the driver of the vehicle shown above right was driving along a busy main road in the direction shown when she swerved to avoid a dog. As a result, her vehicle left the main carriageway, mounted the kerb, clipped a tree and then rolled over eventually coming to rest in an adjacent service road. She wore her seat belt but there were no other safety features in the vehicle. No other occupants were present in the vehicle. Her injury details were as follows;

	Driver
Age	29 years
Sex	Female
Weight	54kgs
Height	168cms
MAIS	5
ISS	42
Belt use	Used
Injury Details	Fracture dislocation of C6/C7 with complete cord syndrome and associated quadraplegia (roof) Pulmonary contusions (steering wheel) Mediastinal haematoma (steering wheel)