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Biography

Dr David Logan has a PhD in Mechanical Engineering and several years experience in the consulting engineering industry in the areas of machine condition monitoring, mechanical testing, advanced vibration analysis and acoustics. He manages the crashed vehicle investigation team at MUARC, collecting around 200 in-depth cases per year across a number of different studies involving both cars and motorcycles. His research interests include vehicle crashworthiness, crash involvement and vehicle design.

Abstract

ANCIS (Australian National Crash In Depth Study) has been running for over three years, with over 300 cases collected to date in Victoria and NSW. Participants of this retrospective study have been hospitalised as a result of injuries sustained in a motor vehicle crash, where the vehicle in which they were travelling was no more than 10 years old. Data relating to the participant's recall of crash events is collected via a structured interview, their medical records examined, the vehicle inspected and photographed and the crash site inspected in detail. A best evidence synthesis approach is utilised to determine the crash circumstances, occupant injury causation and potential contributing factors to the crash.

Across all crash types, 67% of participants suffered a chest injury, with 44% being AIS2+. Approximately two thirds received injuries to the upper or lower extremities respectively, but only between 28% and 42% were AIS2+. Head injuries were found in 39% of participants and 22% were AIS2+. Information relating to the types of injuries suffered in frontal impacts, side impacts (both struck and non-struck), rear and rollover crashes is presented.

ANCIS is unique in that study sponsors from such varied backgrounds as the automobile industry, state and federal governments, automobile clubs and road designers are collaborating successfully. This study offers a more detailed set of vehicle crash data for analysis and intervention than is available in mass data, helping researchers to develop a better understanding of the effectiveness of the safety of modern vehicles.

1. INTRODUCTION

Figure 1 demonstrates that over 70% of road-users hospitalised in 1997 were either drivers or passengers of motor vehicles, emphasising the value in improving occupant protection. The ANCIS project manages and collects data for an in-depth real world crash database consisting of more than 1300 fields. It endeavours to contribute to the development of effective occupant protection measures by carrying out in-depth analysis of the relationships between injury outcomes, external vehicle damage, passenger compartment intrusion, contact points and crash configurations. The project has been running for more than 3 years and the database continues to grow. At this stage in ANCIS' development, the database has sufficient cases to conduct fairly broad analyses, however as the cases build during the next three years, more detailed studies will become possible.

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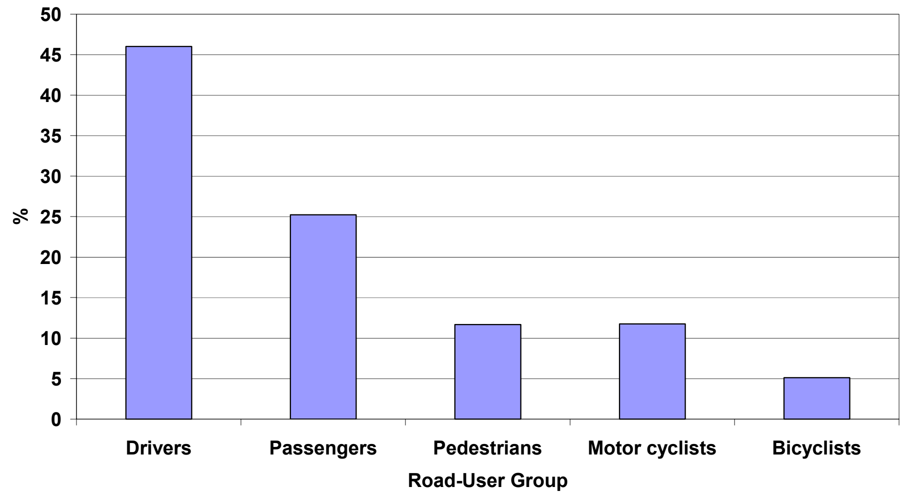

Figure 1: Australian Road Casualties: Hospitalised Road-Users in 1997.

2. METHOD

Data collection procedures were previously outlined in Logan et al (2002). Briefly, the prerequisite for inclusion is that an occupant of a passenger vehicle that is no more than 10 years old was hospitalised as a result of a crash. Once permission is granted by the participant or their next-of-kin, a research nurse conducts an in-depth interview with the occupant, covering human, vehicle and road environment factors. Medical records are also examined to accurately identify the participant's injuries which are coded according to the Abbreviated Injury Scale (AIS) (AAAM, 1998). Then an inspection of the vehicle and site of the crash is made. All this information is collated for further analysis (for example, inspection of the damage profile of the vehicle allows the calculation of the crash severity in terms of delta-V or the Equivalent Barrier Speed). The case is then de-identified and entered into the database. There are currently well over two hundred individual cases in the ANCIS database.

In this paper a subset of these cases will be studied. The criteria for selection of the 187 cases is that information on the anthropometric characteristics of the case individual, as well as the crash configuration, were known. Data analysis will be restricted to frequency tables and cross-tables.

3. RESULTS AND DISCUSSION

Males represented 53% (n=99) of the sample. Table 1 reveals that the mean age of all 187 participants was 42 years with a mean Injury Severity Score of 15.

Table 1: Occupant characteristics.

Age	Mean=42 years	Range 4-87 years
Height	Mean=170 cm	Range 120-201 cm
Weight	Mean=74 kg	Range 22-150 kg
ISS	Mean=15	Range 0-75

ANCIS is intended to be an on-going project and as the number of cases increases it will be used to study the influence that the introduction of new safety technologies has had on occupant protection. Table 2 shows that since the 2001 Road Safety Conference, the number of cases has doubled. However, the distribution of the impact classification of the sample has not changed in the three years. This is as expected, as the recruitment criteria have remained the same to date. From July 2003 the vehicle age criterion has been changed, with vehicles manufactured from 1989 onwards now included. This is intended to increase the recruitment rate.

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

Impact Classification	% of ANCIS Crashes as of July 2003 (n=187)	% of ANCIS Crashes as of July 2001 (n=91)	% of Victorian hospitalised sample – vehicle occupants in cars 1991 onwards (TAC[2] database)
Frontal	50% (n=94)	48% (n=44)	68.7% (n=860)
Side	35% (n=65)	36% (n=33)	19.3% (n=241)
Rollover	9% (n=17)	10% (n=9)	4.6% (n=58)
Rear	5% (n=10)	6% (n=5)	7.4% (n=92)

Table 2 also shows that the distribution of impact classification in ANCIS differs from the Victorian hospitalised sample. For example, the proportion of vehicle occupants hospitalised in Victoria through involvement in a frontal collision is 68.7%, while in ANCIS the proportion is 50%. Furthermore, 35% of the ANCIS sample was involved in side impacts, while such crashes only account for 19.3% of the hospital admissions. Similarly, 9% of the ANCIS sample was involved in rollover crashes, compared with the TAC database. This is probably a reflection of the higher severity of the latter two types of crashes. The ANCIS recruitment method tends to capture the more seriously injured crash victims.

Table 3: Impact classification with associated mean Injury Severity Scores.

Impact Classification	%	Mean ISS
Frontal	50% (n=94)	14
Side, driver	25% (n=46)	18
Side, passenger	10% (n=19)	16
Rollover	9% (n=17)	19
Rear	5% (n=10)	9

Table 3 explains the over-representation of side impacts and rollover crashes in ANCIS. It can be seen that hospitalised cases resulting from an impact to the driver's side or a rollover have a mean Injury Severity Score (ISS) of 18 and 19 respectively, with hospitals generally regarding ISS of 15 or above as major trauma. Hence, while Table 2 shows that such crashes occur less frequently than frontals, when they do occur they tend to have more severe outcomes for occupants. The lower severity of frontal crashes is likely a result of advances in frontal protection made during the last 10-15 years.

[2] Transport Accident Commission

Table 4: Mean ISS for side impacts.

Side Impact Classification	%	Mean ISS	Mean EBS (km/h)	Mean Delta-V (km/h)
Near side	82 (n=53)	20 (n=53)	33 (n=45, 8 u/k)	34 (n=32, 11 u/k)
Far side	19 (n=12)	9 (n=12)	40 (n=12)	44 (n=10, 2 u/k)

A near side impact is where the occupant is on the same side of the vehicle as the impact, while far side represents an impact location on the other side of the vehicle from the occupant seating position. As Table 4 demonstrates, the mean ISS for near side impacts is much higher than that of far side impacts. Both EBS and Delta-V are quoted in the table, because the mass and stiffness characteristics of the collision partner must be known in order to calculate Delta-V.

Table 5: Object struck by case vehicles.

Object Struck	%	Mean ISS
Tree/pole/post	28 (n=52)	18
Car or ute	26 (n=49)	12
Truck/bus/semi-trailer	7 (n=13)	15
4 by 4	7 (n=13)	9
Roll with pre-impact	6 (n=12)	19
Roll	3 (n=5)	14
Other	5 (n=10)	14
Multiple impacts	16 (n=29)	17
Unknown	2 (n=4)	10
Total	100 (n=187)	15

ANCIS also collects information on the collision partner. Table 5 shows that the most common collision partners are narrow objects such as trees, poles or posts, followed by cars or utes (28% and 26% of the sample respectively). Impacts with the narrow objects are more severe (mean ISS=18) than those with other vehicles. The most severe types of crashes are rollover crashes where the rollover was preceded by an initial impact (mean ISS=19). Crashes involving multiple impacts (excluding rollover) also proved fairly severe, with mean ISS of 17.

Table 6: Equivalent barrier speed and delta-v in urban vs rural crashes.

	Urban (n=102)	Rural (n=75)	Mixed (n=8)
Equivalent Barrier Speed (km/h)	39 (n=86, 16 u/k)	52 (n=61, 14 u/k)	49 (n=8)
Delta-V (km/h)	38 (n=61, 41 u/k)	56 (n=40, 35 u/k)	43 (n=7, 1 u/k)
Mean Injury Severity Score	14 (n=102)	17 (n=75)	22 (n=8)

* There were 2 cases where the location-type of the crash was unknown.

ANCIS also collects information on the scene where the crash occurred. It can be seen from Table 6 that most of the ANCIS sample were crashes that occurred in urban areas (55%). However, while crashes that occurred in rural areas were less common, they were more severe in that their crash severity was much higher (EBS of 52 km/h compared with 39 km/h). The high mean ISS of rural crashes is likely due in part to the higher speeds at which they occurred; the mean ISS for rural crashes was 17, compared with 14 for urban areas. Another factor is that most of the hospitals in which recruitment is conducted are in Melbourne. Rural crash recruitment primarily occurs through those crash victims who are airlifted from severe rural crashes to The Alfred.

Table 7: Mean Crash and Injury Severity by frontal and side impact crashes.

	Frontal		Side impacts	
	Car-to-Car (n=37)	Car-to-Pole/Tree (n=29)	Car-to-Car (n=23)	Car-to-Pole/Tree (n=21)
Mean EBS (km/h)	51 (n=35, 2 u/k)	53 (n=29)	32 (n=21, 2 u/k)	36 (n=18, 3 u/k)
Mean Delta-V (km/h)	58 (n=22, 15 u/k)	54 (n=27, 2 u/k)	37 (n=13, 8 u/k)	36 (n=18, 3 u/k)
Mean ISS	12 (n=37)	15 (n=29)	12 (n=23)	24 (n=21)

* In this table "Car" includes cars, utes and 4WDs

In Tables 3 and 5, it was shown that collisions with narrow objects such as poles or trees as well as side impacts resulted in more severe injury outcomes. Table 7 shows that the mean ISS caused by side impacts with poles or trees is 24, compared with 12 for car-to-car impacts. Furthermore, the mean ISS for frontal collisions with poles or trees is 15 (which is also the average for the entire sample). The mean EBS and delta-V for side impact collisions with poles or trees are both 36 km/h. This is less than the mean EBS of frontal collisions and about the same as side impacts with other cars. Thus the high mean ISS for side impacts with poles or trees cannot be attributed to speed. Rather it is probably more likely due to the incompatibility of narrow rigid objects with the side of passenger vehicles and the propensity for such collisions to result in higher levels of passenger compartment intrusion in side impacts.

Table 8: Percentage of occupants with MAIS 2+ injuries and collision partners.

Body region	All impacts (n=187)	Car-to-car (n=62)	Car-to-Pole/ Tree (n=52)	Car-to-Truck/ Bus (n=13)	Rollover (n=17)	Multiple Impacts (n=29)	Other (n=10)
Head	22%	16%	25%	15%	35%	24%	20%
Face	12%	11%	6%	8%	18%	14%	30%
Neck	4%	5%	0%	8%	0%	7%	10%
Chest	44%	42%	40%	69%	47%	45%	60%
Abdomen	20%	19%	29%	15%	0%	21%	10%
Upper ex.	28%	15%	31%	46%	47%	31%	40%
Lower ex.	42%	44%	54%	23%	41%	45%	10%
Spine	16%	15%	21%	8%	24%	10%	10%

* In this table "Car" includes cars, utes and 4WDs

ANCIS also collects detailed information about injuries suffered in crashes. Table 8 presents the distribution of body regions that receive an injury of severity greater than AIS1 with respect to collision partners. The body region that most commonly receives an MAIS2+ injury is the chest (44% of occupants receive such injuries), followed by the lower extremities. In rollover crashes, 35% of occupants in the sample received MAIS2+ injuries to the head, compared with 22% for the entire sample. Furthermore, 47% of occupants in rollovers received an MAIS2+ injury to the upper extremities, compared with 28% of the entire sample.

Table 9: Percentage of occupants with MAIS 2+ injuries in frontal and side impacts.

Body region	Frontal		Side Impacts			
	Car-to-Car (n=37)	Car-to-Pole/Tree (n=29)	Car-to-Car (n=23)	Car-to-Pole/Tree (n=21)	Near side (n=53)	Far Side (n=12)
Head	16%	14%	17%	43%	28%	25%
Face	19%	7%	0%	5%	6%	0%
Neck	3%	0%	4%	0%	4%	0%
Chest	38%	41%	48%	43%	60%	17%
Abdomen	19%	24%	22%	33%	32%	8%
Upper extremity	16%	35%	13%	29%	23%	8%
Lower extremity	43%	52%	48%	62%	57%	33%
Spine	8%	17%	22%	29%	17%	33%

* In this table “Car” includes cars, utes and 4WDs

Table 9 shows the distribution of the body region that receives an MAIS2+ injury with respect to the crash configuration and the impact partner. Interestingly, 43% of side impacts with poles or trees result in an MAIS2+ injury to the head (compared with 22% in the entire sample). Hence, if head injuries could be minimised in such crash scenarios, the overall incidence of head injuries would be greatly reduced. Similarly, 60% of the occupants involved in near side impacts suffer MAIS2+ chest injuries. Hence, indicating another important focus for countermeasure development. Near side impacts and side impacts with poles or trees also often result in MAIS2+ injuries to the lower extremities (occurring in 62% and 57% of such cases respectively). Although there were only 12 far side impacts, it is worth noting that a third of these cases received MAIS2+ spinal injuries, compared with only 16% for the entire sample. It could be that occupants in far side collisions are especially susceptible to spinal injuries perhaps due to the performance of frontal crash-oriented restraint systems in far side crashes. Three of the four were non-contact injuries, with the remaining injury being caused by contact with another occupant’s seat.

4. CONCLUSION

This paper has briefly presented the ANCIS process of collecting data on passenger vehicle crashes that result in hospitalisation to one or more of their occupants. However, the aim of the paper was to demonstrate how in-depth investigations will lead to valuable information becoming available to address areas of improvement in occupant protection. It was demonstrated that side impacts with poles or trees resulted in higher mean ISS values than other crash configurations and also provides detailed data on the body regions affected. For example, near side crashes commonly resulted in chest and head injuries, while occupants involved in far side crashes (despite a small sample size) were particularly prone to spinal injuries. Among other findings, it was also shown that head and upper extremity injuries were especially common in rollovers.

References

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