# THE CAUSE AND NATURE OF HEAD INJURIES SUSTAINED BY PEDESTRIANS

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## INTRODUCTION

A number of studies have described pedestrian trauma. It is generally agreed that the head and the lower limbs are the body areas most frequently injured and that when all severities of injury are considered injuries to the lower limbs are most frequent, but that when only non-minor injuries are considered the head is the most frequently injured area. Tables 1, 2 and 3 show the results of a number of studies for the incidence of head and leg injuries to pedestrians for all severities of injury, for non-minor injuries and for fatalities respectively. Differences between the results may be partly due to variations in the definition of injuries and in the samples used.

Causes of head injuries to pedestrians are less well documented. Robertson et al (1966) reported that 64.6% (n=48) of all severities of head injury and 50.0% (n=6) of fatal head injuries were caused by road contact. A study by the T.R.R.L. (1974) found that for non-minor head injuries 39.4% (n=104) were caused by contact with the road. It was further noted that 33.9% (n=62) of the head injuries caused by vehicle contact came from the windscreen frame. When only fatalities were considered it was reported that 40.0% (n=35) of all fatal injuries could be attributed to the road or to being run over, whilst for vehicle contacts 47.6% (n=21) could be attributed to contact with the windscreen frame or facia.

In this paper cases from an on-going at-the-scene study of pedestrian accidents in the city of Birmingham will be used to describe the injuries sustained by pedestrians struck by cars. In particular the cause and severity of head injuries will be examined.

## THE SAMPLE

Since November 1973 an at-the-scene investigation of pedestrian accidents has been made by the Accident Research Unit of the Dept. of Transportation and Environmental Planning at the University of Birmingham. The methodology of this study has been previously described (Ashton, Hayes and Mackay 1974). To date studies of approx. 280 accidents have been made. The accidents considered for analysis in this paper were those in which the vehicle involved was a car or car derivative, the location of the first contact between the vehicle and the pedestrian was to the front or to the side of the vehicle forward of the 'A' pillars, the accident investigation had been completed at the time of analysis, and the mechanisms of injury could be determined. This gave 171 cases for analysis.

Figure 1 shows the location of the first vehicle-pedestrian contact for children and adults in the sample; a child being defined in this study as a person aged 14 years or under. Table 4 gives the age distribution of the cases by severity of injury sustained. The injury severity was classified using a modified version of the 1974 revision of the Abbreviated Injury Scale (AIS) (States, Huelke and Hames. 1974). Injuries rated as critical (AIS 05) have been subdivided according to whether or not the pedestrian subsequently died, the fatalities being rated as 05F.

Children accounted for 48.0% of the cases in the sample and adults $\geq$60 years old for 20.5% of the cases. Nationally in 1971 46.8% of pedestrian casualties were

children and 18.3% were adults over 60 years old.

Table 5 shows the severity of injuries sustained by children and adults in the sample and by children and adults nationally for 1971. For the sample cases the slight injuries are those rated AIS 01, and the serious injuries are those rated AIS 02 to AIS 05. A comparison of the severity of injuries sustained by the sample cases and the national data showed that they were significantly different (For children $\chi^2_2 = 16.90$; for adults $\chi^2_2 = 92.43$; $\chi^2_2(0.001) = 13.82$). Both the child and adult samples are biased to the severe end of the accident spectrum. For children the sample is under-represented in slight injuries and over-represented in serious injuries, whilst for adults the sample is under-represented in slight injuries and over-represented in both serious and fatal injuries.

OVERALL INJURY SEVERITY AND IMPACT SPEED

Table 6 gives the overall injury severity by impact speed for children and adults.

The speed of the vehicle at impact was assessed by considering such factors as the length of skid marks, the skid resistance of the road surface, the position of the pedestrian on the road at impact, statements of the driver and of witnesses and typical speeds of other vehicles at the accident site.

Five people (2.9%) received no injury; 64 (37.4%) sustained minor injuries and 24 (14.0%) were killed. Ten of the fatalities died at the scene, 13 died later as a direct result of their injuries and one person died from bronchopneumonia a month after the accident. Twelve of the fatalities (50.0%) were people over 60 years old.

The impact speed distributions for the two groups - children and adults were found to be significantly different ($\chi^2_5 = 14.18$; $.02 < p < .01$), the adult group containing higher speed accidents than the child group. For children 15.8% of the cases occured at less than 10 km/h, 13.4% at greater than 40 km/h and 3.7% at greater than 50 km/h. For adults only 4.5% occured at less than 10 km/h, 33.7% at greater than 40 km/h and 14.6% at greater than 50 km/h.

Due to these differences in impact speed distributions it was impossible to compare the injury severity distributions for the child and adult samples in toto. A comparison of the injuries sustained could be made however for certain speed ranges.

In the 0-20 km/h speed range it was not possible to compare the injuries due to the dissimilar impact speeds.

In the 21-40 km/h speed range there was no significant difference between the impact speed distributions for children and adults or between the injuries sustained by children and adults when grouped into the two groups AIS $\leq$ 02 and AIS $\geq$ 03.

In the 41+ km/h speed range there was again no significant difference between the impact speed distributions for children and adults but there was a highly significant difference ($\chi^2 = 7.43$; $.01 < p < .001$) between the injuries sustained when grouped into the two groups AIS $\leq$ 03 and AIS $\geq$ 04. One child (8.3%) and nineteen adults (63.3%) sustained life threatening or fatal injuries (AIS $\geq$ 04).

It would appear therefore that at low speeds there is no difference in the severity of injuries sustained by children and adults but at higher speeds

children sustain less severe injuries than adults.

## LOCATION AND SEVERITY OF INJURIES

For the purposes of this study head injuries included injuries to the face, injuries to the spine were included with neck, chest or abdominal injuries depending upon the location of the injury and pelvic injuries were included with lower limb injuries.

Tables 7a, 8a, 9a and 10a describe the location and severity of the injuries sustained by children and adults for frontal impacts and front corner plus side impacts.

The head and the lower limbs were the body areas most frequently injured; 77.2% of the children and 82.8% of the adults injured sustained a head injury, and 69.6% of the children and 87.4% of the adults sustained a lower limb injury.

When only non-minor injuries were considered it was found that 69.2% of the children and 76.2% of the adults sustained a head injury, and 38.5% of the children and 68.3% of the adults sustained a lower limb injury.

Twenty-five (92.6%) of the pedestrians sustaining critical or fatal injuries (AIS 05 and 06) sustained head injuries.

## HEAD INJURIES

Tables 7b, 8b, 9b and 10b describe the severity of head injuries by impact speed for all contacts, road contacts and vehicle contacts.

A comparison of the severity of head injuries sustained by children and adults showed that in the 21-40 km/h speed range there was no significant difference in the severity of injuries sustained; 13.1% (n = 46) of children and 11.6% (n = 43) of adults sustained head injuries of severity AIS $\geq$ 03. In the 41+ km/h speed range there was a significant difference in the severity of head injuries sustained; 9.1% (n=11) of children and 66.6% (n=30) of adults sustained head injuries of severity AIS $\geq$ 03. ($\chi^2 = 8.5$; $.01 < p < .001$)

It appears that the reason for adults sustaining more severe injuries than children at high impact speeds is due to the adults sustaining more severe head injuries than children.

## ASSESSMENT OF CAUSE OF HEAD INJURY

The determination of the cause of head injury in pedestrian accidents is complicated due to the fact that the head could have contacted either or both the vehicle and the ground. However careful at-the-scene accident investigation can normally provide sufficient information for the cause of injury to be determined.

Examination of the vehicle indicated whether or not there had been a head contact on the vehicle. The contacts seen varied from a cleaning of the surface dirt to physical indentation of the structure. Occasionally hair and/or tissue was found, particularly when there had been a serious head injury.

A detailed examination of the road surface was made and positive identification of a head to ground contact was sometimes made by the presence of hair, tissue or bone on the road surface.

The nature of the wound itself often gave an indication of the cause.

Some situations clearly identify the cause of the injury. Where there had been no head contact on the vehicle but a head injury had been sustained the cause was probably ground contact. Conversely where a vehicle head contact had been identified but no head injury had been sustained it could be positively said that that contact was not injurious.

## CAUSE OF HEAD INJURIES

Minor head injuries were found to be more frequently caused by road contact than vehicle contact, 70.0% (n=40) of the minor injuries sustained by children and 66.7% (n=42) of the minor injuries sustained by adults came from contact with the road surface. Minor injuries accounted for 71.8% (n=39) of the road induced and 42.9% (n=28) of the vehicle induced injuries sustained by children, 56.0% (n=50) of the road induced and 35.0% (n=40) of the vehicle induced injuries sustained by adults.

Life-threatening or fatal injuries (AIS$\geqslant$04) were found to be more frequently caused by head contact with the vehicle, 75.0% (n=4) of these injuries sustained by children and 59.1% (n=22) sustained by adults being caused by vehicle contact. Life-threatening or fatal injuries accounted for 2.5% (n=39) of the road induced and 10.7% (n=28) of the vehicle induced injuries sustained by children, and 18.0% (n=50) of the road induced and 32.5% (n=40) of the vehicle induced injuries sustained by adults.

## ROAD HEAD CONTACTS

A comparison of the severity of head injuries sustained by children and adults from contact with the road showed that in the 21-40 km/h speed range there was no difference in the severity of the injuries. Above 41 km/h there was a higher incidence of severe head injury in adults from contact with the road; no children sustained a head injury of severity AIS$\geqslant$03 whilst seven (23.3%) of adults sustained head injuries of severity AIS$\geqslant$03.

## VEHICLE HEAD CONTACTS

In frontal impacts no head contacts were seen at impact speeds less than 20 km/h. ( Tables 7c, 8c, 9c and 10c$\frac{1}{4}$)

For children head contacts occurred in 60.0% (n=15) of the cases in the 21-30 km/h speed range, 81.8% (n=11) in the 31-40 km/h range and in 100% (n=10) of the cases at impact speeds above 41 km/h. A similar pattern was seen for adults, the incidence of head contact being 61.1% (n=18) in the 21-30 km/h group, 85.7% (n=14) in the 31-40 km/h group and 100% (n=12) for impacts above 50 km/h. In the 41-50 km/h group the incidence of head injury was 69.2% (n=13), this lower figure being due to the presence of cases where due to the vehicle size there was a shoulder contact on the leading edge of the roof and no vehicle head contact.

In the front corner and side front impacts there was one case (12.5%) of head contact in the 11-20 km/h speed range, this being to a child. The incidence of head contact was not seen to be speed dependent as with frontal impacts, there being a 27.3% (n=11) incidence in the 21-30 km/h group and 22.2% (n=9) in the 31-40 km/h group for children. For adults the incidence figures were 20% (n=5) in the 21-30 km/h group, 33.3% (n=6) in the 31-40 km/h group and 25% (n=4) in the 41-50 km/h group.

## LOCATION AND SEVERITY OF VEHICLE HEAD CONTACTS

For children the bonnet was the vehicle structure most frequently contacted by the head; 20 (57.1%) of the head contacts being on the bonnet, 4 (11.4%) on both the windscreen frame and the scuttle and 3 (8.6%) on the windscreen glass.

A contact on the windscreen frame was defined as a contact on either of the 'A' pillars, the leading edge of the roof, or to the sheet metal fold to the rear of the scuttle to which the windscreen is attached. A windscreen contact was defined as a contact on the windscreen only. If there had been a contact on the 'A' pillar and screen it would have been classified as a frame contact. The scuttle was defined as the sheet metal between the rear edge of the bonnet and the windscreen, excluding that defined as frame but including air intake grills when applicable.

Three children sustained life-threatening or fatal injuries from head impacts on the vehicle, 2 of these were caused by contacts with the windscreen frame and one from contact with the scuttle.

Thirteen (65.0%) of the head impacts on the bonnet resulted in no injury or minor injury. All the contacts on the windscreen and one (25.0%) of the scuttle contacts resulted in no injury or minor injury.

With adults the windscreen frame was the vehicle structure most frequently contacted by the head; 35.4% (n=48) of the head contacts being on the windscreen frame, 29.2% on the bonnet, 20.8% on the windscreen glass and 8.3% on the scuttle.

Thirteen adults sustained life-threatening or fatal head injuries from contact with the vehicle; 11 (84.6%) of these injuries came from contact with the windscreen frame, one from contact with the bonnet and one from contact with the scuttle. Life-threatening or fatal injuries accounted for 64.7% (n=17) of the contacts on the windscreen frame.

No injury or minor injury resulted from 11 (78.6%) of the bonnet contacts, 3 (17.6%) of the windscreen frame contacts, 5 (50.0%) of the windscreen glass contacts and one (25.0%) of the scuttle contacts.

## DISCUSSION

The results of this study suggest that at high impact speeds children sustain less serious injuries than adults and that this is mainly due to children receiving less serious head injuries.

Consideration of the causes of these head injuries suggests that children are receiving less severe head injuries than adults from both the ground and vehicle contacts.

The low incidence of severe head injuries to children from vehicle contact appears mainly due to the fact that the windscreen frame is rarely contacted.

Kühnel (1974) has suggested that the lower the initial point of vehicle contact on the pedestrian the greater the pedestrian's angular rotation and the higher they are thrown into the air. This could be one of the factors contributing to children sustaining less severe head injuries than adults from the ground. The higher leading edge of the bonnet height to pedestrian height ratio for children results in lower angular rotation and lower throw height and thus in less severe ground contacts.

The difference in injury experience between children and adults may be only partly explained by vehicle and pedestrian geometry. Other considerations such as the smaller mass of children and possible differences in injury tolerance could contribute to these findings.

One aspect of the influence of geometrical consideration on head impacts is illustrated by considering the effect of the height of the leading edge of the bonnet and the pedestrian's height on head contacts on the vehicle.

Table 11 shows the incidence of vehicle head contact in the speed range 21-30 km/h by the ratio of leading edge of bonnet height to pedestrian height, for frontal impact. The incidence of vehicle head contacts was found to decrease with increasing bonnet height/pedestrian height ratio from 77.8% (n=11) when the ratio is 0.31 - 0.40 to 50% (n=4) when the ratio is 0.71 - 0.80.

## CONCLUSIONS

For pedestrians struck by cars the following conclusions are made:

- children sustain less severe injuries than adults at high impact speeds and this is mainly due to their sustaining less severe head injuries.
- for both children and adults the head is the body area sustaining life-threatening or fatal injuries.
- life-threatening or fatal head injuries are more often caused by vehicle contact than road contact.
- the windscreen frame is responsible for most of the life-threatening or fatal head injuries caused by vehicle contact.

THE RESEARCH ON WHICH THIS PAPER IS BASED IS BEING DONE UNDER CONTRACT TO THE TRANSPORT AND ROAD RESEARCH LABORATORY. ANY VIEWS EXPRESSED IN THE PAPER ARE NOT NECESSARILY THOSE OF THE TRANSPORT AND ROAD RESEARCH LABORATORY OR ANY OTHER PART OF THE DEPARTMENT OF THE ENVIRONMENT.

TABLE 1 INCIDENCE OF HEAD AND LEG INJURIES - ALL SEVERITIES OF INJURY

| STUDY | | n | % HEAD | % LEGS |
|---|---|---|---|---|
| Hall and Fisher | (1972) | 4421 | 50 | 86 |
| Jamieson et al. | (1971) | 51 | 65 | 71 R 73 L |
| Robertson et al. | (1966) | 63 | 76 | 87 |
| Stürtz et al. | (1974) | 66 | 85 | 77 |

TABLE 2 INCIDENCE OF HEAD AND LEG INJURIES - EXCLUDING MINOR INJURIES

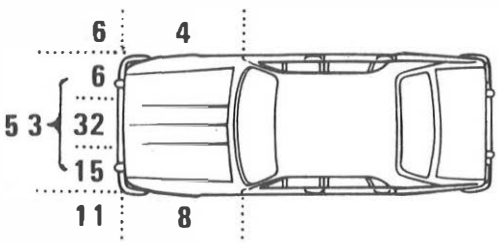
| STUDY | | n | % HEAD | % LEGS |
|---|---|---|---|---|
| Gögler | (1962) | 1149 | 67 | 38 |
| Jamieson and Tait | (1966) | 243 | 67 | 50 |
| T.R.R.L. | (1974) | 149 | 70 | |

TABLE 3 INCIDENCE OF NON-MINOR HEAD AND LEG INJURIES - FATALITIES

| STUDY | | n | % HEAD | % LEG |
|---|---|---|---|---|
| Sevitt | (1968) | 125 | 63 | 48 - fractures only |
| Solheim | (1964) | 168 | 72 | 33 |
| Huelke and Davis | (1969) | 232 | 61 | 58 |
| Jamieson and Tait | (1966) | 86 | 85 | 55 |
| Hall and Fisher | (1972) | 287 | 75 | 91 |

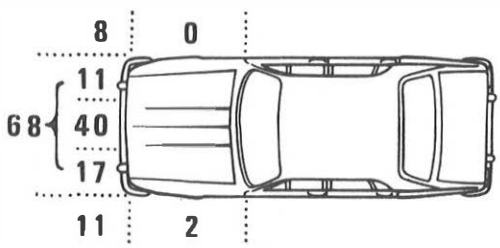
FIGURE 1 LOCATION OF FIRST CONTACT BETWEEN PEDESTRIAN AND VEHICLE

a) Children 0 - 14 years




TOTAL 82

b) Adults 15 + years




TOTAL 89

TABLE 4 OVERALL INJURY SEVERITY BY AGE OF PEDESTRIAN

| AIS | AGE OF PEDESTRIAN | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0-4 | 5-9 | 10-14 | 15-19 | 20-29 | 30-39 | 40-49 | 50-59 | 60-69 | 70-79 | 80+ | TOTAL |
| 06 | | | | 1 | 2 | 1 | | | 2 | 2 | 2 | 10 |
| 05F | | | 1 | | 1 | 1 | 3 | 2 | 1 | 2 | 2 | 13 |
| 05 | 1 | 1 | 1 | | 1 | | 1 | | | | | 5 |
| 04 | | | | | | | | | | 1 | | 1 |
| 03 | 1 | 8 | 5 | 3 | 2 | 2 | 2 | 3 | 5 | 3 | 2 | 36 |
| 02 | 2 | 10 | 9 | 5 | | 1 | 1 | 3 | 2 | 4 | | 37 |
| 01 | 6 | 24 | 10 | 3 | 5 | 3 | 5 | 2 | 2 | 3 | 1 | 64 |
| 00 | | 1 | 2 | | 1 | | | | | 1 | | 5 |
| | 10 | 44 | 28 | 12 | 12 | 8 | 12 | 10 | 12 | 16 | 7 | 171 |

NOTE In Table 4 and in Table 6 the critical injury class (AIS 05) has been subdivided according to whether or not the pedestrian finally died; the fatalities being classified as 05F

TABLE 5 COMPARISON OF SEVERITY OF INJURIES - THE SAMPLE AND NATIONAL DATA 1971

a) CHILDREN

| | INJURY SEVERITY | | |
|---|---|---|---|
| | SLIGHT | SERIOUS | FATAL |
| THE SAMPLE | 50.6% | 48.1% | 1.3% |
| NATIONAL DATA | 70.8% | 27.4% | 1.7% |

b) ADULTS

| | INJURY SEVERITY | | |
|---|---|---|---|
| | SLIGHT | SERIOUS | FATAL |
| THE SAMPLE | 27.6% | 47.1% | 25.3% |
| NATIONAL DATA | 64.3% | 30.5% | 5.2% |

NOTE In Tables 4, 6, 7, 8, 9, 10 injury severity has been classified using the 1974 revision of the Abbreviated Injury Scale (AIS) and impact speed has been classified in 10 km/h increments; class 1 being impact speeds 0-10 km/h, class 2 being 11-20 km/h, class 3 being 21-30 km/h and so on up to class 7 which includes all impact speeds above 61 km/h.

TABLE 6 OVERALL INJURY SEVERITY BY IMPACT SPEED

a) CHILDREN

| AIS | IMPACT SPEED | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | ALL |
| 06 | | | | | | | | 0 |
| 05F | | | | 1 | | | | 1 |
| 05 | | | | 2 | | 1 | | 3 |
| 04 | | | | | | | | 0 |
| 03 | | | 3 | 6 | 4 | 1 | | 14 |
| 02 | 1 | 2 | 7 | 8 | 2 | | 1 | 21 |
| 01 | 9 | 10 | 16 | 3 | 2 | | | 40 |
| 00 | 3 | | | | | | | 3 |
| | 13 | 12 | 26 | 20 | 8 | 2 | 1 | 82 |

b) ADULTS

| AIS | IMPACT SPEED | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | ALL |
| 06 | | | | | 4 | 5 | 1 | 10 |
| 05F | 1 | | 2 | 2 | 4 | 3 | | 12 |
| 05 | | | | | | 1 | 1 | 2 |
| 04 | | | | 1 | | | | 1 |
| 03 | | 2 | 4 | 10 | 5 | 1 | | 22 |
| 02 | 1 | 2 | 6 | 4 | 2 | 1 | | 16 |
| 01 | 1 | 7 | 11 | 3 | 2 | | | 24 |
| 00 | 1 | 1 | | | | | | 2 |
| | 4 | 12 | 23 | 20 | 17 | 11 | 2 | 89 |

TABLE 7 INJURIES SUSTAINED BY CHILDREN IN FRONTAL IMPACTS

a) LOCATION AND SEVERITY OF INJURIES

| LOCATION | SEVERITY AIS | | | | | | |
|---|---|---|---|---|---|---|---|
| | 00 | 01 | 02 | 03 | 04 | 05 | 06 |
| HEAD | 12 | 24 | 13 | 2 | | | |
| NECK | 51 | | | | | | |
| CHEST | 48 | 3 | | | | | |
| ABDOMEN | 43 | 7 | | 1 | | | |
| UPPER LIMBS | 36 | 12 | 3 | | | | |
| LOWER LIMBS | 11 | 28 | 4 | 8 | | | |

51 Cases

b) SEVERITY OF HEAD INJURIES BY IMPACT SPEED

ALL CONTACTS

| AIS | IMPACT SPEED | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 06 | | | | | | | |
| 05 | | | | | | | |
| 04 | | | | | | | |
| 03 | | | 1 | 1 | | | |
| 02 | | | 4 | 4 | 4 | | 1 |
| 01 | 3 | 5 | 7 | 4 | 4 | 1 | |
| 00 | 3 | 4 | 3 | 2 | | | |
| | 6 | 9 | 15 | 11 | 8 | 1 | 1 |

ROAD CONTACTS

| AIS | IMPACT SPEED | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 06 | | | | | | | |
| 05 | | | | | | | |
| 04 | | | | | | | |
| 03 | | | | 1 | | | |
| 02 | | | 2 | 2 | | | |
| 01 | 3 | 5 | 3 | 3 | 4 | | |
| 00 | 3 | 4 | 10 | 5 | 4 | 1 | 1 |
| | 6 | 9 | 15 | 11 | 8 | 1 | 1 |

VEHICLE CONTACTS

| AIS | IMPACT SPEED | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 06 | | | | | | | |
| 05 | | | | | | | |
| 04 | | | | | | | |
| 03 | | | 1 | | | | |
| 02 | | | 2 | 2 | 4 | | 1 |
| 01 | | | 4 | 4 | 2 | 1 | |
| 00 | | | 2 | 3 | 2 | | |
| | 0 | 0 | 9 | 9 | 8 | 1 | 1 |

c) LOCATION OF HEAD CONTACT ON VEHICLE

| | | IMPACT SPEED | | | | | | | INJURY SEVERITY AIS | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 00 | 01 | 02 | 03 | 04 | 05 | 06 |
| WING | 3 | | | | 1 | 1 | | | | 1 | 1 | | | | |
| WING MIRROR | 0 | | | | | | | | | | | | | | |
| BONNET | 20 | | | 8 | 6 | 4 | 1 | 1 | 7 | 6 | 6 | 1 | | | |
| SCUTTLE | 3 | | | 1 | | 2 | | | | 1 | 2 | | | | |
| WINDSCREEN FRAME - BOTTOM | 0 | | | | | | | | | | | | | | |
| 'A' PILLARS | 0 | | | | | | | | | | | | | | |
| WINDSCREEN FRAME - TOP | 0 | | | | | | | | | | | | | | |
| WINDSCREEN GLASS | 3 | | | | 2 | 1 | | | | 3 | | | | | |
| ROOF | 0 | | | | | | | | | | | | | | |
| | | 0 | 0 | 9 | 9 | 8 | 1 | 1 | 7 | 11 | 9 | 1 | 0 | 0 | 0 |

TABLE 8 INJURIES SUSTAINED BY CHILDREN IN FRONT CORNER AND SIDE FRONT IMPACTS

a) LOCATION AND SEVERITY OF INJURIES

| LOCATION | SEVERITY AIS | | | | | | |
|---|---|---|---|---|---|---|---|
| | 00 | 01 | 02 | 03 | 04 | 05 | 06 |
| HEAD | 6 | 10 | 7 | 1 | | 4 | |
| NECK | 28 | | | | | | |
| CHEST | 26 | 2 | | | | | |
| ABDOMEN | 26 | 2 | | | | | |
| UPPER LIMBS | 21 | 7 | | | | | |
| LOWER LIMBS | 13 | 12 | | 3 | | | |

28 Cases

b) SEVERITY OF HEAD INJURIES BY IMPACT SPEED

ALL CONTACTS

| AIS | IMPACT SPEED | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 06 | | | | | | | |
| 05 | | | | 3 | | 1 | |
| 04 | | | | | | | |
| 03 | | | | 1 | | | |
| 02 | | 2 | 3 | 2 | | | |
| 01 | 3 | 1 | 5 | 1 | | | |
| 00 | 1 | | 3 | 2 | | | |
| | 4 | 3 | 11 | 9 | 0 | 1 | 0 |

ROAD CONTACTS

| AIS | IMPACT SPEED | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 06 | | | | | | | |
| 05 | | | | 1 | | | |
| 04 | | | | | | | |
| 03 | | | | 1 | | | |
| 02 | | 1 | 1 | 2 | | | |
| 01 | 3 | 1 | 4 | 2 | | | |
| 00 | 1 | 1 | 6 | 3 | | 1 | |
| | 4 | 3 | 11 | 9 | 0 | 1 | 0 |

VEHICLE CONTACTS

| AIS | IMPACT SPEED | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 06 | | | | | | | |
| 05 | | | | 2 | | 1 | |
| 04 | | | | | | | |
| 03 | | | | | | | |
| 02 | | 1 | 2 | | | | |
| 01 | | | 1 | | | | |
| 00 | | | | | | | |
| | 0 | 1 | 3 | 2 | 0 | 1 | 0 |

c) LOCATION OF HEAD CONTACT ON VEHICLE

| | | IMPACT SPEED | | | | | | | INJURY SEVERITY AIS | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 00 | 01 | 02 | 03 | 04 | 05 | 06 |
| WING | 1 | | | | 1 | | | | | | | | | 1 | |
| WING MIRROR | 1 | | | 1 | | | | | | 1 | | | | | |
| BONNET | 0 | | | | | | | | | | | | | | |
| SCUTTLE | 1 | | | 1 | | | | | | | 1 | | | | |
| WINDSCREEN FRAME - BOTTOM | 0 | | | | | | | | | | | | | | |
| 'A' PILLARS | 4 | | 1 | 1 | 1 | | 1 | | | | 2 | | | 2 | |
| WINDSCREEN FRAME - TOP | 0 | | | | | | | | | | | | | | |
| WINDSCREEN GLASS | 0 | | | | | | | | | | | | | | |
| ROOF | 0 | | | | | | | | | | | | | | |
| | | 0 | 1 | 3 | 2 | 0 | 1 | 0 | 0 | 1 | 3 | 0 | 0 | 3 | 0 |

TABLE 9 INJURIES SUSTAINED BY ADULTS IN FRONTAL IMPACTS

a) LOCATION AND SEVERITY OF INJURIES

| LOCATION | SEVERITY AIS | | | | | | |
|---|---|---|---|---|---|---|---|
| | 00 | 01 | 02 | 03 | 04 | 05 | 06 |
| HEAD | 11 | 21 | 12 | 3 | 1 | 11 | 7 |
| NECK | 62 | 1 | | 2 | | | 1 |
| CHEST | 49 | 10 | | 3 | 2 | | 2 |
| ABDOMEN | 53 | 5 | 1 | 3 | 2 | 2 | |
| UPPER LIMBS | 38 | 22 | 7 | 3 | | | |
| LOWER LIMBS | 8 | 32 | 9 | 27 | | | |

66 Cases

b) SEVERITY OF HEAD INJURIES BY IMPACT SPEED

ALL CONTACTS

| AIS | IMPACT SPEED | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 06 | | | | | 3 | 4 | |
| 05 | 1 | | 2 | | 2 | 5 | 1 |
| 04 | | | | 1 | | | |
| 03 | | | | 1 | 2 | | |
| 02 | | | 3 | 6 | 2 | 1 | |
| 01 | | 6 | 7 | 3 | 4 | | 1 |
| 00 | | 2 | 6 | 3 | | | |
| | 1 | 8 | 18 | 14 | 13 | 10 | 2 |

ROAD CONTACTS

| AIS | IMPACT SPEED | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 06 | | | | | 2 | | |
| 05 | 1 | | 2 | | | 2 | |
| 04 | | | | | | | |
| 03 | | | | 1 | 1 | | |
| 02 | | | 1 | | 1 | 1 | |
| 01 | | 6 | 5 | 2 | 6 | 3 | 1 |
| 00 | | 2 | 10 | 11 | 3 | 4 | 1 |
| | 1 | 8 | 18 | 14 | 13 | 10 | 2 |

VEHICLE CONTACTS

| AIS | IMPACT SPEED | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 06 | | | | | 1 | 4 | |
| 05 | | | | | 2 | 3 | 1 |
| 04 | | | | 1 | | | |
| 03 | | | | | 1 | | |
| 02 | | | 2 | 6 | 1 | 2 | |
| 01 | | | 5 | 2 | 4 | 1 | 1 |
| 00 | | | 4 | 3 | | | |
| | 0 | 0 | 11 | 12 | 9 | 10 | 2 |

c) LOCATION OF HEAD CONTACT ON VEHICLE

| | | IMPACT SPEED | | | | | | | INJURY SEVERITY AIS | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 00 | 01 | 02 | 03 | 04 | 05 | 06 |
| WING | 1 | | | | | 1 | | | | 1 | | | | | |
| WING MIRROR | 0 | | | | | | | | | | | | | | |
| BONNET | 14 | | | 7 | 4 | 3 | | | 6 | 4 | 2 | 1 | | 1 | |
| SCUTTLE | 3 | | | | 2 | | 1 | | | 1 | 2 | | | | |
| WINDSCREEN FRAME - BOTTOM | 5 | | | 1 | 1 | | 2 | 1 | 1 | | | | 1 | 2 | 1 |
| 'A' PILLARS | 4 | | | | | 1 | 3 | | | | | | | 2 | 2 |
| WINDSCREEN FRAME - TOP | 7 | | | 1 | 3 | 1 | 2 | | | 2 | 2 | | | 1 | 2 |
| WINDSCREEN GLASS | 10 | | | 2 | 2 | 3 | 2 | 1 | | 5 | 5 | | | | |
| ROOF | 0 | | | | | | | | | | | | | | |
| | | 0 | 0 | 11 | 12 | 9 | 10 | 2 | 7 | 13 | 11 | 1 | 1 | 6 | 5 |

TABLE 10 INJURIES SUSTAINED BY ADULTS IN FRONT CORNER AND SIDE IMPACTS

a) LOCATION AND SEVERITY OF INJURIES

| LOCATION | SEVERITY AIS | | | | | | |
|---|---|---|---|---|---|---|---|
| | 00 | 01 | 02 | 03 | 04 | 05 | 06 |
| HEAD | 4 | 5 | 7 | 2 | | 2 | 1 |
| NECK | 20 | | | | | 1 | |
| CHEST | 17 | 1 | 1 | 1 | | 1 | |
| ABDOMEN | 19 | | | | 1 | 1 | |
| UPPER LIMBS | 5 | 12 | 3 | 1 | | | |
| LOWER LIMBS | 3 | 11 | | 7 | | | |

21 Cases

b) SEVERITY OF HEAD INJURIES BY IMPACT SPEED

ALL CONTACTS

| AIS | IMPACT SPEED | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 06 | | | | | 1 | | |
| 05 | | | | 1 | 1 | | |
| 04 | | | | | | | |
| 03 | | 1 | | | 1 | | |
| 02 | | 1 | 3 | 3 | | | |
| 01 | | | 2 | 2 | | 1 | |
| 00 | 2 | 1 | | | 1 | | |
| | 2 | 3 | 5 | 6 | 4 | 1 | 0 |

ROAD CONTACTS

| AIS | IMPACT SPEED | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 06 | | | | | 1 | | |
| 05 | | | | | 1 | | |
| 04 | | | | | | | |
| 03 | | 1 | | | | | |
| 02 | | 1 | 3 | 3 | | | |
| 01 | | | 2 | 2 | | 1 | |
| 00 | 2 | 1 | | 1 | 2 | | |
| | 2 | 3 | 5 | 6 | 4 | 1 | 0 |

VEHICLE CONTACTS

| AIS | IMPACT SPEED | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 06 | | | | | | | |
| 05 | | | | 1 | | | |
| 04 | | | | | | | |
| 03 | | | | | 1 | | |
| 02 | | | | | | | |
| 01 | | | | 1 | | | |
| 00 | | | 1 | | | | |
| | 0 | 0 | 1 | 2 | 1 | 0 | 0 |

c) LOCATION OF HEAD CONTACT ON VEHICLE

| | | IMPACT SPEED | | | | | | | INJURY SEVERITY AIS | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 00 | 01 | 02 | 03 | 04 | 05 | 06 |
| WING | 1 | | | | | 1 | | | | | | 1 | | | |
| WING MIRROR | 0 | | | | | | | | | | | | | | |
| BONNET | 1 | | | 1 | | | | | | 1 | | | | | |
| SCUTTLE | 1 | | | | 1 | | | | | | | | | 1 | |
| WINDSCREEN FRAME - BOTTOM | 0 | | | | | | | | | | | | | | |
| 'A' PILLARS | 0 | | | | | | | | | | | | | | |
| WINDSCREEN FRAME - TOP | 0 | | | | | | | | | | | | | | |
| WINDSCREEN GLASS | 0 | | | | | | | | | | | | | | |
| ROOF | 1 | | | | 1 | | | | | | 1 | | | | |
| | | 0 | 0 | 1 | 2 | 1 | 0 | 0 | | 1 | 1 | 0 | 1 | 0 | 1 | 0 |

TABLE 11 VEHICLE HEAD CONTACT IN SPEED RANGE 21 - 30 KM/H BY RATIO OF HEIGHT OF LEADING EDGE OF BONNET TO HEIGHT OF PEDESTRIAN

| | RATIO OF BONNET HEIGHT TO PEDESTRIAN HEIGHT | | | | |
|---|---|---|---|---|---|
| | .31-.40 | .41-.50 | .51-.60 | .61-.70 | .71-.80 |
| Head Contact | 7 | 7 | 2 | 2 | 2 |
| No Head Contact | 2 | 3 | 1 | 2 | 2 |

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