MOTORCYCLE SAFETY - ACCIDENT SURVEY & RIDER INJURIES

J. WHITAKER. Transport and Road Research Laboratory,
Department of the Environment. Crowthorne, (England).

Information not available from national statistics was required about motorcycle accidents. Topics of interest in the survey now being reported include causes of injury, braking and handling performance, conspicuity, riding experience, and safety helmets. A Laboratory report covering all aspects of the survey is in preparation.

The accidents studied come from an area of about 1500 km^2 in Berkshire and Buckinghamshire, and included four towns of populations greater than 20,000 and one greater than 50,000. All motorcycle accidents reported to two divisions of the Thames Valley Police during 1974 were considered. The constable reporting the accident completed a questionnaire, the motorcycle rider was interviewed, and medical information was obtained. In multi vehicle accidents, drivers of other vehicles were not interviewed. Where accidents involved head injuries, riders' safety helmets were borrowed for examination at the Laboratory.

501 accidents were recorded, data being available on 483 of them. The 483 accidents involved 43 pillion passengers. Seventy-six riders and passengers were uninjured, leaving a final sample of 421 injured riders and 29 injured pillion passengers involved in 425 accidents.

The riders and their motorcycles:-

(a) Riders 63% of injured casualties were in the age group 16-19 years. With no data currently available in the UK on age distribution of motorcycle usage, it is not possible to say whether this accident peak is due to inexperience or simply reflects the age pattern of motorcyclists. No age group, including those over 40, was more prone to serious injury than any other.

9% of the sample were females and 6% were pillion passengers. Pillion passengers fared neither better nor worse than their drivers.

(b) Motorcycles 27% of the sample were mopeds, 5% were scooters and 68% were motorcyles. 65% of the vehicles had conventional frames, with the petrol tank between the knees, while 27% were of the 'step through' type (8% not known). The most common engine size was 49 cc (34%), followed by the group 150 - 299 cc (28%).

The accident situation

(a) 75% of the accidents occurred in built up areas(1), and two thirds of these (50% of whole) happened in daylight.

(1) defined as having a speed limit of 40 mile/h or less.

(b) 78% of personal injury accidents involved other persons, either in other vehicles, or as pedestrians or cyclists. 68% of these 'multi vehicle' accidents happened at junctions or roundabouts; the rest occurring on bends or going straight ahead.

(c) The motorcycle was going ahead, and the other vehicle manoeuvring, in 73% of multi vehicle junction accidents. This is reflected in Fig 1 which gives the distribution of speed prior to impact for multi vehicle accidents. It shows a peak in the frequency of motorcycle speeds in the band 21 - 30 mile/h (33-48 km/h), associated with going ahead, but an equally large peak for the other vehicles at 0 - 10 mile/h (0-16 km/h), corresponding to starting a manoeuvre from rest. The estimates of speed are approximate, being based on rider and witness comments and any other evidence available.

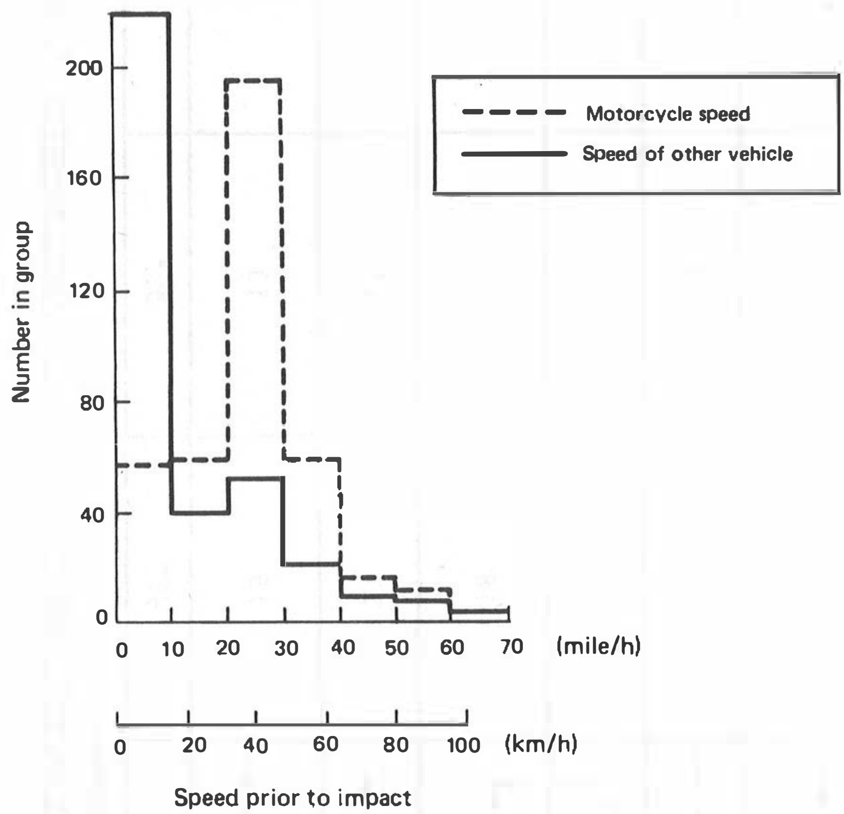

Fig.1 SPEED DISTRIBUTION IN MULTI VEHICLE ACCIDENTS

Some of the more common conflicts are given in table 1.

(d) Accidents were classified into three broad groups. Collisions accounted for 72% of the sample, and included accidents involving skidding of the motorcycle due to heavy braking prior to impact. 12% were loss of control accidents in which no contact was made with other obstacles. (A hazard that the rider avoided may have been present). The third group (15%) took account of accidents where loss of control and collision occurred as two separately identifiable events. A glancing blow against another vehicle followed by an unsuccessful attempt to control the motorcycle, or skidding on a bend and then colliding with a parked vehicle are two examples which would be included in this category.

Movements before accident		Injury severity of motorcyclists (1)			
		Minor (242 casualties)	Moderate (122 casualties)	Severe & Fatal (83 casualties)	All injured casualties (450)
Vehicle emerged turning right into path of other vehicle coming from the right		37	16	13	66
Two vehicles facing the same direction of travel		31	12	10	53
90° collision (including pedestrian impacts)		28	13	4	45
Vehicle turned right across the path of oncoming vehicle		18	15	7	40
Single vehicle going ahead		17	13	9	39
Two vehicles from opposing directions in collision		15	13	9	37
Other		96*	39*	31	170

* 4 cases where severity unknown.

(1) See page 5.

Table 1: Incidence of most common conflicts by injury severity of motorcyclists

Collisions were classified by direction and location as shown in Fig 2.

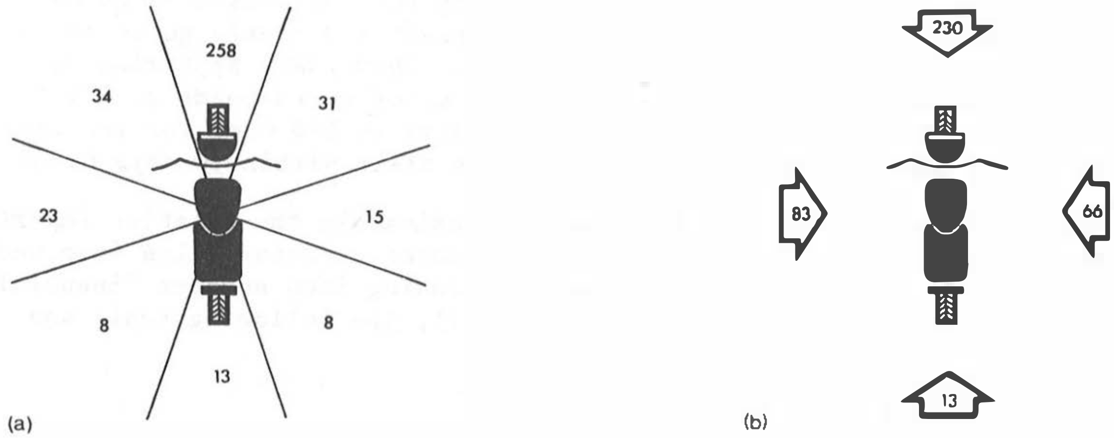

Fig.2 (a) DIRECTION OF IMPACT (b) LOCATION OF IMPACT

The most common group was in a frontal direction to the front of the motorcycle. However it was noted that in many cases the object hit (usually a car) was not perpendicular to the direction of impact and there was a glancing off effect. This is important because the injury pattern, particularly to the legs, will be different from that in a perpendicular impact, and should be considered when designing rider protection devices.

84% of the objects hit by the motorcycle were other vehicles, 5% were pedestrians or cyclists, and 10% were other objects. 12% of the motorcycles hit no object.

Relation to national data

Several aspects of the local survey were compared to national accident data (ref 1) to see if national trends could be observed in the sample. Comparisons of built up with non built up areas, male with female riders, riders with pillion passengers and conditions of the road surface, day of the week and hour of the day all agreed reasonably well with national conditions. A higher proportion of motorcyclists were seriously injured (44% local to 30% national) and a corresponding lower proportion slightly injured (54% local to 69% national) in the local survey. Incidence of fatal casualties was similar considering the small number in the local sample (1.1% local to 1.7% national). Age groups showed more 16 year olds (15% local to 10% national) and less 20 - 24 year olds (13% local to 19% national). Distribution of accidents by month of the year was more scattered in the local sample.

However, there is sufficient similarity between the two to suggest that the more detailed information of the local survey is relevant to motorcycle accidents nationally.

Injuries and causes

In this survey injuries were classified using the TRRL classification which is used on data acquired before 1975. It gives a reliable guide to severity of injury as measured in clinical terms. This scale approximates to the Abbreviated Injury Scale (ref. 2) in that minor corresponds to AIS 1, moderate to AIS 2, severe to AIS 3, 4 or 5 and fatal to AIS 6 or for the body as a whole to any lower category which results in death within 30 days of an accident.

A weighting scale was derived to assess approximately the relative importance of each severity group when looking at the number of motorcycles involved in different aspects of the accident situation. Taking into account financial cost (ref 1) and length of stay in hospital (ref 3), the following scale was produced:-

Minor	1
Moderate	1.5
Severe	15
Fatal	90

The numbers refer to the relative importance which should be attached to an individual motorcyclist with a particular injury severity rating. By summing the numbers for all the riders in each group being considered it will be possible to identify the outstanding features of the sample. For example, the scale focuses attention almost exclusively on severe and fatal injuries even though they represented only 18% of casualties.

Causes of injury were obtained from interviews with the riders. Many minor injuries were reported which did not appear in other sets of data.

Injury pattern

The distribution of injuries over the body varied little amongst the non-fatal groups. Most injuries were to the legs, and there was no significant difference in the numbers of injuries to the left and right of the body in any category. (fig 3). A relatively high proportion of moderate injuries were to the head, most being mild concussion caused by the head hitting the road or another object.

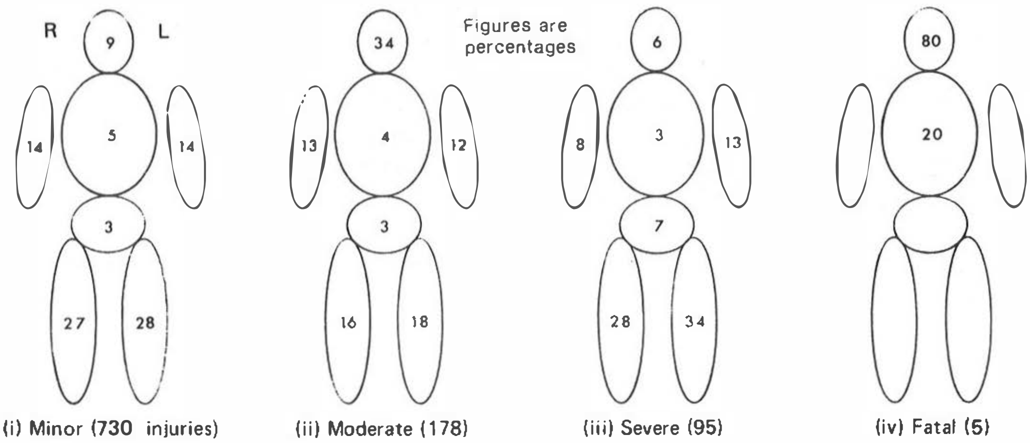

Fig.3 DISTRIBUTION OF INJURIES BY SEVERITY

Five riders were killed. Four died from head injuries and one from injuries to the chest. All were wearing helmets. However, with such small numbers, no conclusions can be drawn about the distribution of fatal injuries. Grattan and Clegg (ref 4), with a slightly larger sample, showed that fatal injuries were equally divided between head and chest.

Causes of injury

Table 2 gives a summary of data collected on causes of injury to the motorcyclists at different severity levels. The proportion of injuries caused by riders hitting either another vehicle or object, or getting their legs trapped between their motorcycles and another obstacle, increases with severity of injury. Conversely the proportion of injuries caused by the road or parts of the motorcycle decreases with severity.

Object	Injury severity			
	Minor	Moderate	Severe & Fatal	All Severities
Handlebars	46	5	3	54
Petrol tank	5	3	1	9
Other motorcycle part	34	7	1	42
Road	399	69	21	489
Other vehicle	134	52	38	224
Other object	35	14	10	59
Trapped between m/c & other object	22	15	15	52
Not known	55	13	6	74
Total	730	178	95	1003

Table 2. Objects causing injury to motorcyclists by severity

When looking in detail at the areas of the body involved, several points can be made:-

(i) Injuries from handlebars, petrol tank, and other parts of the motorcycle occurred mainly to the legs and abdomen. The handlebars also caused several minor injuries to the lower arms and hands.

(ii) The road caused injuries to all parts of the body. One fatal head injury arose from hitting the road. Nearly half of the moderate injuries and one third of the severe injuries caused by the road were to the head. Over a quarter of minor injuries from the road were to the knees.

(iii) Other vehicles were the predominant cause of injury in the severe and fatal groups. They caused injuries all over the body, but especially to the legs. Two people were killed by hitting other vehicles, one with his head, and one with his chest.

(iv) Injuries to riders hitting obstacles such as fences and bollards were present all over the body. One rider received a fatal head injury from hitting a lighting column.

(v) Several riders received injuries from being caught between their motorcycles and another object. The object was usually a car, and injuries were almost exclusively to the legs.

Factors affecting severity of injury

Motorcycle speed and obstacles hit by the rider were the only factors that showed a relation to the severity of injury of the motorcyclist. Patterns in all other aspects of the accident situation did not vary significantly from one injury class to another (including type of conflict, proportion of skidding to collision, direction and location of impact on the motorcycle, speed of the other vehicle, type and size of motorcycle etc).

Figure 4 shows that more severe injury accidents have a greater proportion at the higher speeds. It is known that 3 of the 5 fatals were travelling faster than 64 km/h.

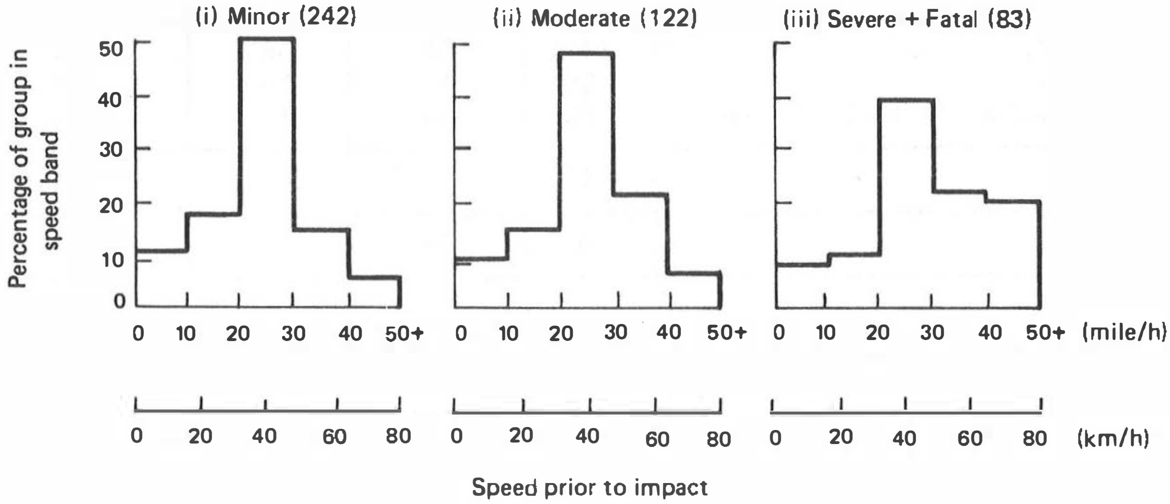

Fig.4 SPEED OF MOTORCYCLE BY INJURY SEVERITY

Safety helmets

Safety helmets were worn by 409 of the 450 injured riders, and not worn by three (38 not known) [compulsory wearing was introduced in 1973] Helmets to British Standard 2001 were worn by 35%, to BS 1869 by 20%, to BS 2495 by 3%, and to foreign standards by 2% (39% not known). There were about five times as many open face helmets as full face, and only a small number of the hard cap type.

The helmets of seven riders did not have their straps fastened, and three of these came off. Chin cups were present on single strap helmets in about half the sample. 14 helmets came off when the strap was fastened, and 12 of these were fitted with chin cups.

Helmet damage was assessed as none, minor or major, major being defined as permanent deformation or cracking of the shell or inner liner. Helmets of casualties with moderate head injuries were no more badly damaged that those of people with only minor head injuries. The number of severe and fatal head injuries (6 severe, 4 fatal) was really too small to establish any pattern. Of the four fatal injuries, damage to the helmet was major in one case but unknown in the other three.

The road was the most common obstacle to be hit by a helmet when head injury was involved. Many head injuries also resulted from hitting solid obstacles such as cars and fences.

Discussion and Conclusions

Other vehicles were the most prominent cause of injury to motorcyclists, being responsible for 42% of severe injuries. Three quarters of such injuries were to the legs. Legs being trapped between the motorcycle and an obstacle accounted for another 17% of severely injured; and, all told, 60% of all severe injuries were to the legs. There seems to be a good opportunity therefore to reduce severe injuries dramatically by giving some protection to the legs.

Although the road accounts for most of minor and moderate injuries, it is not so important for severe injuries (24% of severe injuries were caused by the road, mostly above the legs).

Injuries from the motorcycle itself appear to be much less of a problem than anticipated. Previous work by Bothwell (ref 5) suggested that abdominal injury from the tank was a problem. Only one severe injury due to this was noted. Handlebars caused three severe injuries. Using the weighting scale mentioned earlier, it was deduced that hitting obstacles after being thrown from the motorcycle was an order of magnitude more important than hitting parts of the motorcycle. Effort directed at protecting the rider from his motorcycle would hence only marginally reduce injuries.

Four of the five fatal injuries were to the head and were all a result of hitting a hard object at high speed with the whole body weight behind the head. Protection from severity of this kind is well outside the scope of present helmet standards. It would seem that the best approach would be to reduce the rider's energy before such a severe impact to bring it within the scope of modern safety helmet design. Further attention to helmets, however, may well reduce the high incidence of mild concussion.

Most minor injuries are caused by the road and are spread all over the body. Suitable protective clothing would seem to be a simple answer to minimize these "nuisance" injuries.

Recommended items for further study (based on this survey):-

Injury severity	Dominant features	Recommended developments
Minor	Caused by road, all over body	Clothing, protection from cuts and abrasions
Moderate	Head, mild concussion	Helmet design
Severe	Legs, caused by other objects than the motorcycle, or getting caught between motorcycle & object	Leg protection on motorcycle
Fatal	Extreme severity of impact on vulnerable parts of body	Energy absorbers fitted to motorcycle

Concluding Note

TRRL has, since 1973, been investigating rider trajectories in frontal collisions as part of its overall motorcycle safety programme. This impact configuration was chosen after the results of a small survey undertaken in 1972 showed that this was the most common direction of impact. The present study confirms these findings.

Tests using anthropometric dummies on a rig simulating motorcycle crash behaviour have shown characteristic differences in trajectory for riders of stepthrough mopeds and conventional motorcycles with various shapes of petrol tank. Leading on from this work several energy absorbing devices fitted to the motorcycle are being investigated with the aid of a computer programme simulating rider behaviour. Results will be published subsequently.

This survey has also pointed to the high priority that should be attached to protecting motorcyclists legs, and work on this aspect is now being considered.

Acknowledgements

The work described in this paper forms part of the programme of the Transport and Road Research Laboratory and the paper is published by permission of the Director. The assistance of the Slough and Newbury Divisions of the Thames Valley Police, and the staff of the several hospitals in the same area are gratefully acknowledged. Thanks are also due to Accident Investigation Division TRRL, for their help in collecting and processing the medical and other data and to Road User Characteristics Division, TRRL, for the work of their interviewing staff.

References

1. Department of the Environment. Road Accidents. Great Britain 1974. London 1976 HMSO.

2. **The Abbreviated Injury Scale. Proceedings of the 19th Conference of the American Association for Automotive Medicine, 1975.**

3. E GRATTAN & MAUREEN E KEIGAN. Patterns and severity of injury in a hospital sample of road traffic accident casualties. 5th International Conference of the International Association for Accident and Traffic Medicine, Sept 1975.

4. E GRATTAN & N G CLEGG. Clinical causes of death in different categories of road user. International Research Committee on Biokinetics of Impacts. Conference proceedings June 26-27 1973.

5. P W BOTHWELL. Motorcycle crash tests. Jim Clark Foundation Research Report.