

A STUDY OF TWO-WHEELED VEHICLE CASUALTIES TREATED AT A
CITY HOSPITAL

by

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INTRODUCTION

This paper describes a sample of two-wheeled motor vehicle* and pedal cycle accident casualties treated at a hospital in the city of Birmingham, England. Under reporting of two-wheeled vehicle accidents in national official statistics is shown and the possible reasons and implications of this finding are discussed. The patterns of injuries sustained by the 2 groups of casualties are described with comments on the likely reasons for the observed differences in their injury patterns. A comparison is drawn between the injuries sustained by the TWMV riders in this hospital study and a sample of fatally injured TWMV riders. Finally, the validity of the Treatment Period criteria of the Comprehensive Research Injury Scale is examined.

THE SAMPLE

The sample used for the main part of this paper comprises all pedal cycle and two-wheeled motor vehicle casualties who were treated at the Birmingham Accident Hospital, (BAH) during a 16 month period in 1977-1978. The catchment area for this hospital is essentially urban. However the hospital is also used to treat seriously injured casualties from further afield, where local hospitals do not have the necessary treatment facilities (1). So the sample is not fully representative of casualties involved in road traffic accidents in the BAH catchment area as there is probably a slight over-representation of serious injuries.

During the study period, 545 TWMV riders and 462 pedal cyclists were treated at the hospital. Injury data were collected on all of these casualties through a retrospective examination of the relevant hospital notes. The injuries sustained by each body area were assessed using the Abbreviated Injury Scale (AIS)(2) and 2 injury scaling criteria from the Comprehensive Research Injury Scale (CRIS) namely the Permanent Impairment (PI), and the Treatment Period (TP) scales(3). As the AIS is primarily a 'threat to life' scale it was considered that the PI and TP scales of the CRIS provided a

*The abbreviation 'TWMV' is used for 'two-wheeled motor vehicle'.

convenient means of assessing the relative importance of injuries to the various body areas for casualties in this sample. The PI scale purports to rank injuries according to their likely contribution to permanent impairment or disability, whilst the TP scale is an attempt to represent the period of medical care. If a specific injury was not described in the CRIS dictionary it was assigned a value according to the authors' best estimates of the importance of the injury. Although this was rarely necessary, the unlisted injuries and their assigned PI and TP values are described in Appendix 1.

Police records in the catchment and surrounding areas covered by the Birmingham Accident Hospital were also examined to determine the number of casualties involved in accidents which had been reported to the police.

RESULTS

OFFICIAL ACCIDENT STATISTICS - UNDER REPORTING OF INJURY ACCIDENTS

The published statistics of road accidents in Great Britain describe only those accidents which have been reported to the police (4,5). The police are notified of all fatalities. However, by law, the only other accidents which must be reported to the police are those where the driver of a motor vehicle which has caused injury to another person, has failed to produce the relevant insurance and security certificates(6). Although in practice, other accidents are often reported to the police; it has been shown that official statistics still seriously underestimate the true incidence of persons injured in road traffic accidents. Bull and Roberts(7) in a study of 1200 road accident victims who attended Birmingham Accident Hospital found that 17.7% of the seriously injured and 35.1% of the slightly injured casualties did not appear in police accident records. Hobbs, Grattan and Hobbs(8) reported similar trends in a study of 3641 road traffic accident casualties who attended a hospital in Berkshire, England; 21.3% of the seriously injured and 33.7% of the slightly injured were involved in accidents not reported to the police. Both studies noted an overall greater under-reporting of two-wheeled vehicle accidents.

The present study, covering a more recent period, supports these findings; 87.9% of the pedal cyclists and 44.0% of the TWMV riders were injured in accidents not reported to the police. A breakdown of the relative under reporting in this and the previously mentioned studies is given in Table 1 according to the Ministry of Transport (MOT), definitions for slight and serious injuries. These injury classifications and the MOT fatal criterion are used for official accident statistics (see Appendix 2). Unless otherwise stated, the MOT categories of slight, serious and fatal injuries are also used in this paper.

Accidents Not Reported

The extremely high under reporting of casualties in two-wheeled vehicle accidents probably largely reflects the nature of the accidents. The police do not have to be notified of single vehicle accidents in which only the drivers are injured. In this study, 65.3% of the TWMV riders and 98.6% of the pedal cyclists injured in single vehicle accidents were not included in police accident reports. A significantly higher incidence of notification was found for casualties injured in accidents where another vehicle was involved

Table 1 Percentage of Slightly and Seriously Injured Two-Wheeled Vehicle Casualties Involved in Accidents Not Reported to the Police.

TWMV Casualties:

Data Source	% Casualties in Non-Reported Accidents		Total Sample ⁺ Size
	Slightly Injured	Seriously Injured	
Current Study	57.9%	28.6%	540
Bull & Roberts (7)	36.7%	27.7%	145
Hobbs, Grattan & Hobbs (8)	45.4%	26.8%	754

+Fatalities have been excluded.

Pedal Cycle Casualties:

Data Source	% Casualties in Non-Reported Accidents		Total Sample ⁺ Size
	Slightly Injured	Seriously Injured	
Current Study	91.2%	83.0%	459
Bull & Roberts (7)	80.7%	65.0%	154
Hobbs, Grattan & Hobbs (8)	71.0%	58.5%	488

+Fatalities have been excluded.

($\chi^2 = 363$). In light of the common misconception that all accidents involving injury to a third party must be notified to the police, the high percentage of multi-vehicle accidents reported, is not surprising. Table 2 compares the reporting rates for the slightly and seriously injured riders involved in single or multi-vehicle accidents. The accident type was not established for 40 of the casualties. Notwithstanding the over-representation of casualties who suffered slight injuries in the single vehicle accident sample, there also seems to be a higher incidence of notification to the police for seriously injured casualties. As expected, all fatalities were included in police accident records.

Implications of Under Reporting

As official accident statistics for Great Britain describe only those accidents which have been reported to the police, accidents involving pedal cyclists and TWMV riders are significantly under stated in these statistics. So resource planning or the assessment of legislative changes based solely on the national published figures are likely to be invalid unless recognition is taken of the findings of this and other studies of under reporting. Alternatively, there would seem to be good reasons for making use of hospital records as the basis of official statistics.

THE TWO-WHEELED MOTOR VEHICLE CASUALTIES

General Description of the Sample

There were 545 TWMV riders treated at BAH during the study period. It was established that 483 (88.6%) of these riders were operating the TWMVs at the time of their accidents; 92.1% of these drivers were males. In all, 471 (86.4%) of the casualties were male and 440 (80.7%) were aged 16-19 years. In Great Britain the minimum legal age for driving a TWMV is 16 years, only one driver in the study was under this age. The large number of young males in the sample probably reflects the great popularity and use of TWMVs by this section of the population. However, at present there are no published national data which allow us to examine this speculation.

Admission Status and Treatment Period

There were 44 casualties who did not attend BAH until at least 24 hours after their accidents; 75.0% of these casualties were slightly injured and 25.0% seriously injured. There were 177 (32.5%) casualties who received inpatient care; 5 of these casualties subsequently died. Almost a third of the remaining casualties stayed in hospital for only 1 or 2 nights, but in contrast 23.1% were detained as inpatients for more than 4 weeks. The remaining 368 (67.5%) TWMV casualties received only outpatient care and 57.8% of these riders received no further treatment at BAH following their first visit. Only 14.9% of all the outpatients were referred to other medical services, commonly their own doctors.

The TP values which were assessed for each casualty are presented with the observed lengths of hospital care in tables 3 and 4 for inpatients and outpatients respectively. Using Spearman's rank coefficient, a correlation value of 0.6489 was found between TP and actual length of inpatient care, and the correlation between TP and the number of hospital visits

Table 2 Police Notification of Single Vehicle and Multi-Vehicle Accidents Involving Slightly and Seriously Injured Riders.

TWMV Casualties:

	<u>Single Vehicle Accidents</u>		<u>Multi-Vehicle Accidents</u>	
	Slight (N=124)	Serious (N=100)	Slight (N=121)	Serious (N=139)
Not Reported to Police	77.5%	47.0%	28.9%	13.7%
Reported to Police	22.5%	53.0%	71.1%	86.3%

Pedal Cycle Casualties:

	<u>Single Vehicle Accidents</u>		<u>Multi-Vehicle Accidents</u>	
	Slight (N=259)	Serious (N=110)	Slight (N=38)	Serious (N=32)
Not Reported to Police	98.8%	99.1%	34.2%	28.1%
Reported to Police	1.2%	0.9%	65.8%	71.9%

Table 3 Observed Length of Inpatient Care Compared to 'Treatment Period' Value for TWMV Casualties (N=161)

Nights Detained in Hospital	TP Value					TOTAL	
	1	2	3	4	5	N	%
1 (24 hours or less)	22	5	5	5	2	39	24.2
2 Nights	4	2	3	0	0	9	5.6
3 Nights	1	2	3	1	0	7	4.3
4 Nights	2	1	3	2	0	8	5.0
5 Nights	1	3	2	1	0	7	4.3
6 Nights	0	0	3	2	1	6	3.7
7-14 Nights	2	7	8	6	2	25	15.5
15-21 Nights	1	1	2	8	3	15	9.3
22-28 Nights	0	1	1	3	4	9	5.6
>28 Nights	0	0	3	20	13	36	22.4

+Unknown values and fatalities have been excluded.

Table 4 Observed Number of Outpatient Visits for TWMV Casualties Receiving Only Outpatient Care Compared to 'Treatment Period' Value (N=351)+

Number of Visits	TP Value				TOTAL	
	1	2	3	4	N	%
1	191	14	0	1	206	58.7
2	52	9	4	1	66	18.8
3	17	9	2	3	31	8.8
4	11	3	4	3	21	6.0
5	5	1	6	0	12	3.4
6	1	0	4	0	5	1.4
7	2	0	3	1	6	1.7
≥8	0	2	2	0	4	1.1

+Unknown values and fatalities have been excluded.

made by casualties who only received outpatient care, was 0.4734. The validity of using TP as a predictor of injury severity is considered later in the paper.

Pattern of Injuries

Examination of the body regions which have the highest or equally highest AIS and PI values shows that both leg and arm injuries play a significant part in TWMV rider injuries. Both the AIS and PI scales rate leg injuries as the most important type of injury with arm injuries rated as second in importance. The AIS ratings for injuries sustained in different body regions are presented in table 5. There is a relatively low incidence of severe head injuries. Head injuries rated AIS ≥ 4 were reported for only 5 casualties. Injuries to the surface of the face were sustained by 74 (16.3%) of the casualties, 11 involving facial bone fractures. Unfortunately neither the police nor hospital records held any information about the riders' helmets, but it seems reasonable to suggest that the great majority of riders were wearing protective helmets at the time of their accidents. In Great Britain, since June 1973, it has been compulsory for all TWMV riders to wear protective head-gear (9), and conformity to this legislation has been observed to be good.

The importance of upper and lower limb injuries for this sample of casualties has already been shown. For this reason, it would seem worthwhile to consider means of protecting these body regions from direct impacts. The fitting of protective leg guards to TWMVs is one possibility and the potential role of clothing in ameliorating these injuries should not be overlooked. There were 99 (18.2%) casualties with lower limb fractures, over half of these were injuries with a AIS ≥ 3 and there were 11 multiple long bone fractures. In 95 (17.6%) cases the riders sustained one or more fractures of the upper limbs.

Comparison with a Study of Fatalities

It is interesting to compare the patterns of injuries suffered by the surviving TWMV riders in this hospital study with those of a group of fatally injured riders examined in an in depth accident investigation. Table 6 shows the nature of injuries for these 2 groups of TWMV riders. Clearly the injuries sustained by the fatalities are far more severe and numerous than those received by the hospitalised casualties. The relative importance of leg and arm injuries for the hospital TWMV casualties in comparison to injuries in other body areas contrasts markedly with our findings in the study of fatalities. Overall, in the group of fatally injured TWMV riders, the head featured as one of the most frequently and most severely injured body regions followed by chest and abdominal injuries; the importance of leg and arm injuries tended to be minimized by the life-threatening and fatal injuries in other body areas.

One of the observations in the study of fatalities was the quite outstanding severity of the head injuries; frequently the whole cranium and its contents were destroyed. In comparison head injuries were not only less important in the sample of survivors, but the characteristic head injuries was typically rated AIS ≤ 2 . In conclusion it seems that head injuries are not evenly distributed up the AIS scale - survivors have either no head injury or

Table 5 Location and Severity of Injuries Sustained by TWMV Casualties
(N = 545)+

Body Area	Injury Description	AIS Score					
		0	1	2	3	4	5
Head	Surface	528	17	0	0	0	0
Head	Skeletal	536	0	7	0	2	0
Head	Internal	473	13	49	1	0	5
Face	Surface	471	68	6	0	0	0
Face	Skeletal	534	6	4	1	0	0
Chest	Skeletal	536	0	4	4	1	0
Chest	Internal	538	0	0	7	0	0
Abdomen	Internal	540	0	0	0	3	1
Upper Limbs	Surface	354	189	2	0	0	0
Upper Limbs	Skeletal	444	8	61	26	0	0
Pelvis	Skeletal	527	0	6	12	0	0
Lower Limbs	Surface	203	313	28	1	0	0
Lower Limbs	Skeletal	445	8	36	44	11	0

+ Different row totals indicate exclusion of those cases where there was insufficient injury information for an AIS value to be assigned.

Table 6 Frequencies of Injuries Sustained by Surviving TWMV Riders in Hospital Study Cases Compared to a Sample of Fatally Injured Riders

	Fatalities (N = 194)	Survivors (N = 540)
	<u>% with AIS >1</u>	<u>% with AIS >1</u>
Head, skeletal	54.4	1.3
Head, internal	76.4	9.5
Face, skeletal	17.0	0.9
Face, internal	4.1	0
Neck, skeletal	11.9	0.2
Chest, skeletal	36.1	1.7
Chest, internal	65.5	0.9
Abdomen, internal	51.5	0.7
Pelvis, skeletal	7.2	3.3
Arms, skeletal	29.9	16.1
Legs, skeletal	34.0	16.7

head injuries rated AIS ≤ 2 , whilst fatalities suffer gross head injuries, rated AIS 5 or 6.

THE PEDAL CYCLE CASUALTIES

General Description of the Sample

In the hospital sample of 462 pedal cycle casualties 79.0% were males and 57.7% of all the riders were aged between 5-14 years. The age and sex distribution of the pedal cyclists are given in table 7. As far as the authors are aware there are no national data on the usage of pedal cycles by males and females of different ages. Therefore it is not possible to use the sample to evaluate the risk of a male or female rider of a particular age being involved in a pedal cycle accident.

Admission Status and Treatment Period

Only half of the pedal cycle casualties had arrived at Birmingham Accident Hospital within an hour of their accidents; 126 (27.7%) of the entire sample attended more than 6 hours after the accident. In light of the relative proximity of most accident locations to the hospital the time taken to attend hospital probably does not indicate access difficulties, but rather the high incidence of slightly injured casualties; 67.5% of the pedal cyclists were slightly injured.

There were only 54 (11.7%) casualties who were treated as inpatients. The remaining 408 (88.3%) pedal cyclists were given outpatient treatment only with 59.3% discharged from B.A.H. after their first visit. However one quarter of all these outpatients were referred to other medical services, typically their own doctors. Of the 54 inpatients 3 died in the hospital; 35 (71.4%) of the remaining patients were discharged from inpatient care after a stay of 1 or 2 nights. However, 61.1% of the surviving inpatients subsequently attended outpatient clinics at Birmingham Accident Hospital.

The relationship between actual treatment time and the treatment period injury scale was considered for inpatients and outpatients respectively (Tables 8 & 9). Using Spearman's rank coefficient, a correlation value of 0.3856 was found between TP and the length of inpatient care, the correlation between TP and the number of outpatient visits for casualties who received only outpatient care was 0.5618. The validity of TP is considered later.

Patterns of Injury

Injuries to the arm are rated as the most important type of injury by both the AIS and PI scales. Leg injuries are rated as second in importance. This is a reversal of the comparative importance of these injuries for TWMV casualties. It is interesting to speculate on the possible reasons for this difference. One explanation might lie in a difference in the nature of their accidents. There were 48.3% of the TWMV casualties involved in multi-vehicle accidents compared to 15.6% of the pedal cyclists. The susceptibility of the riders' legs to the violence of direct impacts with other vehicles may reduce the relative importance of subsequent blows. A further possibility is that pedal cyclists are more likely to be travelling at relatively low speeds at the time of their accidents; so given the prevalence of single vehicle accidents,

Table 7 Age Distribution of Male and Female Pedal Cycle Casualties.

Age (Years)	Male (N=366)		Female (N=95) ⁺		TOTAL (N=461) ⁺	
	N	%	N	%	N	%
0-4	8	2.2	2	2.1	10	2.2
5-9	77	21.0	29	30.5	106	23.0
10-14	122	33.3	38	40.0	160	34.7
15	26	7.1	1	1.1	27	5.9
16	35	9.6	3	3.2	38	8.2
17-19	38	10.4	4	4.2	42	9.1
20-29	27	7.4	4	4.2	31	6.7
30-39	15	4.1	4	4.2	19	4.1
40-49	9	2.5	4	4.2	13	2.8
50-59	2	0.5	3	3.2	5	1.1
60-69	6	1.6	3	3.2	9	2.0
70 and over	1	0.3	0	0	1	0.2

⁺The age of one female casualty was not ascertained

Table 8 Observed length of Inpatient Care Compared to 'Treatment Period' Value for Pedal Cycle Casualties (N=50)⁺

Nights Detained in Hospital	TP Value				TOTAL	
	1	2	3	4	N	%
1 Night (24 hours or less)	20	1	5	1	27	54.0
2 Nights	1	1	1	1	4	8.0
3 Nights	2	1	1	0	4	8.0
4 Nights	1	1	0	0	2	4.0
5 Nights	1	0	0	0	1	2.0
6 Nights	1	0	0	0	1	2.0
7-14 Nights	0	1	1	1	3	6.0
15-21 Nights	0	1	2	0	3	6.0
22-28 Nights	1	0	0	0	1	2.0
>28 Nights	0	1	2	1	4	8.0

+Unknown values and fatalities have been excluded.

Table 9 Observed Number of Outpatient Visits for Pedal Cycle Casualties Receiving Only Outpatient Care Compared to 'Treatment Period' Value (N=396)⁺

Number of Visits	TP Value				TOTAL	
	1	2	3	4	N	%
1	229	6	6	0	241	60.9
2	53	11	11	0	75	18.9
3	19	17	8	1	45	11.4
4	4	2	6	0	12	3.0
5	4	1	4	1	10	2.5
6	2	3	2	0	7	1.8
7	0	0	1	2	3	0.8
≥8	0	1	0	2	3	0.8

+Unknown values and fatalities have been excluded.

they may have time to use their arms in an attempt to protect themselves. The nature of the arm fractures sustained by many pedal cyclists supports this suggested pre-crash behaviour.

The nature of the injuries sustained in different body areas are presented in table 10. There were 55 (12.0%) casualties who suffered head injuries, 47.3% of these casualties received head injuries rated AIS ≥ 2 . In comparison 76 (14.0%) TWMV casualties sustained head injuries, 9.6% rated AIS ≥ 2 . Facial injuries, predominately to the surface of the face, were sustained by 109 (23.6%) pedal cyclists, compared to 14.1% TWMV riders. Given the overall more severe nature of the injuries sustained by the TWMV riders the relatively high incidence of head and facial injuries for the pedal cyclists may reflect their lack of head protection.

Although 153 (33.1%) of the pedal cyclists suffered lower limb surface injuries, only 15 (3.2%) suffered fractures in this region. In contrast 79 (17.3%) of the riders sustained one or more fractures of the upper limbs, 17.7% of these skeletal injuries were rated AIS > 2 . In view of the large numbers of pedal cycle casualties injured in single accidents and the suggested cause of upper limb injuries it is difficult to propose protective measures to prevent such injuries. However, the use of protective clothing including headgear would seem one means of preventing or reducing the high incidence of surface injuries suffered by this group of pedal cyclists.

The Validity of the Treatment Period Scale

The Comprehensive Research Injury Scale (CRIS) was developed in response to the recognised need for a more detailed scale than AIS (11). As mentioned earlier, the Treatment Period (TP) and Permanent Impairment (PI) scales, two of the scaling criteria used in CRIS were selected for use in this study. As assessment of the PI was not possible from the data collected on the hospital casualties, but it seems that consideration should be given to a working definition of impairment. The long term effect of the low level impairment as recorded by PI values for the hospital sample should not be underestimated.

Using the Spearman's rank correlation coefficients for observed length of medical treatment compared to TP values, the TP scale appears to be a good predictor of the period of medical care for pedal cycle and TWMV casualties. The best correlation was recorded for length of inpatient care for TWMV casualties and their assessed TP values. However, future work might usefully involve an examination of the validity of TP in predicting the length of medical care which is likely to be necessary for specific injuries and combinations of these injuries. Finally, there seems to be a need to update the TP scale to encompass changes in medical care procedures, for example, the more aggressivetreatment of salvaging grossly damaged limbs.

Table 10 Location and Severity of Injuries Sustained by Pedal Cycle Casualties (N=462)+

Body Area	Injury Description	AIS Score					
		0	1	2	3	4	5
Head	Surface AIS	429	29	4	0	0	0
Head	Skeletal AIS	457	1	3	0	1	0
Head	Internal AIS	423	10	23	1	1	1
Face	Surface AIS	354	99	9	0	0	0
Face	Skeletal AIS	447	11	3	0	0	0
Leg	Surface AIS	309	150	3	0	0	0
Leg	Skeletal AIS	444	1	12	3	0	0
Arm	Surface AIS	269	189	4	0	0	0
Arm	Skeletal AIS	377	11	54	13	1	0

+ Different row totals indicate exclusion of those cases where there was insufficient injury information for an AIS value to be assigned.

CONCLUSIONS

1. There were 545 TWMV riders and 462 pedal cyclists treated at BAH in the 16 month study period.
2. In this study only 56.0% of the TWMV casualties and 12.1% of the pedal cycle casualties were injured in accidents reported to the police. Of all the casualties injured in single-vehicle accidents, only 15.2% appeared in police accident reports.
3. The TP scale from the CRIS seems to be a good predictor of the period of medical care for both TWMV and pedal cycle casualties.

The Sample of 545 TWMV Casualties

1. In all, 86.4% of the TWMV casualties were male and 80.7% of the entire sample were aged 16-19 years.
2. There were 32.5% casualties who received inpatient care, almost a third were detained at BAH for ≤ 2 nights.
3. Of the 368 TWMV casualties who received only outpatient care, 57.8% received no further treatment at BAH following their first visit.
4. Lower limb injuries were rated as the most important type of injury by both the AIS and PI scales. Fractures in the lower limbs were suffered by 18.2% of the casualties. Arm injuries were rated as second in importance.
5. The patterns of injuries suffered by this hospital sample differ markedly from those reported for a sample of fatalities. In the group of fatally injured TWMV riders, the head featured as one of the most frequently and severely injured body regions. Head injuries sustained by casualties in these 2 samples were not evenly distributed up the AIS scale.

The Sample of 462 Pedal Cycle Casualties

1. In this sample, 79.0% were males and 57.7% of all the pedal cycle casualties were between 5-14 years.
2. Only 11.7% of the casualties received inpatient care and 71.4% of these patients were detained for ≤ 2 nights.
3. The remaining 88.3% pedal cyclists were treated as outpatients, 59.3% discharged from BAH after their first visit.
4. The upper limb injuries were rated as the most important type of injury for the pedal cycle casualties, 17.3% suffered upper limb fractures. Lower limb injuries were rated as second in importance.
5. Facial injuries were sustained by 23.6% of the pedal cycle casualties in comparison to 14.1% of the TWMV riders. This and the relatively high incidence of head injuries suffered by the pedal cyclists may reflect the lack of head protection, but without further data this cannot be confirmed.

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APPENDIX 1: The Definitions of the Ministry of Transport (MOT) Categories of Injury Severity (11).

- Slight Injury : An injury of a minor character such as a sprain or bruise, or a cut or laceration not judged to be severe.
- Serious Injury : An injury for which the person is detained in hospital as an 'in-patient' or any of the following injuries whether or not the person is detained in hospital: fractures, concussion, internal injuries, crushing, severe cuts and lacerations, or severe general shock requiring medical treatment.
- Fatality : Death within 30 days of the accident.

APPENDIX 2: Values Inserted in the TP and PI Scales of the CRIS.

	<u>TP Value</u>	<u>PI Value</u>
Face, sutured laceration	1	2
Chest, simple rib fracture	1	1
Chest, displaced rib fracture	2	2