A Review of Pedestrian Fatalities in Singapore from 1990 to 1994

G Lau,*FAMS, MRCPath, DMJ (Path), E Seow,**FAMS, FRCS (A&E) (Edin), E S Y Lim,***BSc, MA (Econ) (Manc), ME Soc (Aust)

Abstract

The authors reviewed 369 consecutive pedestrian fatalities, which occurred from 1990 to 1994. This represented 28.5% (range 23.3 to 37.2; 95%CI 26% to 31%) of all road accident autopsies during that time.

The mean and median ages of this population were 51 (95% CI 48.63 to 53.37) and 54 years, respectively. There were 160 (43.3%) who were in the economically productive ages of 20 to 59 years. Of the 369 victims, 224 (60.7%) were males and 145 (39.3%) females, there being a preponderance of males across all age groups.

Most of these accidents occurred during the hours of daylight and in conditions of good weather and visibility. It was estimated that pedestrian behaviour contributed, in part, to at least three-quarters of these fatalities.

The majority of these pedestrians died from multiple injuries (181; 49.1%) and closed head injury (146; 39.6%). The vast majority of subjects (357; 96.7%) had injury severity scores (ISS) ≥16.

A total of 100 subjects (27.1%) died at the sites of the accidents. Of these, 99 had ISS ≥16, with 31 having had ISS = 75 (maximum score). Similarly, all 55 deaths that occurred in the A&E departments were associated with ISS ≥16, with 6 having ISS = 75. This would imply that most of the deaths that had occurred on site and at A&E departments were not unexpected. Interestingly, no pedestrian aged ≤12 years had an ISS ≤16, suggesting that they may be more vulnerable to serious or life-threatening injury than adults.

There were 46 (12%) victims who had detectable levels of ethanol in their blood samples, of whom, 10 had ISS = 75. However, the difference between the latter proportion and that of the rest of the pedestrian population who had no alcohol detected in their blood samples (31/323), was only marginally significant (95% CI 0.002 to 0.245).

There was a high prevalence of pre-existing and intercurrent diseases, such as ischaemic heart disease (58.8%), hypertensive heart disease (30.4%), chronic obstructive airways disease (47.4%), bronchopneumonia (18.2%) and evidence of systemic hypertension (40.7%). It is submitted that the existence of these underlying conditions should be anticipated, or suspected, in the management of injured pedestrians, particularly the elderly, as they may influence the outcome of their critical care.

***Ann Acad Med Singapore* 1998; 27:830-7**

Key words: Alcohol intoxication, Injury severity, Natural disease, Necropsies, Risk factor

Introduction

Fatal road accidents are by no means uncommon in Singapore, a modern tropical metropolis with a population of approximately 3 million. Statistics provided by the Traffic Police Department[1] show that, although the accident fatality rate had fallen sharply from 13.4 per 100,000 population in 1984, to 8.0 per 100,000 in 1987, it had remained between 8.7 and 9.0 from 1988 to 1994, before falling again to 7.5 in 1995.

The local fatality rate per 10,000 vehicles for 1994 was 4.2, as compared to 1.3 in Japan, 1.5 in the United Kingdom, 1.8 in Canada, 1.9 in Australia and 2.1 in the United States.

Indeed, traffic fatalities, as a whole, accounted for approximately 12% to 14% of the Coroner's casework performed at the Institute of Science and Forensic Medicine (ISFM) from 1994 to 1996, with pedestrians currently forming the second largest group of victims, after motorcycle accidents.

The primary aim of this study was to document the nature of pedestrian fatalities in Singapore, in relation to the causation of death, injury severity and the prevalence of common intercurrent disease amongst these victims, as well as to identify groups at risk. It was also intended to complement an earlier study on fatalities amongst motorist (excluding motorcyclists), covering a

* *Consultant Forensic Pathologist and Director of Forensic Pathology*
Institute of Science and Forensic Medicine
** *Consultant*
Department of Emergency Medicine
Tan Tock Seng Hospital
*** *Econometrician*
Singapore Broadcasting Authority
Address for Reprints: Dr Gilbert Lau, Institute of Science and Forensic Medicine, Outram Road, Singapore 169608.

similar period, that showed a high prevalence of ischaemic and hypertensive heart disease within this group of road users, and suggested that alcohol consumption might have aggravated the underlying pathology, thus contributing to these motoring fatalities.[2]

As with the previous study, the present one was facilitated by the local medico-legal system, wherein every victim of a fatal road accident is subjected to a Coroner's autopsy, which is invariably conducted at the ISFM.

Materials and Method

The present study comprised a systematic review of medico-legal autopsies (replete with post-mortem toxicological analyses) performed on 369 consecutive pedestrian fatalities, from 1 January 1990 to 31 December 1994, at the Department of Forensic Medicine, ISFM. There was a total of 1294 road accident fatalities during this period.

For each case, the following were documented:

1. Relevant biodata (age, sex and race)
2. Cause of death
3. Underlying or intercurrent pathology
4. Duration of hospitalisation (where appropriate)
5. Place of death
6. Site of the accident
7. Time of the accident
8. Type of vehicle involved
9. Blood ethanol levels

For the purpose of this study, a delayed traumatic death was defined as one occurring after 30 days of hospitalisation.

An injury severity score was calculated for all the cases. This was determined from the autopsy findings and, where appropriate, the hospital inpatient and surgical records. The Injury Severity Score (ISS) was derived from the Abbreviated Injury Scale (AIS),[3] where the ISS is the sum of squares of the highest AIS scores from three out of six body regions, as follows:

1. Head and Neck
2. Face
3. Thorax
4. Abdomen and pelvis
5. Pelvic girdle / extremities
6. External body surface

AIS values range from 1 to 6 and is interpreted as follows:

1. Minor
2. Moderate
3. Serious (non life-threatening)
4. Severe (life-threatening)
5. Critical (survival uncertain)
6. Unsurvivable (with current treatment)

Due to its manner of computation, certain ISS values are inadmissible, e.g. 7, 15, 49, 67 to 74. In this system, subjects with ISS ≥16 are considered to have a poor prognosis,[4,5] with a ≥10% risk of mortality, while AIS = 5 in three body regions and AIS = 6 in any body region correspond to ISS = 75, which is the maximum score, indicating virtually certain death.

Statistical methods such as the *t*-test, the Chi-square test and Pearson's correlation co-efficient hypothesis test were applied where appropriate. A value of $P<0.05$ was taken as being statistically significant.

Results

General Observations

There was a total of 369 fatal pedestrian casualties. These accounted for 3.4% (range 3.0% to 4.2%; 95%CI 3.1% to 3.7%) of all Coroner's autopsies and 28.5% (23.3% to 37.2%; 26.0% to 31.0%) of all road accident cases during the 5-year period in question (Table I). Amongst these were 6 "hit and run" accidents and 10 cases involving subjects who met with accidents overseas, but died whilst receiving medical treatment locally.

Biodata

The mean (95% CI) and median ages of the entire sample were 51 (48.63 to 53.37) and 54 years, respectively; the age range being 2 to 101 years. There was a preponderance of males (60.7%) across all age groups. The mean and median ages of the male population were 49 (45.99 to 52.01) years and 52 years, respectively, while the corresponding values for the female population were 53 (49.3 to 56.7) years and 56 years, respectively.

Over 43% of the victims were in the economically productive age range of 20 to 59 years. There were 7.6% aged ≤12 years old, while 9.5% and 34.4% were aged 60 to 64 years and ≥65 years, respectively (Fig. 1). There appeared to be an over-representation of Indian subjects (there were no foreign workers in this group), while some 4% were foreign workers (Fig. 2).

TABLE I: ANNUAL DISTRIBUTION OF CORONER'S AUTOPSIES

Year	1990	1991	1992	1993	1994	Total
Total coroner's autopsies	2222	2188	2386	2053	2029	10,878
Total RTA autopsies	253	260	239	279	263	1294
Fatal pedestrian accidents	94	69	71	65	70	369
Pedestrians/coroner's autopsies (%)	4.2	3.2	3.0	3.2	3.5	3.4
Pedestrian/Total RTA autopsies (%)	37.2	26.5	29.7	23.3	26.6	28.5

RTA: road traffic accidents

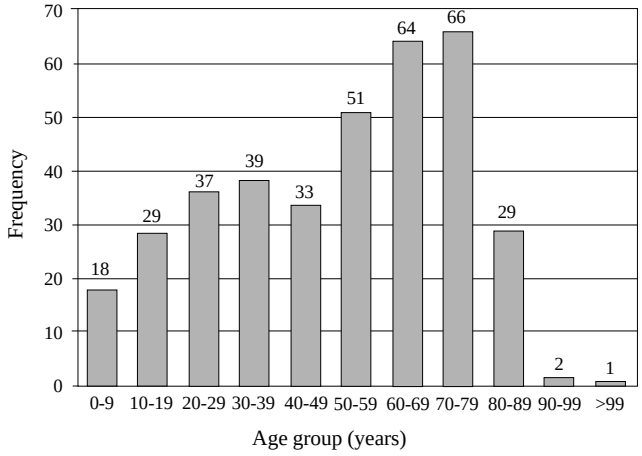

Fig. 1. Distribution by age group of victims.

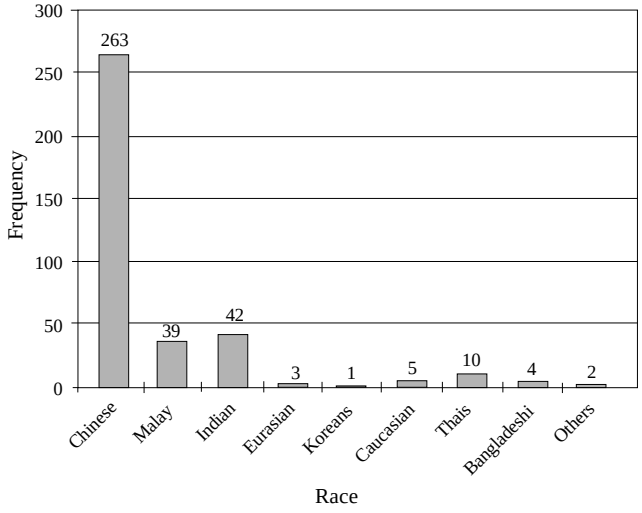

Fig. 2. Distribution by race of victims.

Cause of Death and Principal Fatal Injuries

Almost half of the subjects succumbed to a multiplicity of injuries (usually AIS 3 to 6), often involving at least 2 to 3 body regions (predominantly the head, thorax and abdomen) (Tables IIA and IIB). This was closely followed by severe head injury (over 40%) as the predominant cause. Of those who were certified to have died from multiple injuries, half (89 of 181) had sustained closed head injuries with blunt chest and abdominal injuries. A majority (176) of those who died from multiple injuries had sustained blunt chest injuries. Significantly, there were no natural causes of death, such as fatal myocardial infarction induced by the stress associated with a minor accident.

Other Pathology

There was a high prevalence (58.8%) of ischaemic heart disease (IHD), with moderate to severe stenosis of one or, more often 2 to 3, major coronary arteries being found at autopsy in two-thirds of such patients (Table III). Amongst the latter, there were 4 cases of acute myocardial infarction, which occurred in the face of severe multiple injuries. In this series, IHD was often accompanied by hypertensive heart disease, which was found in about a third of all subjects. Chronic obstructive airways disease was also a common finding (47.4%), while bronchopneumonia or lobar pneumonia (18.2%) seemed to accompany prolonged recumbency and extensive, severe trauma. Although cerebral atheroma was fairly common (27.1%), there were very few cases of cerebral infarction, all of which were old infarcts. Similarly, although pulmonary tuberculosis was found in a small, but appreciable proportion of subjects (8.4%), most of these were old apical lesions. No particular relation between any of these underlying conditions and the causation of the accidents could be discerned.

TABLE IIA: CAUSES OF DEATH

Cause of death	No. (%)
Multiple injuries	181 (49%)
Closed head injury	146 (39.6%)
Open/penetrating head injury	9 (2.4%)
Blunt chest injury	8 (2.1%)
Blunt abdominal injury	8 (2.1%)
Penetrating abdominal injury	2 (0.5%)
Open limb fractures	3 (0.8%)
Cervical spinal injury	8 (2.1%)
Other forms of trauma	4 (1.1%)

TABLE IIB: DISTRIBUTION OF PRINCIPAL FATAL INJURIES IN 369 PEDESTRIANS

Principal fatal injuries	No. (%)
Closed head injury	277 (75.1%)
Open/penetrating head injury	29 (7.9%)
Blunt chest injury	183 (49.6%)
Penetrating chest injury	1 (0.3%)
Blunt abdominal injury	145 (39.3%)
Penetrating abdominal injury	6 (1.6%)
Open limb fractures	40 (10.8%)
Cervical spine injury	46 (12.5%)
Other forms of trauma	4 (1.1%)

Duration of Hospitalisation

Excluding those who died on site and at A&E, the mean and median duration of hospitalisation were 16 days and 1 day, respectively. Of the 269 subjects who were conveyed to a hospital, 160 died within 24 hours of admission with 17 cases of delayed traumatic death; the longest interval being approximately 787 days.

Place of Death

Over a quarter of subjects (27.1%) died on site, 55 (14.9%) died at A&E and the rest died after hospitalisa-

TABLE III: PRE-EXISTING AND INTERCURRENT DISEASES

Disease	No.	(%)
Ischaemic Heart Disease	217	(58.8)
mild (<30% stenosis)	74	(20.1)
moderate (30 to 70% stenosis)	82	(22.2)
severe (>70% stenosis)	61	(16.5)ϕ
ϕ Includes 4 cases of acute myocardial infarction		
Hypertensive Heart Disease	112	(30.4)
mild	67	(18.2)
moderate	21	(5.7)
severe	24	(6.5)
Chronic Rheumatic Valvular Disease	1	(0.3)
Calcific Aortic Stenosis	1	(0.3)
Chronic Obstructive Airways Disease	175	(47.4)
mild	91	(24.7)
moderate	48	(13.0)
severe	36	(9.8)
Bronchopneumonia/Lobar Pneumonia	67	(18.2)
mild	16	(4.3)
moderate	15	(4.1)
severe	36	(9.8)
Pulmonary Thromboembolism	5	(1.4)
peripheral	1	(0.3)
massive	4	(1.1)
Pulmonary Tuberculosis	31	(8.4)
old lesions	29	(7.9)
active lesions	2	(0.5)
Liver Cirrhosis (not specified)	11	(3.0)
Benign Hypertensive Nephrosclerosis	150	(40.7)
Pyelonephritis	14	(3.8)
acute	1	(0.3)
chronic	13	(3.5)
Cerebral Atheroma	100	(27.1)
mild	43	(11.7)
moderate	53	(14.4)
sever	4	(1.1)
Old Cerebral Infarcts	6	(1.6)
cortical/white matter	3	(0.8)
lacunar	3	(0.8)
Malignancy	1	(0.3)
bronchogenic carcinoma	1	(0.3)

tion (Fig. 3). Approximately a fifth (22.2%) died postoperatively, often after extensive surgery involving several surgical disciplines.

The mean (95%CI) and median ages for those who died at the site of accident were 48 and 51 years, respectively. The mean and median ages of the initial survivors were 52 (49.20 to 54.80) years and 56 years, respectively. The mean ages between these two population samples were not significantly different at 5% level.

Site of Accident

Over two-thirds of pedestrian fatalities occurred along roads away from pedestrian crossings. However, a small but appreciable number occurred at pedestrian crossings (32; 8.7%) and along expressways (29; 7.9%) (Table IV).

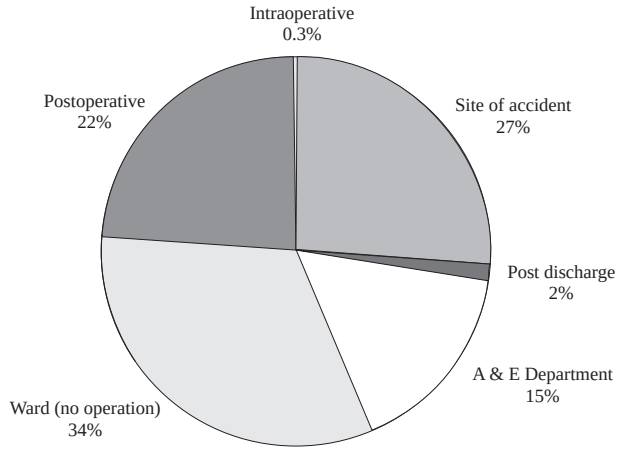

Fig. 3. Distribution by place of death of victims.

TABLE IV: PLACE OF ACCIDENT

Place of accident	No.	(%)
At pedestrian crossing	32	(8.7)
Not at pedestrian crossing	252	(68.3)
Expressway	29	(7.9)
Vehicle skidded/loss of control	13	(3.5)
Collision between vehicles	1	(0.3)
Other circumstances	37	(10.0)*
Unknown	5	(1.3)

* includes 6 "hit & run" incidents; there were also 10 accidents which occurred overseas

Time of Accident

The majority (61.2%) of these accidents occurred between 7 am and 7 pm the hours of daylight, locally. However, almost a third occurred between 6 pm and midnight (Fig. 4). It was also noted that the vast majority of these accidents occurred in good visibility and weather.

Type of Vehicle

Most of the accidents were caused by cars and light-goods vehicles 165 (44.7%) with motorcycles, heavy goods vehicles and omnibuses accounting for most of the remaining cases (Fig. 5). The distribution of principal fatal injuries according to vehicle type is shown in Table V.

Injury Severity Score

The vast majority of subjects (357; 96.7%) had ISS ≥16 (Table VI). None of the 28 subjects in the paediatric age group and only 6 (<5%) of the elderly pedestrians had ISS ≤14. There were similar proportions of younger adults (aged 20 to 59 years) and elderly pedestrians in

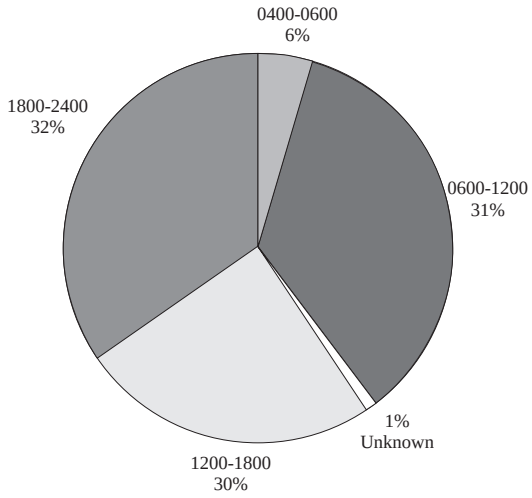

Fig. 4. Distribution of victims by time of accident.

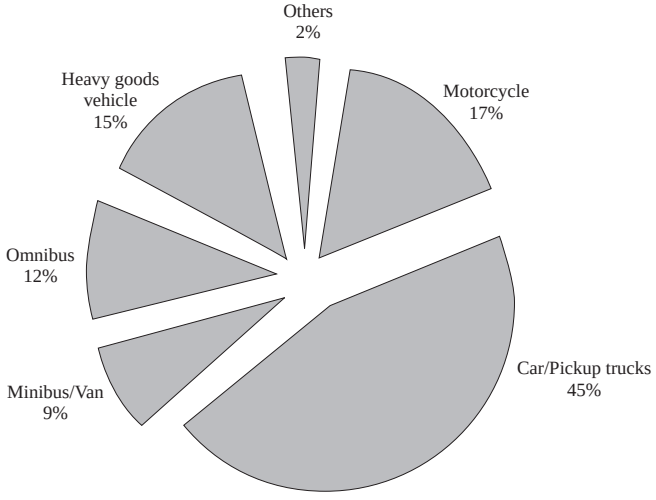

Fig. 4. Distribution by types of vehiccles involved in accident.

TABLE VI: INJURY SEVERITY SCORE AGAINST SEX, AGE AND BLOOD ALCOHOL LEVEL

ISS	1 to 14	16 to 33	34 to 48	50 to 66	75
Overall (%) (n = 369)	12 (3.3)	156 (42.3)	104 (28.2)	56(15.2)	41(11.1)
Sex					
Male (n = 224)	9 (4.0)	105(46.9)	61 (27.2)	28(12.5)	21 (9.4)
Female (n = 145)	3 (2.1)	51(35.2)	43 (29.7)	28(19.3)	20(13.8)
Age (year)					
≤6 (n = 8)	-	1	4	2	1
7 to 12 (n = 20)	-	8	7	3	2
20 to 59 (n = 160)	6	67	47	24	16
≥65 (n = 127)	6	56	33	17	15
Blood alcohol level					
≤80 mg/100ml (n = 25)	1	8	7	5	4
>80 mg/ml (n = 21)	-	7	5	3	6

the various ISS brackets. There were no statistically significant difference in the relative proportions of male and female subjects with 16≤ISS≤66 and ISS = 75.

Of those who died at the site of accident, 99% had ISS ≥16 as compared to 95.2% of patients who died at A&E departments or after admission (95% CI for difference: 0.6% to 7.1%; P <0.05). A much wider disparity between both these groups was observed in relation to the maximum ISS of 75 (31% vs 3.7%; 95% CI for difference: 17.9% to 36.6%; P <0.01).

When comparing the sub-group who died at A&E per se, with those who died after admission, all 55 cases in the former category were found to have had ISS ≥16, with 6 having ISS = 75, while 203 (94.9%) of the latter sub-group had ISS ≥16 with 4 having ISS = 75 (95% CI for

TABLE V: DISTRIBUTION OF PRINCIPAL FATAL INJURIES BY VEHICLES*

Vehicle type Fatal injury	Motorcycle (n = 63)	Car/pickup truck/landrover (n = 165)	Minibus/van/ light goods (n = 32)	Omnibus (n = 43)	Heavy goods vehicle/crane (n = 57)	Other vehicle (n = 2)	Unknown (n = 7)
Closed head injury	53	123	26	29	39	1	6
Penetrating head injury	3	10	3	6	5	0	2
Blunt chest injury	24	80	13	25	39	0	2
Penetrating chest injury	0	0	0	0	1	0	0
Blunt abdominal injury	18	65	9	20	32	0	1
Penetrating abdominal injury	0	4	0	0	2	0	0
Open limb fractures	10	22	0	3	5	0	0
Cervical spinal injury	8	28	3	3	4	0	0
Other forms of trauma	0	2	1	0	0	1	0
Total number of injuries	116	334	55	86	127	2	11
Mean number of injuries per vehicle type	1.8	2.0	1.7	2.0	2.2	1.0	1.6

difference: 0.006 to 0.175; $P < 0.05$).

Using Pearson's correlation coefficient hypothesis test, we confirmed that there was no statistically significant correlation between ISS and age (correlation coefficient = 0.0283).

Upon examining the possibility of a correlation between ISS and sex, it was found that they were independent of each other, as there was no statistically significant difference between the proportion of males and females with ISS ≥16 ($\chi^2 = 0.3027$, ldf; $P > 0.5$).

Blood Alcohol Level

Only 12.5% of the entire sample had detectable levels of ethanol in their blood and other body fluid samples. Amongst these, a smaller proportion (35 / 46) had 16≤ISS≤66 (i.e. in the mid-range), as compared to the majority who were free of ethanol (281 / 323); this difference being statistically significant (95% CI 0.55 to 0.71; $P < 0.05$).

Although a larger proportion of intoxicated subjects had maximum ISS scores, compared to those who were sober (10 / 46 vs 31 / 323), this difference was only marginally significant (95% CI for difference: -0.002 to 0.245). The numbers of subjects with blood ethanol levels below and above the legal driving limit of 80 mg / 100 ml were considered to be too small for any meaningful comparison to be made between these sub-groups.

Discussion

It is evident that pedestrian fatalities comprised an appreciable proportion of Coroner's autopsies locally, being some 2 to 3 times as common as fatalities involving motorists (if motorcyclists were to be excluded), as may be inferred by comparison with an earlier study covering a similar period.[2] However, in contrast to that study, which demonstrated an overwhelming preponderance of males (95%) and Chinese subjects (87.1%), the male preponderance in the present review was much less pronounced, while the ethnic distribution reflected that of the local population more closely. Also, it would appear that local pedestrian fatalities tend to involve the elderly some 3 to 4 times more frequently than vehicular fatalities.[2]

The local rate of pedestrian deaths from 1990 to 1994 (28.5%), as a proportion of all road-related fatalities, stands in sharp contrast to widely differing rates, ranging from approximately 14.5% to over 50%,[4-8] reported internationally. The male preponderance demonstrated in this study is compatible with that reported in other series,[6,9,10] although it was consistently observed throughout all age groups, as compared to a slight inversion of the sex ratio amongst elderly pedestrians, observed by Teanby et al.[9,10] The relatively large proportion of elderly victims (44% aged ≥60 years and 34% aged ≥65 years) is also consistent with that observed elsewhere.[8-11] However, only a small proportion (7.6%) were children, who accounted for up to 60% of pedestrian fatalities in other studies.[7,12-14]

There was no discernible relationship between the types of vehicles involved and the principal fatal injuries sustained. We suspect that it may be the speed at which the victim is hit that is of more significance rather than the types of vehicles involved.

Of interest is the fact that the majority of the fatal accidents in the current study occurred during the hours of daylight, largely in conditions of good weather and visibility. This, coupled with the observation that over two-thirds of these victims apparently did not use pedestrian crossings or overhead bridges (both of which are present in abundance along most roads in Singapore), while almost 9% had attempted to cross busy expressways, would seem to indicate that pedestrian behaviour had contributed, at least in part, to no less than 75% of these fatalities. In fact, Teanby et al[9] had arrived at a similar conclusion some years ago, whilst advocating the case for the criminalization of jaywalking. In the local context, what is, perhaps, amazing is that jaywalking has, for some decades, been a offence that potentially attracts stiff fines. On the other hand, alcohol intoxication did not appear to be a major pedestrian factor in the causation of these fatalities, as only 21 out of the cohort of 369 victims had blood ethanol levels which exceeded the legal driving limit of 80 mg / 100 ml, a concentration that would, in the average person, result in at least mild intoxication. This is in contrast to other studies, which reported pedestrian intoxication rates ranging from 22% to 34%,[9] as well as with the local study on motoring fatalities, which showed a rate of 20%.[2]

Whilst on the subject of pedestrian behaviour, it is pertinent to note that some earlier studies[15-17] have drawn attention to the influence of environmental conditions on the behaviour of children. Ironically, however, the absence of pedestrian crossings need not carry an increased risk of accidents.[15] It has also been said that while fatalities involving older children tend to be due to their dashing across streets and being struck down by oncoming vehicles, those involving children below the age of 5 years are more commonly due to non-traffic pedestrian collisions, that is, from being run over by a vehicle along a driveway or in a carpark.[16] However, the latter observation is not supported by the present study, in which the fatal collisions occurred largely whilst the children were crossing roads.

It has also been proposed that long-term trends in child pedestrian death rates are very sensitive to short-term changes in traffic volume, with the result that a fall in the rate of increase in traffic volume may be accompanied by a corresponding increase in the rate of decline in these deaths.[17] This would infer that the areas with busier streets, higher vehicle speed limits or volumes of

traffic, are associated with increased risk for pedestrian injuries. However, our data did not allow us to come to this conclusion.

With respect to injury severity, it is notable that all child fatalities were associated with ISS ≥16, with the majority (25 / 28) being in the mid-range, while 3 were at the extreme end of the scale. This, may to some extent, attest to the vulnerability of children to severe and fatal injury arising from pedestrian accidents.[12,15,16]

As described, most of the victims (49.1%) died from multiple injuries which meant that they had severe injuries to the head, thorax and abdomen any of which could have been the cause of death. It is clear that the multiplicity of injury would have given rise to management problems of considerable, if not enormous difficulty, amongst the 73% of victims who were conveyed to hospital. A review by the relevant authorities of the resources available for prehospital emergency care would be appropriate. Overall, the pattern of fatal injuries observed in the present study was largely similar to that documented in the earlier study on motoring fatalities, except for a comparatively much larger proportion of cases of fatal head injury in the former.[2]

The vast majority had ISS ≥16 with similar proportion of younger adults (aged 20 to 59 years) and elderly pedestrians in the various ISS brackets. Although there was no correlation between age and ISS, we noted that 43.9% of them were aged 60 and above. We postulate that factors that can have contributed to these elderly pedestrian deaths may have been their slower reflexes and poorer eyesight and hearing which comes with ageing.

It would appear that male victims are more prone to sustaining injuries (ISS range of 16 to 33) than females, who generally seem to attract higher scores, although there does not appear to be any statistically significant correlation between sex and ISS, on the whole.

The fact that 99 (99%) of those who died at the site of the accident and all 55 victims who died at the A&E departments had ISS ≥16, and comprised a greater proportion with ISS = 75, than those who died subsequently after admission, would seem to indicate that the deaths at the site of accident and at A&E departments were largely inevitable.

The mean duration of hospitalisation for the remaining victims compares reasonably well with, while the median duration was much shorter than that of, some earlier studies, which yielded figures of 13.8 days and 21 days, respectively.[6,18]

It is conceivable that the high prevalence of various common, pre-existing or intercurrent diseases might have diminished the ability of the victims to survive the severe and, often extensive, injuries which they had sustained. At any rate, the presence of ischaemic heart disease (59%), hypertensive heart disease (30%), chronic obstructive airways disease and bronchopneumonia (18%), or a combination of these conditions, would certainly have complicated their clinical management. It would, thus, be necessary to bear this in mind, when making critical management decisions and, perhaps, to maintain a high index of suspicion of these underlying diseases, when attending to such patients, especially in view of the fact that some 30% to 40% of fatalities tend to involve the elderly.

Although alcohol intoxication did not appear to have been a major pedestrian factor in the causation of most of these accidents, it did, however, appear to be associated with more severe injuries at the extreme end of the scale. However, this observation may not be entirely reliable, as the blood and body fluid samples were obtained post-mortem and may, in an unknown number of cases, fail to reflect the actual state of the subjects who had received intravenous fluid replacement and who died after variable periods of hospitalisation.

A few factors which were not measured in this study that may have a bearing on the number of fatalities were the ambulance response times,[10,19,20] the time from injury to surgery and the quality of care delivered prehospital and in the hospital.

In conclusion, we would recommend that a comprehensive public education on pedestrian safety be conducted.

This could include reminding pedestrians:

1. to use pedestrian crossings
2. of the rudiments of crossing a road like ...look right, then left, then right again before crossing the road
3. to wear light coloured clothes or luminescent markers
4. that special care must be taken by the elderly
5. that children on or near roads should be closely supervised by a responsible adult.

Jaywalking laws should also be strongly enforced.

Acknowledgements

The authors would like to thank the State Coroner of the Republic of Singapore for permission to use the cases that appeared in this study. They are also grateful to Dr Joan Chin and to the technical and mortuary staff of the Department of Forensic Medicine, ISFM, for their kind assistance in the course of this project.

REFERENCES

1. Road Traffic Accidents Statistical Report, 1995. Singapore: Road Traffic Research Branch, Singapore Police Force.
2. Lau G. Natural disease and alcohol intoxication amongst drivers of motor vehicles in Singapore from 1989 to 1993: a study of 140 necropsies. Ann Acad Med Singapore 1996; 25:516-21.

3. The Abbreviated Injury Scale (1990 Revision). Illinois, USA: Association for the Advancement of Automotive Medicine, 1990.
4. Robertson C, Redmond A D. The Management of Major Trauma. New York: Oxford Univ Press, 1991:22.
5. Seow E, Lau G. Who dies at A&E? The role of forensic pathology in the audit of mortality in an emergency medicine department. Forensic Sci Int 1996; 82:201-10.
6. Hill D A, West R H, Abraham K J, O'Connell A, Cunningham P. Impact of pedestrian injury in inner city trauma services. Aust N Z J Surg, 1993; 63:20-4.
7. Gloag D. British road traffic deaths fall but casualties rise. BMJ 1995; 311:281.
8. Salgado M S I, Colombage S M. Analysis of fatalities in road accidents. Forensic Sci Int 1998; 36:91-6.
9. Teanby D N, Gorman D F, Boot D A. Pedestrian accidents on Merseyside: the case for criminalization of jaywalking. Injury 1993; 24:10-2.
10. Teanby D N, Gorman D F, Boot D A. Regional audit of pedestrian accident care. Injury 1993; 24:435-7.
11. Allard R. Excess mortality from traffic accidents among elderly pedestrians living in the inner city. Am J Public Health 1982; 72:853-4.
12. Mazurek A J. Epidemiology of paediatric injury. J Accid Emerg Med 1994; 11:9-16.
13. Pitt R, Guyer B, Hsieh C D, Malek M. The severity of pedestrian injuries in children: an analysis for the pedestrian injury causation study. Accid Anal Prev 1990; 22:549-59.
14. Stutts Jc. Bicycle accidents and injuries: a pilot study comparing hospital and police-reported data. Accid Anal Prev 1990; 22:67-78.
15. Mueller B A, Rivara F P, Lii S M, Weiss N S. Environmental factors and the risk for childhood pedestrian-motor vehicle collision occurrence. Am J Epidemiol 1990; 132:550-60.
16. Brison R J, Wicklund K, Mueller B A. Fatal pedestrian injuries to young children: a different pattern of injury. Am J Public Health 1988; 78:793-5.
17. Roberts I, Crombie I. Child pedestrian deaths: sensitivity to traffic volume —evidence from the USA. J Epidemiol Community Health 1995; 49:136-8.
18. Champion H R, Copes W S, Sacco W J. The Major Trauma Outcome Study: establishing national norms for trauma care. J Trauma 1990; 30:1356-65.
19. Seow E, Lim E. Ambulance response time to emergency departments. Singapore Med J 1993; 34:530-2.
20. Bull J P, Raffle P A B. Factors affecting a fatal outcome in road accidents. Med Sci Law 1990; 30:57-9.