Appendix 2

Table 2.Multiple regression analysis for variables predicting intentions to use a mobile phone while driving (N = 196)

	Variable	B	B	R^2	ΔR^2
Step 1				.02	.02
	Age	.02	.02		
	Sex	-.33	-.07		
	Type of phone use	-.31	-.05		
Step 2				.45	.43***
	Attitude	.71	.62***		
	Subjective norm	-.12	-.09		
	Perceived behavioural control	.21	.19***		
Step 3				.47	.02**
	Mobile phone involvement	.27	.14**		

p*< .05.*p*< .01.****p*< .001.

Note. Weights provided are at the final step of the analysis.

Road trauma, patterns of injury and mortality in an Australian trauma centre

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Abstract

Introduction: Road trauma remains a leading cause of death and permanent disability. The authors investigated differences between road user groups, mortality rates and pattern of injuries. **Methods:** Data were prospectively collected on trauma presentations to the St George Public Hospital (SGH) from January 2002 to June 2008 (n=5118). Injury severity and patterns were evaluated using the Injury Severity Score (ISS), the New Injury Severity Score (NISS) and the Abbreviated Injury Score (AIS). Multiple regression analysis was used to analyse data. **Results:** Risk of death was 5 times higher for injured pedestrians than drivers (OR=5.0 95% C.I 2.97-8.57, p<0.001). Patients with head injuries had an increased risk of death compared to patients without head injuries (adjusted OR=6.04, 95% C.I. 3.79-9.64, p<0.0001).
Conclusion: Vulnerable road users had a significantly higher mortality rate than other road users. These findings highlight the need for further research into factors contributing to pedestrian injury such as road design and pedestrian crossings.

Keywords

AIS, Car occupant, ISS, Mortality, NISS, Pedestrian, Road trauma, Trauma

Introduction

Despite a decrease in the mortality rate of multi-trauma patients over the past two decades, road trauma remains a leading cause of death and long-term morbidity [1]. The decrease is partly due to increased occupant crashworthiness of new vehicle models and safer road design, but is also due to road safety campaigns increasing public awareness of the importance of wearing a seatbelt, avoiding drink driving and speed enforcement legislation [2, 3].

The Crash Injury Research and Engineering Network (CIREN) was developed by the National Highway Traffic Safety Administration (NHTSA) in the United States in 1996. It is a multicentric research collaboration between clinicians and engineers looking at traffic-related injuries presenting to eight 'level 1' trauma centres in the United States. The mission of the

CIREN studies is to improve the prevention, treatment, and rehabilitation of motor vehicle injuries and to reduce death, disability, and human and economic costs [4]. The CIREN research has chosen to focus on individual factors that may affect mortality/outcome such as mortality rates in severely injured patients according to vehicle make [5] and the patient's position in the car (near- vs. far-side car occupants) [6].

There have been limited publications correlating the type of injuries sustained by road user groups - pedestrians, bicyclists, motorcyclists, car-occupants - and outcome indicators, such as death, injury severity or length of stay (LOS). Eid et al. investigated 1070 trauma patients divided into road user types [7]. They focused on ethnicity of patients as well as death, severity of injury (ISS) and injury pattern, and found that predictors for mortality included low GCS, high ISS and low systolic blood pressure on admission[7]. Road user groups were not found to be significant in predicting mortality [7].

Markogiannakis et al. studied 730 consecutive road trauma patients and found that there was an association between road user groups and outcomes and injury profiles[8]. Car occupants were the group with the highest injury severity score (ISS) but pedestrians were the group with the highest mortality[8]. Further, Markogiannakis found that craniocerebral injuries were significantly more frequent in motorcyclists and pedestrians than in the other road user groups[8]. Large autopsy studies of road trauma also indicate head injuries as a leading cause of death [9, 10].

The authors of this study investigated patterns of injury in road trauma to identify differences in mortality rate and pattern of injuries. A better understanding of the mechanisms behind road trauma and its effectson a variety of road user groups may allow us to be better equipped to predict and prevent future road injuries.

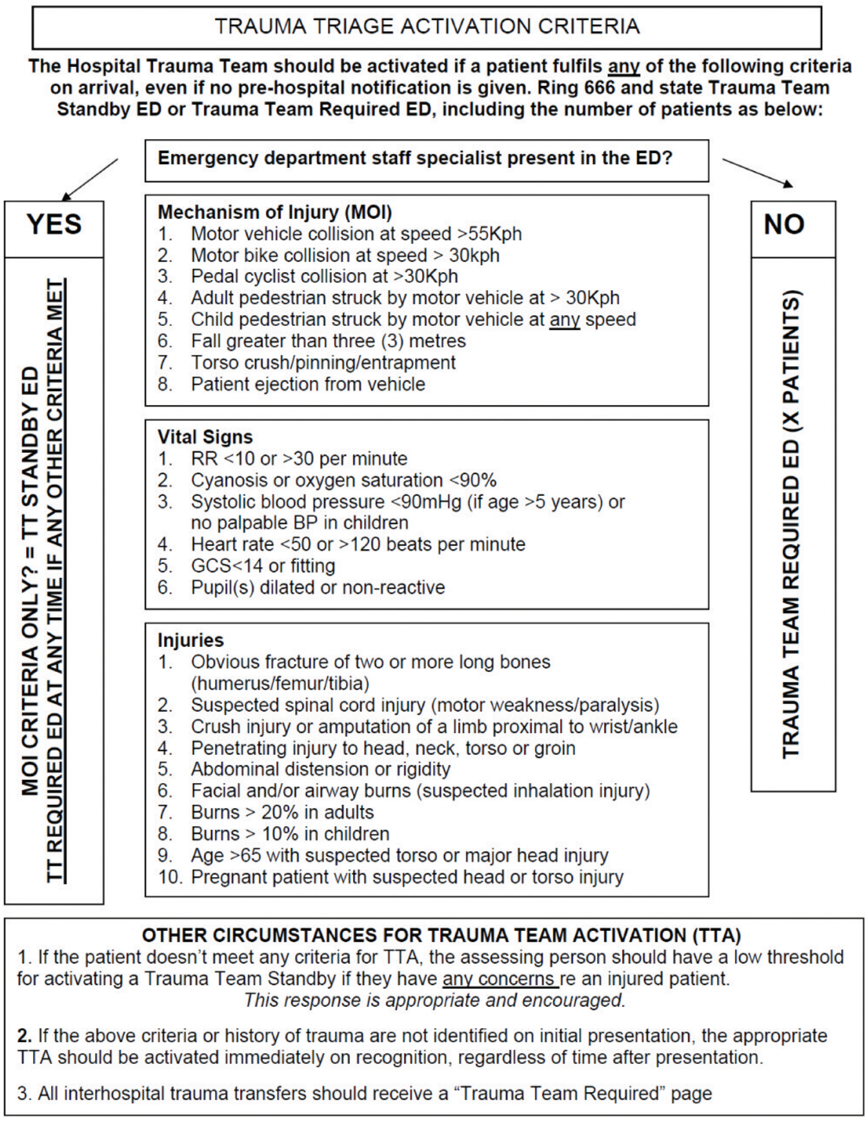

Figure 1. Trauma team activation criteria

Materials and Methods

Analysis of prospectively collected data on patients presenting to St George Public Hospital (SGH) from January 2002 to June 2008 meeting Trauma Team activation criteria was performed (Figure 1). Data is collected prospectively by trauma nurses at the patient bedside. Each trauma nurse has undergone injury coding training. A purpose-built trauma data registry is continuously kept up to date. This data includes patient demographics, mechanism of injury, physiological data, length of stay (LOS), ISS and in-hospital complications. Logarithmic values were used to remove skewness in the LOS data. Patients were assigned to various road user groups: pedestrian, bicyclist, motorcyclist or car occupant. Patient injury severity and injury pattern were evaluated using the Injury Severity Score (ISS), the New Injury Severity Score (NISS) and the Abbreviated Injury Score (AIS)[11].

Statistical analyses were performed using SAS version 9.1.3 (SAS Institute, Inc.,Cary, NC). The association between two categorical variables was assessed through Chi-square tests. One-way ANOVA was used to test the equality of means among groups. Adjusted odds ratios controlling for age and sex, derived from multiple logistic regression were used for pairwise comparisons of binary outcome variables. To evaluate length of stay, a continuous variable, multiple regression was used to control for age and sex. In the presence of numerous post-hoc comparisons, Bonferroni-adjusted p-values, used to control for the experimentwise error rate (EWER), is overly conservative. For this study, the level of significance after a Bonferroni adjustment would be $0.05/15 \approx 0.0033$. As a compromise between controlling for EWER and conservatism, p-values from post-hoc comparisons less than $\alpha=0.005$ are deemed statistically significant. Deviance Goodness of Fit Statistics was used to measure goodness-of-fit for logistic regression.

Results

Between January 2002 and June 2008, 5118 road-related trauma patients meeting trauma triage activation criteria presented to the emergency department (ED), about 1.6% of all ED presentations. 3119 (60.9%) patients were male. The majority of patients in each group were male except front-seat (39%) and rear-seat passengers (43.1%) where the majority of patients were female (Table 1).

There was a significant association between age group and road user type as shown in Table 1. Of the 620 patients less than 17years of age, 35.7% (221) were rear-seat passengers, 26.5% (164) pedestrians and 20.2% (125) pedal-cyclists. In the 17-49 year age group 49.6% (1607 of 3241) were drivers, 16.1% (522) motorcyclists and 13.2% (428) front-seat passengers. In the 50-65 year group, 57% (403 of 707) were drivers, 13.4% (95) front-seat passengers and 11.6% (82) pedestrians. In the >65 year group, 45.1% (248 of 550) were drivers, 28.2% (155) pedestrians and 17.8% (98) front –seat passengers.

5.6% (288) of the 5118 patients required admission to the high-dependency unit (HDU) meaning they required closer observation and monitoring than what was possible on the ward (Table 2). 3.7% of patients (188) required admission to intensive care (ICU) meaning they were so unwell that they required assistance with airway, ventilation and/or circulation (Table 2). Pedestrians had the highest admission rate to ICU (5.8%), and motorcyclists had the highest admission rate to HDU (8.1%). The association between road user group and admission to HDU was statistically significant (Table 2).

The patients staying longest in critical care units were motorcyclists in ICU (1.77 days) and front-seat passengers in HDU (1.18 days). There was a significant association between road user groups, injury and overall length of stay (LOS) in hospital (Table 2).

After controlling for variables such as sex and age, individual linear regression models found that for each unit increase in NISS, LOS in hospital increased by 1.044 days (95% CI 1.003-1.038, $p<0.0001$). For each unit increase in ISS, the LOS increased by 1.057 days (95% CI 1.049 – 1.063, $p<0.0001$). Patients having more than one severe injury (AIS≥3) had an increased LOS of 2.208 days (95% CI 1.578 – 3.089, $p<0.0001$) compared to patients only sustaining one severe injury (AIS≥3).

Table 3 demonstrates the incidence of severe injury (AIS≥3). Drivers and front-seat passengers had a similar pattern of injury, with more severe injuries to thorax (33.7% and 35.6%

Table 1. Age, sex, admission and survival by type of road user - indicative of different rates of exposure and risk across different demographic groups

Cause of injury	Male (%)	Age <17 (%)	Age 17-49 (%)	Age 50-65 (%)	Age >65 (%)	Deaths (%)	Admitted (%)	Total (%)
Driver	1342 (59.12)	12 (1.94)	1607 (49.58)	403 (57.00)	248 (45.09)	25 (1.10)	111(4.89)	2270 (44.35)
Front seat passenger	274 (39.03)	81 (13.06)	428 (13.21)	95 (13.44)	98 (17.82)	8 (1.14)	31(4.42)	702(13.72)
Rear seat passenger	188 (43.12)	221 (35.64)	162 (5.00)	25 (3.54)	28 (5.09)	4 (0.92)	21(4.82)	436 (8.52)
Pedal cyclist	356 (85.58)	125 (20.16)	234 (7.22)	42 (5.94)	15 (2.73)	3 (0.72)	37(8.89)	416 (8.13)
Motor cyclist	543 (89.75)	17 (2.74)	522 (16.11)	60 (8.49)	6 (1.09)	7 (1.16)	47(7.77)	605 (11.82)
Pedestrians	416 (60.38)	164 (26.45)	288 (8.89)	82 (11.60)	155 (28.18)	39 (5.66)	123(17.85)	689 (13.46)
Total	3119 (60.94)	620 (100)	3241 (100)	707 (100)	550 (100)	86(1.68)	370 (7.23)	5118 (100)

Table 2. Length of stay in critical care and hospital according to road user group for admitted trauma patients

	Length of stay (log value)		Days in ICU (log value)		Days in HDU (log value)	
	n	Mean (SD)	n (%)	Mean (SD)	n (%)	Mean (SD)
Driver	111	2.83 (1.19)	79 (3.48%)	1.49 (0.94)	109 (4.80%)	0.95 (0.64)
Front seat Passenger	31	2.69 (1.44)	19 (2.71%)	1.58 (1.02)	36 (5.13%)	1.18 (0.68)
Rear seat Passenger	21	1.54 (1.56)	7 (1.61%)	1.71 (0.51)	15 (3.44%)	1.07 (0.83)
Pedal cyclist	37	1.40 (1.48)	15 (3.61%)	1.19 (0.90)	30 (7.21%)	1.01 (0.65)
Motor cyclist	47	2.38 (1.17)	28 (4.63%)	1.77 (0.83)	49 (8.10%)	1.01 (0.64)
Pedestrians	123	2.04 (1.63)	40 (5.81%)	1.63 (0.91)	49 (7.11%)	1.17 (0.78)
Total	370		188 (3.67%)		288 (5.63%)	

NB Some patients were admitted both to ICU and HDU during their admission and therefore appear in both columns.

Table 3. Incidence of severe injury (AIS≥3) per anatomical region for each road user group

n (%)	Driver	Front - seat passenger	Rear- seat passenger	Pedal Cyclist	Motorcyclist	Pedestrian
Head	96 (26.52)	33 (24.44)	11 (16.92)	33 (33.67)	31 (15.90)	95 (32.87)
Face	10 (2.76)	2 (1.48)	1 (1.54)	1 (1.02)	0 (0.0)	6 (2.08)
Neck	2 (0.55)	1 (0.74)	0 (0.0)	1 (1.02)	3 (1.54)	1 (0.35)
Thorax	122 (33.70)	48 (35.56)	23 (35.38)	13 (13.27)	68 (34.87)	80 (27.68)
Abdomen	29 (8.01)	16 (11.85)	11 (16.92)	9 (9.18)	18 (9.23)	22 (7.61)
Spine	33 (9.12)	16 (11.85)	8 (12.31)	13 (13.27)	13 (6.67)	14 (4.84)
Upper Extreme	39 (10.77)	7 (5.19)	4 (6.15)	9 (9.18)	32 (16.41)	25 (8.65)
Lower Extreme	31 (8.56)	12 (8.89)	7 (10.77)	19 (19.39)	30 (15.38)	46 (15.92)
Skin	0	0	0	0	0	0
Total	362	135	65	98	195	289

NB The number in () signifies what % per road user group had severe injuries to one particular body region; each patient may have more than one injury with AIS≥3

respectively), head (26.5% and 24.4%), and to a lesser extent abdomen (8% and 11.9%) and spine (9.1% and 11.9%). Rear-seat passengers also had a high frequency of severe thoracic injuries (35.4%), but sustained a higher incidence of severe abdominal injuries (16.9%). Rear-seat passengers had fewer severe head injuries (16.9%) compared with other groups.

Pedal cyclists had the highest overall frequency of head (33.7%), spine (13.3%) and lower limb injuries (19.4%) but sustained severe thoracic (13.3%) injuries less often than other groups. Pedal cyclists had a modest proportion of abdominal injuries (9.2%) compared to the other groups. Abdominal injuries ranged from 7.6% for pedestrians to 16.9% for rear-seat passengers.The most frequent area of severe injury sustained by motorcyclists was the thorax (34.9%). They also sustained severe injuries to the head (15.9%) and both upper (16.4%) and lower limbs (15.4%). Pedestrians most frequently sustained severe trauma to the head (32.9%), followed by thorax (27.7%) and lower limb (15.9%).Pedestrians had the highest proportion of severely injured patients with 23.8% having an Injury Severity Score (ISS) >15. 17% of motorcyclists and 12% of pedal cyclists had an ISS>15. Less than 10% of car occupants had an ISS>15 (Table 4). There was a significant association between road user type and ISS ($p<0.0001$).

Pedestrians were significantly more likely to have an AIS≥3 than drivers. When statistically adjusted for the difference in ISS score between groups, the OR for pedestrians was OR=3.36 (95% C.I 2.68-4.19, $p<0.001$), front-seat passengers OR=2.66 (95% C.I 1.99 – 3.55, $p<0.001$) or rear-seat passengers OR=2.33 (95% C.I 1.63 – 3.34, $p<0.0001$). The odds ratios were slightly lower for motorcyclists and pedal cyclists, but they remained significantly higher than those of motor vehicle occupants (Table 5). The odds of having an AIS≥3 were over 4 times greater in patients with more than one body region injured, compared to patients with a single body region injured (adjusted OR=4.68, 95% C.I 3.58-6.11, $p<0.0001$). Multiple high AIS scores in different body regions are required for a high ISS score, and the findings are reflective of that. However, in all patient groups, not just in the group with ISS>15, the odds of having an AIS≥3 were higher for patients with more than one body region injured.

Table 4. Injury severity according to road user type for all trauma presentations

Cause of injury	ISS <9 n (%)	ISS 9-15 n (%)	All ISS >15 n (%)	Mean (SD) Log(ISS)	Log(NISS)
Driver	1855 (81.72)	206 (9.07)	209 (9.21)	1.21 (0.96)	1.31 (1.010
Front-seat Passenger	570 (81.20)	66 (9.40)	66 (9.40)	1.20 (0.98)	1.30 (1.02)
Rear-seat Passenger	368 (84.40)	29 (6.65)	39 (8.94)	0.93 (0.99)	1.02 (1.05)
Pedal cyclist	264 (63.46)	104 (25.00)	48 (11.54)	1.74 (0.85)	1.94 (0.89)
Motorcyclist	352 (58.18)	150 (24.79)	103 (17.02)	1.79 (0.97)	2.01 (1.04)
Pedestrians	361 (52.39)	164 (23.80)	164 (23.80)	1.94 (1.05)	2.14 (1.05)
Test statistics	$x^2(10)=411.6$, P <0.0001			F=116.81 P<0.0001	F=137.60 P<0.0001

The overall risk of death was 1.7% (Table 1). The risk of death was greater for pedestrians than other groups (5.7%) (Table 1). The odds of death in pedestrians compared to that of drivers and pedal cyclists were more than five times higher (odds ratios 5.0 and 5.6 respectively), and 4 times higher than those of front-seat passengers and motorcyclists after controlling for age and gender (Table 5).

Using logistic regression, the association between death and NISS, ISS or multiple injured anatomical areas was found to be significant. The odds of death were increased by 14% with each unit increase in NISS, adjusted OR of death 1.14 (95% C.I. 1.12-1.16, p<0.0001), and by 16% with each unit increase in ISS, adjusted OR of death 1.16 (95% C.I. 1.13-1.18, p<0.0001). The odds of death in those with multiple AIS≥3 injuries were over 6 times those of patients with a single injury with an adjusted OR of death of 6.64 (95% C.I. 2.42-18.21, p<0.001).

The study found that 59 patients (1.2%) were admitted with severe head injuries (AIS>=3). There is a higher pre-dominance of male patients in the head-injured group compared to the non-head-injured group for all road user groups (67.6% vs. 56.7% for drivers, 48.1% vs. 36.9% for front-seat passengers, 53.8% vs. 40.7 for rear-seat passengers, 86.2% vs. 85.1% for bicyclists, 90.5% vs. 89.5% for motorcyclists, 63.7% vs. 57.5% of pedestrians). The risk of death is higher in the head-injured group with 3.7% vs. 0.3% for drivers, 5.3% vs. 0.2% for front-seat passengers, 1.3% vs. 0.8% for rear-seat passengers, 1.1% vs. 0.4% for bicyclists, 1.4% vs. 1.1% for motorcyclists and 8.8% vs. 3% for pedestrians (Table 6).

After controlling for age and sex in a logistic regression model, patients with head injuries have a statistically significant increased risk of death compared to patients without head injuries (adjusted OR=6.04, 95% C.I. 3.79-9.64, p<0.0001) (Table 5). Among patients sustaining head injuries, the risk of death was greater for pedestrians compared to drivers (adjusted OR=2.40, 95% C.I 1.27-4.54, p=0.007), motorcyclists (adjusted OR=6.02, 95% C.I. 1.36-26.73, p=0.0182) and pedal cyclists (adjusted OR=6.14, 95% C.I. 1.41-26.75, p=0.0157)(Table 4).

Discussion

It was found that the most vulnerable road users are pedestrians, followed by motorcyclists, cyclists and then vehicle occupants who are provided the most protection during impact. The probability of death amongst patients with trauma presentations to the emergency department in the study period was five times higher for pedestrians than that for drivers and pedal cyclists and four times higher for pedestrians than for front-seat passengers and motorcyclists. Vulnerable (minimally protected) road users – pedestrians, pedal cyclists and motorcyclists - were significantly more likely to have an AIS≥3 than car occupants. The risk was greatest for pedestrians. A larger proportion of pedestrians were severely injured in comparison with other road users.

There have been a large number of studies investigating how injuries occur to pedestrians struck by cars, buses and bicyclists as a result of crash investigation, reconstruction of real world crashes and computer simulation studies [12-19], yet the type and severity of injuries sustained by each road user group have been less well investigated. For sedans and small vehicles, the pedestrian is usually struck at the legs first. This causes the body to rotate towards the vehicle's bonnet and windscreen leading to the pedestrian's unprotected head hitting either the bonnet or windscreen. The pedestrian is then thrown forward and usually strikes the ground headfirst. In the case of buses and trucks, the head is struck either by the vehicle or when the pedestrian is struck in the chest and thrown backwards striking the back of their head on the pavement[19]. All studies show that greatest risk of injury is to the pedestrian's head as a result of such an impact.

Head injured pedestrians had a significantly higher mortality rate than other vulnerable road users. This could be explained by helmet use in other groups. Cyclists and motorcyclists have a high rate of helmet wearing, reducing impact severity to the head during a crash. Occupants in motor vehicles, have protection in terms of crumple zones, airbags, seatbelts and air curtains. Head injuries to vehicle occupants usually occur as a result of lateral impacts. The occupant's head is struck by an incoming vehicle or strikes an internal surface of the vehicle

Table 5. Odds ratios (with 95% confidence intervals) for outcome (AIS≥3, death, hospital admission, admission to HDU, admission to ICU) for each pairwise comparison of road user groups, after adjusting for sex and age groups

Adjusted OR 95% C.I p-value (sample size)		Driver	Front-seat passenger	Rear-seat passenger	Motor cyclist	Pedal cyclist
AIS≥3 (n=807)[a]	Driver	1				
	Front seat passenger	1.26 (0.97, 1.65) 0.088	1			
	Rear seat passenger	1.44 (1.01, 2.04) 0.043	1.14 (0.77, 1.68) 0.517	1		
	Motor cyclist	2.69 (2.12, 3.41) <0.001	2.13 (1.56, 2.90) <0.0001	1.87 (1.28, 2.74) 0.001	1	
	Pedal cyclist	2.50 (1.88, 3.32) <0.001	1.98 (1.41, 2.79) <0.0001	1.74 (1.17, 2.59) 0.006	0.93 (0.68, 1.27) 0.648	1
	Pedestrian	3.36 (2.68, 4.19) <0.0001	2.66 (1.99, 3.55) <0.0001	2.33 (1.63, 3.34) <0.0001	1.25 (0.95, 1.63) 0.107	1.34 (0.99, 1.81) 0.055
Death (n=86)[a]	Driver	1				
	Front seat passenger	1.26 (0.55, 2.85) 0.586	1			
	Rear seat passenger	1.72 (0.58, 5.11) 0.332	1.37 (0.40, 4.65) 0.617	1		
	Motor cyclist	1.25 (0.53, 2.97) 0.610	1.00 (0.34, 2.89) 0.996	0.73 (0.20, 2.62) 0.629	1	
	Pedal cyclist	0.90 (0.27, 3.03) 0.866	0.72 (0.18, 2.80) 0.632	0.52 (0.11, 2.42) 0.409	0.72 (0.18, 2.82) 0.637	1
	Pedestrian	5.04 (2.97, 8.57) <0.001	4.02 (1.82, 8.85) <0.001	2.94 (1.01, 8.53) 0.047	4.03 (1.70, 9.57) <0.01	5.60 (1.68, 18.69) 0.005
Admitted to ICU	Driver	1				
(n=188)[a]	Front seat passenger	0.98 (0.59, 1.64) 0.9401	1			
	Rear seat passenger	0.92 (0.42, 2.06) 0.8467	0.94 (0.39, 2.29) 0.896	1		
	Motor cyclist	1.22 (0.77, 1.91) 0.3980	1.24 (0.67, 2.30) 0.4945	1.32 (0.55, 3.12) 0.5351	1	
	Pedal cyclist	1.24 (0.70, 2.20) 0.4588	1.27 (0.62, 2.57) 0.5124	1.34 (0.53, 3.39) 0.5316	1.02 (0.54, 1.95) 0.9477	1
	Pedestrian	2.04 (1.36, 3.06) 0.0005	2.08 (1.18, 3.68) 0.0115	2.21 (0.96, 5.06) 0.0610	1.68 (0.99, 2.84) 0.0524	1.64 (0.88, 3.07) 0.1183
Admitted to HDU	Driver	1				
(n=288)[a]	Front seat passenger	1.20 (0.81, 1.79) 0.3663	1			
	Rear seat passenger	1.30 (0.73, 2.31) 0.3772	1.08 (0.57, 2.03) 0.8144	1		
	Motorcyclist	2.06 (1.43, 2.98) 0.0001	1.72 (1.06, 2.77) 0.0269	1.59 (0.85, 2.99) 0.1481	1	
	Pedal cyclist	2.16 (1.40, 3.35) 0.0005	1.80 (1.06, 3.06) 0.0295	1.67 (0.86, 3.23) 0.1284	1.05 (0.65, 1.70) 0.8481	1
	Pedestrian	1.48 (1.03, 2.13) 0.0357	1.22 (0.78, 1.95) 0.3789	1.14 (0.62, 2.11) 0.6777	0.72 (0.46, 1.12) 0.1443	0.68 (0.41, 1.12) 0.1328

Head injuries and died (n=59)[b]	**Driver**	1				
	Front seat passenger	1.76 (0.71, 4.34) 0.2278	1			
	Rear seat passenger	0.54 (0.07, 4.20) 0.5576	0.31 (0.04, 2.61)	0.2813	1	
	Motor cyclist	0.40 (0.09, 1.76) 0.2241	0.23 (0.05, 1.15) 0.07	0.74 (0.06, 8.43) 0.8054	1	
	Pedal cyclist	0.39 (0.09, 1.73) 0.2152	0.22 (0.04, 1.13) 0.0695	0.72 (0.06, 8.21) 0.7927	0.98 (0.13, 7.14) 0.9847	1
	Pedestrian	2.40 (1.27, 4.54) 0.0070	1.37 (0.56, 3.37) 0.4882	4.43 (0.58, 33.91) 0.1516	6.02 (1.36, 26.73) 0.0182	6.14 (1.41, 26.75) 0.0157

[a]All trauma patient presentations [b]Trauma patient presentations with head injuries

Table 6. Demographics grouped by non-head injured and head injured patient

n (%)	Cause of injury	Male	Age<17	Age 17-49	Age 50-65	Age >65	Deaths	Total
Non-head injuries	**Driver**	998 (56.67)	11 (0.62)	1233 (70.02)	324 (18.40)	193 (10.96)	6 (0.34)	1761
	Front seat passenger	210 (36.91)	69 (12.13)	334 (58.70)	81 (14.24)	85 (14.94)	1 (0.18)	569
	Rear seat passenger	145 (40.73)	188 (52.81)	121 (33.99)	23 (6.46)	24 (6.74)	3 (0.84)	356
	Pedal cyclist	200 (85.11)	62 (26.38)	140 (59.57)	26 (11.06)	7 (2.98)	1 (0.43)	235
	Motor cyclist	409 (89.50)	12 (2.63)	391 (85.56)	50 (10.94)	4 (0.88)	5 (1.09)	457
	Pedestrians	214 (57.53)	89 (23.92)	163 (43.82)	45 (12.10)	75 (20.16)	11 (2.96)	372
Head injuries	**Driver**	344 (67.58)	1 (0.20)	374 (73.48)	79 (15.52)	55 (10.81)	19 (3.73)	509
	Front seat passenger	64 (48.12)	12 (9.02)	94 (70.68)	14 (10.53)	13 (9.77)	7 (5.26)	133
	Rear seat passenger	43 (53.75)	33 (41.25)	41 (51.25)	2 (2.50)	4 (5.00)	1 (1.25)	80
	Pedal cyclist	156 (86.19)	63 (34.81)	94 (51.93)	16 (8.84)	8 (4.42)	2 (1.10)	181
	Motor cyclist	134 (90.54)	5 (3.38)	131 (88.51)	10 (6.76)	2 (1.35)	2 (1.35)	148
	Pedestrians	202 (63.72)	75 (23.66)	125 (39.43)	37 (11.67)	80 (25.24)	28 (8.83)	317

during impact [18, 20, 21]. Side impact crashes into poles and trees also result in serious head injuries when the occupant's head strikes the intruding tree or pole as a result of body inertia [16, 22]. Similarly, chest injuries are dominant in side impact pole and tree crashes.

Patients with head injuries have a higher mortality rate than non-head injured patients. This is consistent with previous epidemiological studies that have looked at cause of death and trauma scores [9, 10, 17, 23-27]. These studies report Central Nervous System (CNS)-related causes of death in 21.6-71.5% of all trauma-deaths. In 2009 Pfeifer found the majority of deaths were due to CNS-injury (21.6-71.5%) followed by exsanguination (12.5 – 26.6%) and sepsis (3.1 – 17%) [27].

Pfeifer compared mortality rates reported in the 1980s, 1990s and 2000s and an overall decrease in mortality was found. When broken down an increase was found in deaths from injuries to the Central Nervous System (CNS) (50.1% - 44.2% - 63.5%), a small change was found in deaths from sepsis (7.3% - 3% - 5.2%), and a significant decrease was found in deaths from exsanguination (27.6 % - 25% - 15%)[27]. Pfeifer's study included pre-hospital deaths and was partly designed to assess the effect of Advanced Trauma Life Support (ATLS) training on mortality[28]. ATLS was first introduced in 1978 but only became common in the developed world as part of surgical training in the late 1990s and 2000. The decrease in overall mortality and mortality due to exsanguination over the three decades Pfeifer looked at is probably related to the wider implementation of trauma systems and better management of severely injured patients as outlined in the ATLS guidelines [29]. Van Olden et al. demonstrated that the introduction of ATLS training programs significantly reduced overall mortality rates (24.3% pre-ATLS, 0% post-ATLS) [29, 30].

Several factors may be responsible for the rate of CNS-related deaths not having changed over the last three decades. Both Pfeifer and Van Olden looked at mortality rates only; it is possible that the majority of patients recorded as CNS-related deaths were too severely injured for the introduction of ATLS guidelines to make a difference in their outcome. In this study population, however, ISS, NISS, having multiple injuries with AIS>=3, or having a head injury were all statistically significantly associated with increased chance of dying in all road user groups.

The data was collected prospectively on patients brought into hospital. In 1996, Hill et al. performed a population-based study showing that 67% of car occupants in their population died at the scene, frequently from blood loss due to aortic rupture. This was in contrast to pedestrians, where 67% died in hospital predominantly from head injuries[13]. Trauma victims who died at the scene were not included in this study. This may alter the results slightly, as some trauma groups may be more likely to sustain injuries resulting in immediate and 'at the scene' death than others.

Conclusion

Vulnerable road users, in particular pedestrians, had a significantly higher mortality rate than other road users with 5.7% mortality rate. Patients with head injuries had an increased risk of death compared to patients without head injuries, particularly pedestrians, with an 8.8% mortality rate. These findings highlight the need for further research into factors contributing to pedestrian injury, such as road design and pedestrian crossings.

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