Patterns of Anatomical Injury Severity to Different Types of Road Users in Road Crashes

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ABSTRACT

Detailed injury descriptions from road crashes are essential for road injury prevention analysis. This study aims to describe the anatomical injury severity of the victims and its relation to the types of road users. Injury data and diagnoses were collected from the accident and emergency departments from hospitals in Kuala Lumpur, Malaysia. A total of 14,196 victims were enrolled, of which 173 (1.22%) suffered major trauma (ISS × 16). Severe injuries in this study are defined as victims with any injury of AIS score × 3 on at least one of the body region. A majority of vehicle occupants sustained external injuries (34.4%) while severe injuries commonly occurred to the head region with internal organs the most frequently (73.5%) injured; specifically cerebrum subdural hematoma. Most frequent region of injury for motorcyclists commonly found at the lower extremity region (27%), in which abrasion is the common type of injury. Severe injuries to motorcyclists also frequently occur at the lower extremity region (43.4%) and head (42.8%). Severe head injuries to motorcyclist were common at the cerebrum section. Pedestrian injuries frequently occur at the lower extremity region (32%); majority suffering fibula fracture while severe injuries commonly occurred to the cerebrum part of the head region. Findings from this study show underlying patterns of injuries sustained by each type of road users and would be useful in helping researchers and engineers design a new and improved safety device that can help reduce injuries in future road crashes.

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Keywords: Road crash; Injury Severity; Injury pattern; Road trauma registry

INTRODUCTION

As a developing country, Malaysia experiences a remarkable growth in terms of population, number of registered vehicles and increment in road length. Despite prosperous economic growth, the number of road traffic casualties is at an alarming rate, with an increase in number of road crashes by 56% in the past 10 years, with recent data recorded 414,421 road accidents in year 2010 and 6,872 road deaths (Royal Malaysian Police, 2010). The number of people who experienced severe and slight injuries decreased by 48% (40,812 in 2005; 21,397 in 2010), but the number of fatalities had increased by 11% (6,200 in 2005; 6,872 in 2010), indicating that the level of severity for road crashes in Malaysia is increasing.

Many countries including Malaysia rely on police data alone for road crash analysis and investigation. Circumstances of road crashes, characteristics of the people and vehicles involved in the crash and the environmental condition at the time of the crash are routinely collected by the police (Hashim & Syed Mohamed Rahim, 2009). However, previous research has identified the level of incompleteness in the police crash surveillance system (Tsui, 2009). To improve road safety performance, death statistics alone would not be sufficient as the injury details also play an important part for injury prevention. In Malaysia, vital injury details are not collected in crash investigations and this often limits the research study that can be carried out.

Globally, the first world conference on injury prevention and control which was held in Stockholm, Sweden in 1998 recognized that there was no sufficient injury information available in helping to plan for prevention or reducing the harms caused by injuries (Holder, et al., 2001). World Health Organization statistics show that road crashes is the 9th leading cause of death in the world and it is estimated to become the 5th leading cause by year 2030 (World Health Organization, 2009). Complete and accurate information on injuries and their causes is essential to improve the situation through road safety research, injury risk and outcome research, as well as for policy development and evaluation (McKenzie et al., 2008; Rosman, 2001; Rosman & Knuiman, 1994). Quality, reliable and representative information is vital in understanding the issues and in formulating strategies to address the issues (Gururaj, Rayan, Rot, & Amarnath, 2008).

By having comprehensive information on road crashes, research and intelligence to guide in solving the issue can be made as road crashes are usually preventable and predictable; most road crashes result from human error (Baker, OøNeill, Ginsburg, & Li, 1992). Road injuries follow certain patterns and previous research demonstrated the patterns of injuries between victims associated with various types of road users (Marshall & Langley, 1994), based on specific group, for example pedestrian (Arregui-Dalmases, Lopez-Valdes, & Segui-Gomez, 2010), motorcycles (Wyatt, OøDonnell, Beard, & Busuttil, 1999), high speed crashes (Weninger & Hertz, 2007), age (Newgard, 2008), children (Adesunkanmi, Oginni, Oyelami, & Badru, 2000), gender (Lindqvist, 1991), psychological outcomes (Mayou & Bryant, 2004) or specific issues such as the use of seat belts (Arajarvi, 1988). Specific case selection provides insight on the specific group or issues,

which however does not provide the overall picture. There are very little studies conducted in Malaysia to investigate the anatomical injury and this study would be the first in the country specific on road crashes occurred on Malaysian roads. A comparison on parts of body injured, number of injuries sustained and injury patterns are made for each of the road users. In addition, the influence of passive safety towards the severity of injury was also evaluated.

METHODS

Study design and setting

The National Trauma Database (NTrD), a national initiative data registry by the Ministry of Health to gather information on major trauma around the country, was used to help in data recording for this study. NTrD platform was used to store additional crash information. A modified version of NTrDøs case report form was developed with more emphasize given on data collection for details related to the road crash. The additional information required by this study includes demographic information, admission details, events related to injury, pre-hospital care and management, injury details, AIS, operative procedures, victim outcome and alcohol/drug use. A five month (April ó August 2010) cross-sectional study of all road crashes victims visiting Emergency Department in six hospitals in Klang Valley was undertaken. Hospitals involved in this study include the Kuala Lumpur Hospital, Ampang Hospital, Sungai Buloh Hospital, Klang Hospital, Serdang Hospital and Selayang Hospital. All of these hospitals are government-funded hospitals which most of road crash victims in the Klang Valley area would be sent to.

The details of injury were coded in Abbreviated Injury Scale (AIS). AIS use six point ordinal scales to classify injuries by parts of the body region. The coding provides researchers with a simple, numerical method of ranking and comparing injuries by severity, and standardized the terminology used to describe injuries (Rosman, Knuiman, & Ryan, 1996). AIS is also the most widely used scale to assess injury severity related to motor vehicular crash injury (Arregui-Dalmases et al., 2010). Additional personnel called data registrars were employed to assist in performing the data coding and collections. They helped in compiling data from various sections of the hospital and code the injury. However, data registrars first need to be trained to furnish them with the expertise in medical terminology, anatomy and physiology, clinical classifications, AIS as well as the health information systems used in the hospitals. An intensive course on AIS coding was conducted where data registrars were trained to code injuries into AIS. Only successful data registrars whom pass the training and pose the required skills were allowed to perform data coding and collection.

Main outcome measure

Injury diagnoses were coded using the AIS version 2005 update 2008 (Gennarelli, 2008). The AIS severity score is an ordinal scale ranges from 1 (minor) to 6 (nonsurvivable) as follows: AIS 0 = no injury, AIS 1 = minor, AIS 2 = moderate, AIS 3 = serious, AIS 4 = severe, AIS 5 = critical; AIS 6 = maximum/nonsurvivable. The Injury Severity Score (ISS) was then used to integrate the severity of the victims sustaining several injuries. ISS combines the three most

severe injuries in three separate body regions based on AIS to create an ordinal scale ranging from 1 to 75 (Baker et al., 1974).

A majority of road injury cases received by the participating hospitals in this study were outpatient cases. From the total victims enrolled in the study (n = 14,196), 16.33% was admitted to the hospital and 1.22% from the total sample sustained major trauma. Major trauma is defined as ISS × 16 (Soreide, 2009). To determine the extent of threat to life to these road user victims, only serious injuries were analyzed. Serious injuries in this study are defined as those that attain an AIS score of × 3 to any of the AIS body region. Potential differences in the proportions of serious injuries to different type of AIS body regions (head, face neck, thorax, abdomen, spine, upper extremity, lower extremity external and others) were also recorded for each type of road users.

Road user characteristics

Among the variables included in the analysis are common and known risk factors that would affect injury severity. These variables include: demographic information (gender and age), injury diagnosis and type of road user with regard to the vehicle (car/van driver, front car/van occupant, rear car/van occupant, motorcycle rider/pillion, pedestrian, bicyclist or lorry/bus users); transportation to hospital (pre-medical care treatment); number of injuries sustained; number of body regions injured; AIS codes, and the total ISS (Eid et al., 2009; Newgard, 2008).

Data analysis

To compare the injury severity outcome among the different types of road users, ISS score is used. ISS score is an ordinal scale of measurement (Linn, 2005). Therefore, nonparametric approach is suitable for data analysis as it does not require the assumptions of normality. The Kruskal-Wallis test is the nonparametric test equivalent to the independent samples of ANOVA. It tests the null hypothesis that the probability distributions of ordinal scale variables are the same for k independent populations, whereby $k > 2$. The test is applicable to data that is ranked or quantitative, independent samples, populations are not normally distributed, and level of measurement is at least ordinal (Washington, 2003), as reflected in the injury data collected in this study. The Mann-Whitney-U test is actually a Kruskal-Wallis test for two independent populations. In this study, comparisons are made for three major types of road users (pedestrians, private vehicle passengers, and motorcyclists). Whenever there is a significant difference between the groups, Mann-Whitney-U test will be conducted to see the differences between the groups. Data were analyzed with the Statistical Package for the Social Sciences (version 17, SPSS Inc.).

RESULTS

Demographic data and injury patterns

There were 14,196 road injury victims enrolled in this study. Of these victims, 1062 (7.5%) had at least one injury of AIS × 3 severity and is considered as serious injury victims. A total of 125

victims were recorded to have died during the data collection period. Within this sample, the distributions of injuries to all road users according to the AIS score were: AIS 1 = 74.22%; AIS 2 = 17.73%; AIS 3 = 7.31%; AIS 4 = 0.52%; AIS 5 = 0.20%; AIS 6 = 0.02%.

Table 1 below summarizes the injury severity sustained by each road user according to hospitals, age, gender, number of injuries and ISS score for victims of those sustained at least one injury of AIS × 3. The highest number of victims is from Hospital Kuala Lumpur, followed by Hospital Sungai Buloh and Hospital Klang. Both Hospital Kuala Lumpur and Hospital Klang are also categorized as referral hospitals.

Looking at road user categories, the highest percentage comes from motorcycles with 80.6% from the total victims. Private passenger vehicle occupantsø account for 9.2%, pedestrian 6.0% and followed by others 4.2%. Male victims outnumber female in all categories, with 85% involvement. The age group of 15 ó 29 makes up half of the statistics across road user categories, both as drivers and passengers, of which the majority are motorcyclists. On transportation to hospitals, 45% of victims were brought to hospitals by the public or the victim himself, and 54% by ambulance and the rest were by police or the fire brigade.

In terms of passenger vehicle occupants, at least 40% of them experienced 2-3 injuries, to at least two areas of body region. The same pattern can also be observed from two-wheel vehicle occupants, whereby 39% suffered 2-3 injuries, but the majority (47%) were injured at only one part of the body region. Across all road users, 80% of victims suffered at least two injuries and more, but only 17% suffered injuries to more than three parts of the body. ISS score shows that 84% had ISS score of less than 16, while the rest suffered an ISS score of 16 and above which is considered to be major trauma.

Passive safety device use

Helmet were used by 68.7% (n = 11,825) of the motorcyclist who were involved in the road crashes. Seat belts were used by 32.6% (n = 1,201) of the private passenger vehicles road crash victims. Airbag use was rather low, with only 1.7%, while 9.9% of the victims have airbag in their cars but they were not triggered during the crash. A majority (88.3%) has unknown status of airbag (n = 1,201).

Table 1 Select characteristics of road traffic injuries with AIS × 3, by road user type (n = 1,062)

	Private passenger vehicle								Two-wheel motor vehicles								Pedestrians		Others[a]		Total	
	Drivers		Passengers		Unknown		Total		Drivers		Passengers		Unknown		Total							
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
Hospitals																						
Selayang	5	8	1	3	0	0	6	6	92	12	8	9	2	33	102	12	4	6	4	9	116	11
Kuala Lumpur	16	25	7	22	0	0	23	23	235	31	30	34	2	33	267	31	25	39	7	16	322	30
Sungai Buloh	18	28	12	38	1	100	31	32	155	20	24	27	2	33	181	21	9	14	12	27	233	22
Ampang	5	8	2	6	0	0	7	7	39	5	7	8	0	0	46	5	7	11	3	7	63	6
Serdang	7	11	7	22	0	0	14	14	65	9	10	11	0	0	75	9	6	9	6	14	101	10
Klang	14	22	3	9	0	0	17	17	176	23	9	10	0	0	185	22	13	20	12	27	227	21
Gender																						
Male	57	6	18	2	0	0	75	8	679	75	54	6	5	1	738	82	53	6	35	4	901	85
Female	8	5	14	9	1	1	23	14	83	52	34	21	1	1	118	73	11	7	9	6	161	15
																					1062	
Age																						
0-14	0	0	8	25	1	100	9	9	42	6	18	20	0	0	60	7	7	11	9	20	85	8
15-29	33	51	18	56	0	0	51	52	426	56	52	59	3	50	481	56	28	44	8	18	568	53
30-44	19	29	5	16	0	0	24	24	159	21	11	13	1	17	171	20	19	30	14	32	228	21
45-59	10	15	1	3	0	0	11	11	89	12	5	6	2	33	96	11	5	8	8	18	120	11
>59	3	5	0	0	0	0	3	3	46	6	2	2	0	0	48	6	5	8	5	11	61	>6
Transport to Hospital																						
Public/Self	21	32	16	50	0	0	37	38	364	48	40	45	0	0	404	47	26	41	16	36	483	45
Ambulance	43	66	15	47	1	100	59	60	395	52	48	55	6	100	449	52	37	58	28	64	573	54
Police/Fire Brigade	0	0	1	3	0	0	1	1	3	0	0	0	0	0	3	0	1	2	0	0	5	0
Unknown	1	2	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0

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	Private passenger vehicle								Two-wheel motor vehicles								Pedestrians		Others[a]		Total	
	Drivers		Passengers		Unknown		Total		Drivers		Passengers		Unknown		Total							
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
Number of Injuries[b]																						
1	12	18	5	16	0	0	17	17	156	20	18	20	0	0	174	20	8	13	12	27	211	20
2-3	29	45	13	41	1	100	43	44	318	42	17	19	3	50	338	39	28	44	14	32	423	40
4-5	18	28	7	22	0	0	25	26	167	22	33	38	1	17	201	23	14	22	12	27	252	24
>5	6	9	7	22	0	0	13	13	121	16	20	23	2	33	143	17	14	22	6	14	176	>17
Number of body region's injured[c]																						
1	24	37	11	34	1	100	36	37	359	47	39	44	4	67	402	47	52	81	23	52	513	48
2	31	48	9	28	0	0	40	41	276	36	31	35	2	33	309	36	11	17	11	25	371	35
3	8	12	8	25	0	0	16	16	91	12	16	18	0	0	107	13	1	2	7	16	131	12
4	2	3	4	13	0	0	6	6	33	4	1	1	0	0	34	4	0	0	2	5	42	4
×5	0	0	0	0	0	0	0	0	3	0	1	1	0	0	4	0	0	0	1	2	5	0
ISS[d]																						
1-15	50	77	20	63	1	100	71	72	656	86	75	85	4	67	735	86	49	77	35	80	890	84
16-25	12	18	10	31	0	0	22	22	92	12	12	14	2	33	106	12	11	17	8	18	147	14
26-40	2	3	2	6	0	0	4	4	10	1	1	1	0	0	11	1	4	6	1	2	20	2
41-66	1	2	0	0	0	0	1	1	3	0	0	0	0	0	3	0	0	0	0	0	4	0
67-75	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	1	0
Total	65	100	32	100	1	100	98	100	762	100	88	100	6	100	856	100	64	100	44	100	1062	100

[a]Others include lorry, bicycle, bus and unknown

[b, c]Includes severe and non-severe injuries

[d]Injury Severity Score for road crash victims with at least one severe injury (AIS × 3) only

Passive safety (seatbelt)

Non parametric Mann-Whitney test was conducted to see if the ISS differs between road crash victims who were using seatbelt and those who were not. Based on the results, at 5% confidence level (Mann-Whitney U = -2.199, p-value = 0.028), it is concluded that there is a significant difference in the ISS of those who had used seatbelt in their passenger vehicles. Those who were using a seatbelt have lower mean rank, indicating that those who were using a seatbelt have lower ISS as compared to those who were not.

Table 2 Mann-Whitney test for seatbelt use

	Ranks			
	Seatbelt use	n	Mean Rank	Sum of Ranks
ISS	yes	375	331.68	124380
	no	312	358.81	111948
	Total	687		

Passive safety (helmet)

Non parametric Mann-Whitney test was conducted to see if the ISS differs between those who were using a helmet and those who were not. Based on the results, at 5% confidence level (Mann-Whitney U = -3.756, p-value = 0.0001), it is concluded that there is a significant difference in the ISS of those who were using a helmet. Victims who were using a helmet have a lower mean rank, indicating that those who were using a helmet have a lower ISS compared to those who were not.

Table 3 Mann-Whitney test for helmet use

	Ranks			
	Helmet use	n	Mean Rank	Sum of Ranks
ISS	yes	7644	4304.83	32906129.50
	no	1027	4567.99	4691326.50
	Total	8671		

Injury severity score by road users

Table 4 below describes the summary of the statistics for three main road users. Looking at the most frequent (mode) ISS, all three road users have the same ISS of 9. The same pattern with the median shows that 50% of all cases involving the three types of road users have the ISS of 10, for both below and above. 75% of passenger car occupants had ISS of 16 and below. The maximum ISS for car occupants is 41. Interquartile range shows that 50% of private passenger vehicle occupants had ISS in the range of 9 to 16.

Table 4 ISS summary of road users

Road user	Private passenger vehicle	Motorcycle	Pedestrian
n	98	861	64
Mean	13.08	11.42	12.97
Variance	40.376	28.113	48.32
Standard deviation	6.354	5.302	6.951
Minimum	0	0	2
Maximum	41	75	38
1st quartile (25%)	9	9.00	9
Median	10	10.00	10
3rd quartile (75%)	16	13.00	14
Interquartile Range	7	4	5
Mode	9	9	9

For motorcycles, the mean ISS is slightly lower (11.42, standard deviation 5.302). 75% had ISS of below 13 and 50% of pillion-riders had ISS of 9 to 13. Looking at Figure 1 below, the boxplot for motorcyclist has a lot of outlier points. These points represent severely injured victims, with ISS more than 20, which warrant for another research to look at the injury characteristics.
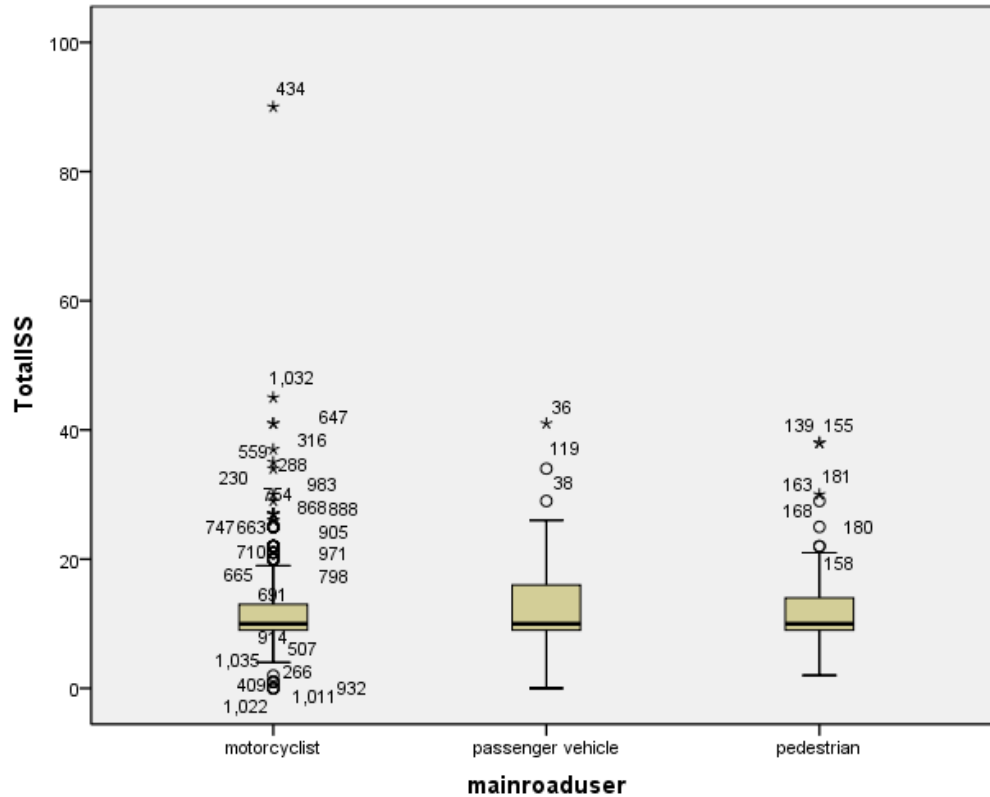
Figure 1 Box-plot for road user type

Motorcycle (n = 861)

Motorcycle represents the biggest sample in this study (80.6%). Majority of the motorcyclists involved in road crashes came from the age group 16-20 (26.23%) and followed by those who are 21-25 years old (23.5%). Most of the accidents experienced by motorcyclists occurred between 1600 ó 2000 h.

A closer look on severe injury patterns suffered by motorcyclists reveals that severe injuries were concentrated at the lower extremity region of the body (43.4%), followed by the head (42.8%), thorax (10.9%), abdomen (1.4%), upper extremity (0.9%), spine (0.4%), face (0.1%), neck (0.1%) and external/other (0.1%). Mayou and Bryant (2003) also reported lower extremity as the most frequent part of body injured for motorcyclists. At the lower extremity region, severe injuries frequently occurred at the skeletal structure (99%) and 24.15% from them were shaft femur fracture.

Whereas for injuries to the head region, 81% happened to the internal organs, 15% to the skeletal structure and followed by the whole area (2%) and concussive injuries (2%). It was found out that 26.9% from injuries to the internal organs were inflicted to the cerebrum part; specifically injuries to the subdural hematoma. In addition, Wyatt et al. (1999) indicate in his study that despite helmet use, the head and neck was the most severely injured region in those

motorcyclists who died with potentially survivable injuries. Head injury is also the most common specific injury for children (Adesunkanmi, 2000).
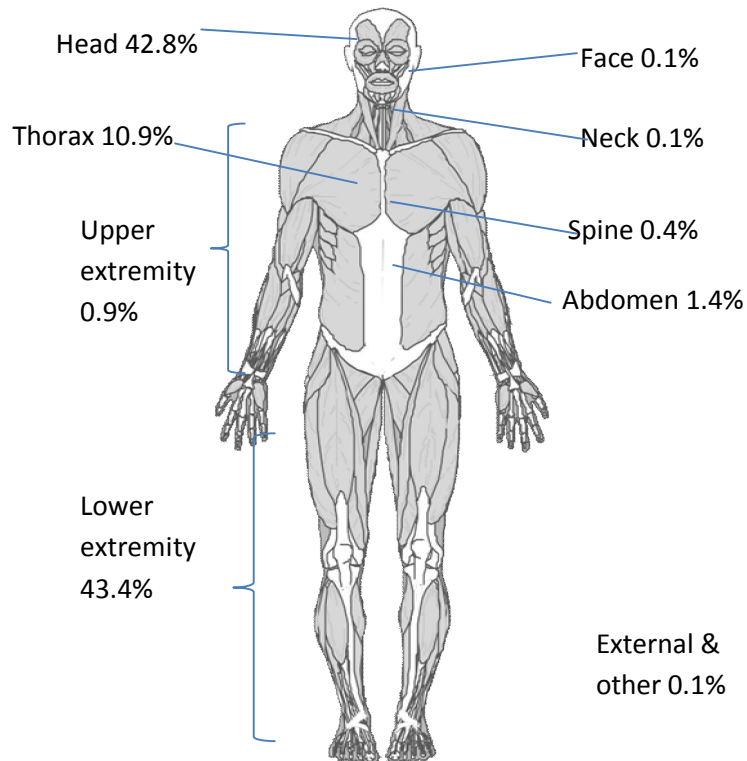

Figure 2 Breakdown of severe injuries suffered by motorcyclist

Private passenger vehicle (n = 98)

Private passenger vehicle in this study is defined as cars or vans and they represent a total of 8.87% of the total study sample. Demographic analysis shows that the age group of 21 ó 25 years old were the majority (22.94%); followed by the age group of 26 ó 30 years old (18.57%). Road crashes experienced by these road users frequently occurred during 1600 ó 2000 h (16.83%).

Injury patterns of these road users show that the majority of severe injuries occurred at the head region (38.9%), followed by the lower extremity (35.7%), thorax (19.1%), abdomen (4%), spine (0.8%) neck (0.8%), upper extremity (0.8%) with no severe injury to the face and external/other region as shown in Figure 3 below.

Severe injuries to the head region specifically occurred to the internal organs (73.5%), followed by nerves, cranial (16.3%), concussive injury (8.2%) and the whole head area (2%). Within the internal organs, 100% of the injuries occurred to the cerebrum areas with a majority of it (19%) to the subdural hematoma. Other studies conducted have also found that head is the most frequent part of body injured for private vehicle occupants (Eid et al., 2009; Weninger & Hertz, 2007; Langley & Marshall, 1994).
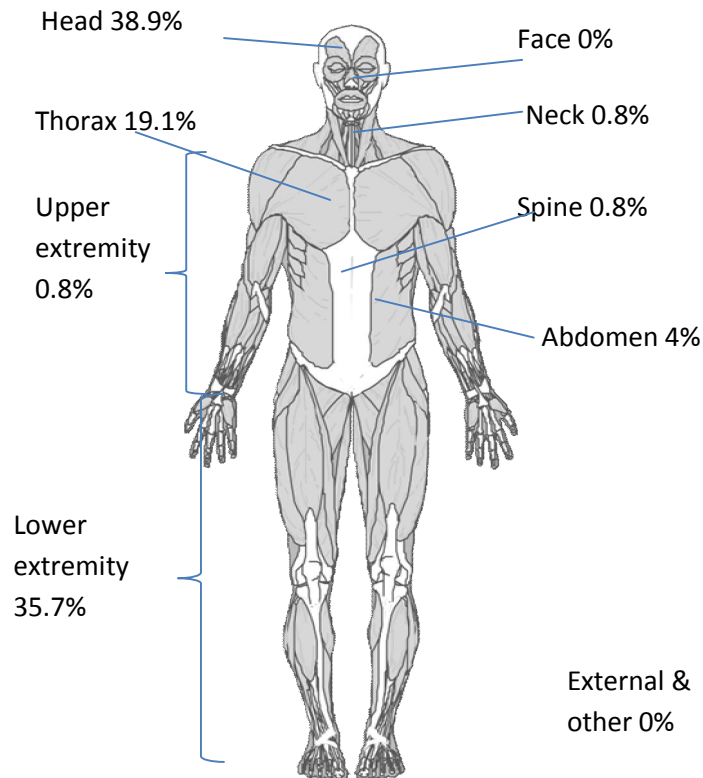
Head 38.9%

Face 0%

Neck 0.8%

Thorax 19.1%

Spine 0.8%

Upper extremity 0.8%

Abdomen 4%

Lower extremity 35.7%

External & other 0%

Figure 3 Breakdown of severe injuries suffered by private vehicle passengers

Pedestrian (n = 64)

Pedestrian road traffic injuries studied in this research represent 3.99% from the total sample. Majority of the pedestrians involved in road crashes came from the young adult by age group of 21 ó 25 (18.34%) and followed by the age group 16 ó 20 (13.05%). Mayou and Bryant (2003) in their study however found pedestrian road user group were older as compared to other road user group with mean age of 33.5 and standard deviation of 14.3. Time of injury occurrence was mostly from 1600 ó 2000 h (21.52%).

Looking at parts of body injured, shows a majority of severe injuries to the head region (50.9%), followed by lower extremity (30.2%), thorax (16%), spine (1.9%) and face with 0.9%. Arregui-Dalmases et al. (2010) and Wong et al. (2002) also reported head as the most frequent part of body injured, but the order of lower extremities and thorax as the second most frequent body region injured varies between the studies. Figure 4 below shows the region of severe injury suffered by pedestrians.

Looking at the specific structure of the head region, pedestrians frequently suffer injuries to the internal organs (75.9%), and this is followed by the nerves, cranial (11.1%), whole area (9.3%) and concussive injuries with 3.7%. whereas when looking at the internal organs, 75.9% injuries occurred at the cerebrum area and 25% of injuries to the cerebrum were suffered by the subdural hematoma.
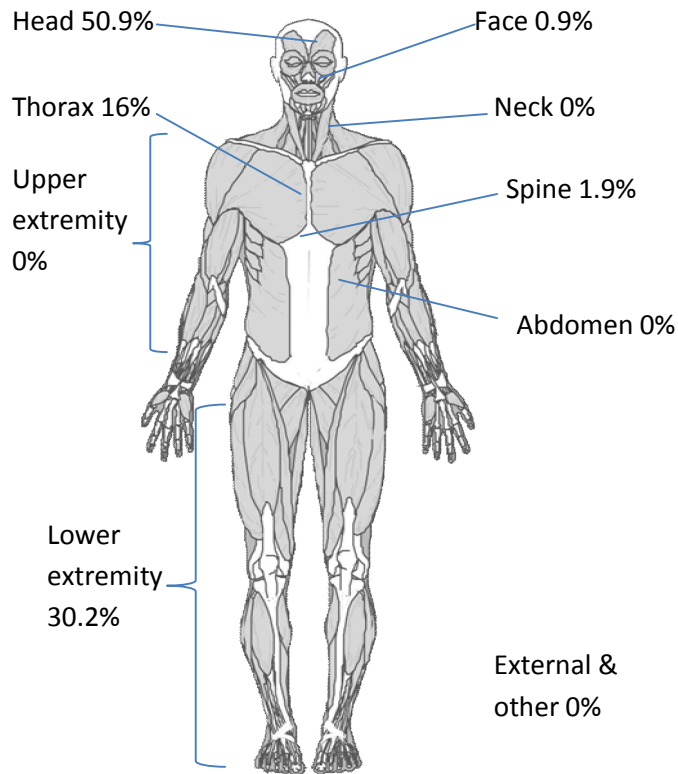
Head 50.9% Face 0.9%

Thorax 16% Neck 0%

Upper extremity 0% Spine 1.9%

Abdomen 0%

Lower extremity 30.2%

External & other 0%

Figure 4 Breakdown of severe injuries suffered by pedestrians

Differences in ISS score between road users by using Kruskal-Wallis test

Kruskal-Wallis one-way analysis of variance by ranks was conducted. It tests the null hypothesis that multiple independent samples come from the same population. Results showed that all the ISS for the three road users groups does not come from the same population (Chi- square value = 16.23, p-value = 0.0001) meaning, there are differences in the ISS for the three main road user groups. From the Mann-Whitney test conducted, it was discovered that there is a difference between the ISS of motorcyclists and those of the passenger vehicle drivers and occupantsø However, there is no significant difference between motorcyclists and pedestrians, and also among pedestrians and passenger vehicle occupants.

Table 5 P-value for Mann-Whitney test (=0.05)

	Motorcyclist	Pedestrian
Pedestrian	0.380	
Private Passenger vehicle	0.0001*	0.157

Table 6 Mean Rank of ISS by type of road user

	Road User Type	n	Mean Rank
Total ISS	Motorcycle	872	513.18
	Private passenger vehicle	119	626.05
	Pedestrian	64	547.67
	Total	1055	

Table 7 Test Statistics[a]

	Total ISS
Chi-Square	16.233
df	2
Asymp. Sig.	.000

a. Kruskal Wallis Test

DISCUSSIONS

This study provides information about the demographic profiles and patterns of road traffic injuries by type of road user. The main profile is internal organ injuries in the head region, repeated in all groups, although with some variations. By examining severe injuries in detail only, the study helps to quantify the magnitude of threat to life faced by all road users.

Motorcyclists suffer lower extremity injuries more frequently as compared to other road users with the head being the body part that is the most frequently injured. On the other hand, private passenger vehicle occupants have a higher tendency to suffer thorax and abdominal injuries as compared to motorcyclists and pedestrians. Pedestrians on the other hand have a higher frequency of suffering head injuries, followed by those to the lower extremity.

Out of the three main road user groups, motorcyclists have the highest involvement in road crashes in Malaysia, with 80.62% of the total victims in the study area, followed by private passenger vehicles (9.2%) and pedestrians (6%). Looking at victims who had AIS score >=3, 80% of them suffered at least two injuries or more, but only 17% had more than three parts of body injured. On ISS, 84% had ISS of less than 15, while 16% had ISS of 16 and above. 121 motorcyclist had ISS 16 and above, warranting a niche area of research on the injuries sustained.

On the differences of ISS across road users, motorcyclists have lower ISS compared to passenger vehicle occupants and pedestrians. There is a significant difference between motorcyclists and private vehicle passengers, but no significant difference between motorcyclists and pedestrians. There is no significant difference also between private vehicle passengers and pedestrians.
On the issue of safety device, there is a significant differences on the ISS for both who wear seatbelt and helmets. Safety device is proven in reducing injuries as indicated in the Mann-Whitney test for both motorcyclists and passenger vehicle occupants.

Limitation of the study are the lack of information about the circumstances of the road crash i.e. side impact collision, head-on, or rear end. These information are important in order to fully understand the factors influencing the part of body regions injured and will help to study its relation with injuries and the severity that the collisions may cause. As data for this study was only collected at the hospital, this information would be difficult to collect.

CONCLUSIONS

In conclusion it is evident that there are underlying common injury patterns suffered by each road crash victim. Previous studies on this topic as presented throughout this paper have shown the similarity in injury patterns around the globe. Information on injuries as obtained in this study will also would allow researchers and engineers to further understand the body region and type of injuries normally suffered by each type of road user. The findings from this study should be taken into account when designing for new vehicles to mitigate or minimize the injury impact of road crashes not only for the occupants, but by also considering the pedestrians. Vulnerable regions of the human body, especially the head, should be paid more attention to when designing safety devices. In addition to this, this information would also be valuable for the appropriate design of prevention strategies that are specific to each type of road user, and assignment of resources for pre-hospital emergency services and also to help to better prepare hospitals for immediate treatment of severely injured road crash victims.

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