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Spine and Whiplash Injuries Related to Passenger Car Crashes in Malaysia

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Abstract – *Spinal injury is one of the most devastating traumas that can be sustained in a motor vehicle crash. In passenger car crashes, the most common injuries related to the spine is whiplash injury or Whiplash Associated Disorder (WAD); however, the injury was relatively unknown in Malaysia. This study explored the possibility of elucidating whiplash injury locally by studying the insurance claims made by passenger car occupants involved in traffic crashes. The objectives of the study were to investigate the prevalence and to identify the injury pattern of the spine and whiplash injury. The data were collected retrospectively from closed files of the Third-Party Bodily Injury (TPBI) insurance claims database for the year 2013-2015. Each occupants' injuries were extracted from the medical report and were classified according to the Abbreviated Injury Scale (AIS). A total of 500 cases of passenger car crashes were obtained from the insurance database and out of the total occupants involved, 866 injured occupants were included in the analysis. The results demonstrated that spine injuries have very low occurrence in Malaysia relative to other injury types, and whiplash-specific injuries are even rarer among passenger car crash victims in Malaysia. The most common vertebra level to be affected was the cervical spine, especially the C5-C6 vertebra, and this can be seen mostly for the drivers and front* passengers. *The low occurrence of spine injury is comparable to other countries, but the rare whiplash injury may indicate the 'whiplash culture' is not prevalent in Malaysia.*

Keywords: Spine, whiplash injury, car crashes

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1.0 INTRODUCTION

Spinal injury is one of the most devastating traumas that can be sustained in a motor vehicle crash (MVCs). Commonly, post-traumatic spinal-related injuries have the worst functional outcomes and the lowest rates of return to work after injury among all major organ systems (Johansson et al., 1993). In many countries including Malaysia, MVCs are the leading cause of spinal injuries (O'Connor, 2006; Rasouli et al., 2008; Bilston et al., 2011; Ibrahim et al., 2013). Due to the difference in traffic population, in developed countries, spine injuries were found mostly among the car occupants, whilst in developing countries (especially in Asia), spine injuries are more common among motorcyclists.

Spine injury may happen because of single or multitudes of damage to the spinal cord, nerve roots, osseous structures, and disco-ligamentous components of the spinal column (Zhang et al., 2013). Damage to the spinal column can lead to mechanical instability, pain and impaired mobility, while damage to neurological structures commonly results in partial or complete paralysis (Taghhva et al., 2016). In addition, injury to soft tissues surrounding the cervical spine can lead to numerous symptoms such as neck pain and stiffness, shoulder weakness, dizziness, headache and memory loss (Spitzer et al., 1997). This collection of neck-related symptoms is typically defined as whiplash injury or Whiplash Associated Disorder (WAD).

The most common spine injuries among car occupants are cervical spine injuries (Robertson et al., 2002; Freeman & Wendy, 2020). It is mainly because whiplash injury is overrepresented in spinal injuries, especially in developed countries. For example, there is an incidence of perhaps 1 million per year in the US (Hai-bin et al., 2009), while in Australia, whiplash injuries comprise about 75% of all survivable road traffic crash injuries (Conelly & Supanagan, 2006). According to the Association of British Insurers, more than 1,500 whiplash claims are made in the United Kingdom every day, costing the insurance industry more than £2 billion a year (Laporte et al., 2016).

In Malaysia, epidemiology studies have shown that MVCs are the leading cause of traumatic spine injury, with a large portion being motorcyclists. Zulkipli and colleagues had shown that the lumbar spine was the most frequently injured among motorcyclists (Zulkipli et al., 2018); and when the motorcyclist is struck from the rear, they have the highest risk to get spine injury (Zulkipli et al., 2012). However, little is known regarding the pattern and aetiology of spine injuries among car occupants following a crash. Despite the prevalence of extensive studies in developed countries, whiplash injuries are still relatively unknown in Malaysia. To the best of the authors' knowledge, there are no published articles that documented spine injuries and whiplash incidents in Malaysia related to car crashes. Hence, this study is initiated to investigate such occurrences.

2.0 METHODOLOGY

The data were collected retrospectively from closed files of the Third-Party Bodily Injury (TPBI) insurance claims database for the period 2013-2015. A systematic random sampling technique was used to select the cases due to the large sampling frame. Out of the available and archived 7,542 TPBI claims from 2013 to 2015, a total of 500 cases of car crashes of third-party claimants were selected and analysed. Insurance data specific to bodily injury were used for this study as they provided a sufficiently large amount of data set from various types of reports. Medical reports provided in the database have detailed injury information for each victim involved.

Injury to the body region and severity coding used in this study were based on the Abbreviated Injury Scale (AIS), updated version 2008. AIS is an anatomical injury scoring system ranging from minor (AIS 1), moderate (AIS 2), serious (AIS 3), severe (AIS 4), critical (AIS 5) to maximum (AIS 6) severity. AIS codes were assigned using medical records supplied in the data. To minimise AIS coding error one personnel with AIS training was assigned to categorise the injury data in this study. The maximum abbreviated injury scale (MAIS) is the greatest AIS injury sustained by the occupant. Each occupant may have multiple injuries of varying severity and may even have more than one injury with the greatest MAIS. Cases with less than three MAIS injuries are categorised as slight injury, while MAIS 3 and above are considered a severe injury. Descriptive and statistical data analysis was used to describe the aggregated data.

3.0 RESULTS AND DISCUSSION

Out of the 1,142 occupants involved in the 500 cases of passenger car crashes, 54 of them died and another 868 were injured. Out of the 868 injured, 48% were drivers, 30% were front occupants, and 22% were rear occupants. For the injury analysis, deceased occupants were excluded as the injury detail for the fatal occupants was incomplete.

3.1 Demographics

As shown in Figure 1, male drivers were overrepresented in injured occupants whilst female front occupants were significantly higher than male. The injured occupants' proportion reflects the general pattern of all passenger car occupants in Malaysia, where 80% of the drivers are males, and 60% of the front passengers are female. The majority of injured drivers and front occupants were between the ages 18-30 years but the rear occupants were mostly aged below 31 years.

Our findings mirror other studies elsewhere that described men as the main gender to be involved in spine injury (Yousefzadeh et al., 2010; Robertson et al., 2002). In terms of age, there was a difference in distribution between males and females. Most of the male occupants who received spine injury during the crash were aged from 21 to 30 years old, while female occupants with spine injury were mostly between 31 to 40 years old. It was comparable to the previous studies (Heidari et al., 2010; Fakharian et al., 2017). Driver's position had a higher prevalence of spine injury, followed by the front occupant, while the rear occupant had the least number of spine injuries. There were significantly more female front passengers (21 persons, or 78%) with spine injuries though compared to male (6, or 22%).

3.2 Injuries Distribution

In this study, the injured body region was identified for each of the occupants to analyse the injury distribution pattern. Table 1 shows the injury distribution by body region for all injured occupants according to occupants' position. Note that since victims can have multiple injuries, the same victim may appear multiple times in this table. The most predominant type of injury sustained by injured occupants in this study was lower extremities, at 24.1%, followed by the head (20.1%). This concurs with the findings in various previous studies (Robertson et al., 2002; Page et al., 2012). The next two most common body regions involved were upper extremities (19.0%) and face (15.0%). For the driver, the result shows lower extremities being most likely injured, followed by the head, upper extremities, and facial injury. There is a slight difference for the rear passenger, where the head is the region with the highest occurrence of injury, followed by lower extremities and face. Overall the proportion of spine and neck injury (3.9% and 2.4%, respectively) were very low compared to other injuries.

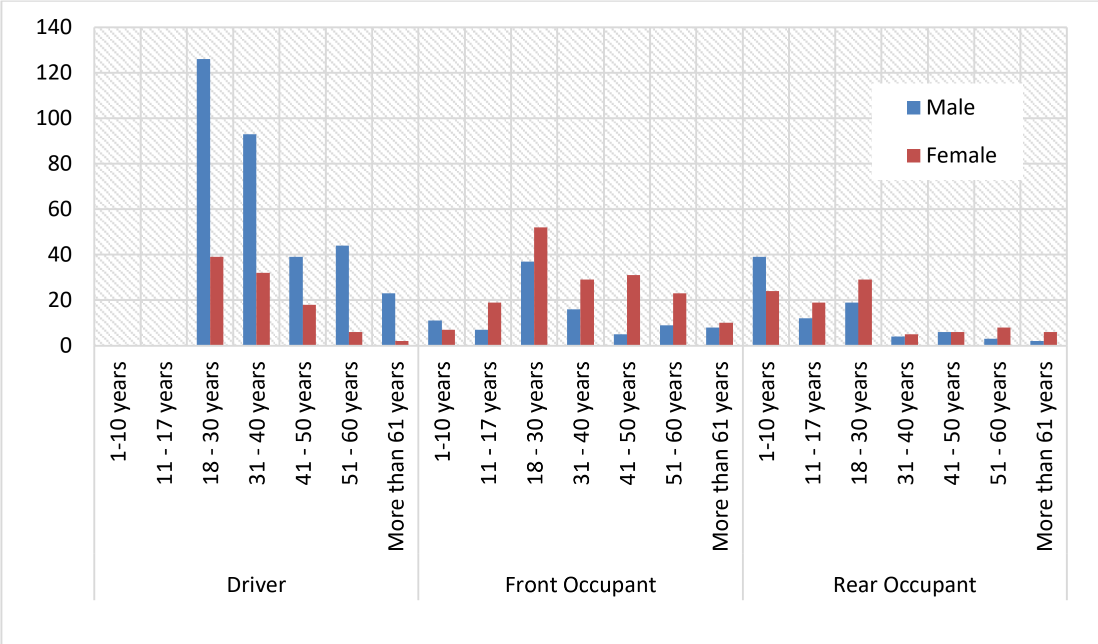

Figure 1: Distribution of injured occupants' age and gender according to seating position

Table 1: Injury distribution by body region according to different seating position in a car

Body Region	**Frequency (%)**	**Driver (%)**	**Front Passenger (%)**	**Rear Passenger (%)**
Head	271 (20.1)	119 (21.0)	81 (21.0)	71 (26.0)
Face	202 (15.0)	89 (16.1)	62 (16.1)	51 (18.7)
Neck	33 (2.4)	19 (2.7)	10 (2.6)	4 (1.5)
Thorax	119 (8.8)	74 (10.7)	33 (8.6)	12 (4.4)
Abdomen	40 (3.0)	24 (3.5)	9 (2.3)	7 (2.6)
Spine	53 (3.9)	26 (3.8)	15 (3.9)	12 (4.4)
Upper Extremity	257 (19.0)	133 (19.2)	82 (21.3)	42 (15.4)
Lower Extremity	325 (24.1)	191 (27.6)	79 (20.5)	55 (20.1)
External	52 (3.8)	19 (2.7)	14 (3.6)	19 (7.0)
Total	1352 (100.0)	694 (100.0)	385 (100.0)	273 (100.0)

3.3 Type of Spine, Neck and Whiplash Injuries

Table 2 shows the type of spine, neck and whiplash injuries among all the occupants according to the seating position. Whiplash injury is rare, with only about four victims out of 866 of total injured occupants. However, several other neck injuries were classified as soft neck injuries, which may still generically fall into the same type of whiplash injury. The scarcity of the specific whiplash injury figures was perhaps due to the term not being very well known in the country compared to elsewhere. This may indicate similar circumstances to two other studies in Lithuania and Greece, where the general population had little to no awareness about Whiplash Associated Disorders (Haneline, 2009).

Table 2: Type of spine, neck and whiplash injuries according to the car seating position

Position	Injury Type	Number	%
Driver	Soft tissue injury of the neck	8	15.7
	Whiplash injury of neck with or without cord contusion	3	5.9
	Contusion / abrasion over neck	6	11.8
	Pain of the neck / cervical sprain	5	9.8
	Vertebra body fracture C2 / C3, C2, compression fracture - C5, C5, burst fracture - L4, L4	6	11.8
	Lamina fracture C3, C2	2	3.9
	Osteophytes fracture C3	1	2.0
	Pedicle fracture C3	2	3.9
	Transverse process C3, L4	2	3.9
	Posterior arch fracture C1	1	2.0
	Cervical spine spondylosis C5/C6, C4-C6, C4-C7, C2-C6, C2, L1-L5	6	11.8
	Cervical spine spondylolisthesis C5/C6 (dislocation), C3-C6, C5/C6, C4/C5 (dislocation)	3	5.9
	Prolapsed intervertebral disc C3-C7, L5/S1	2	3.9
	Sacrum fracture	2	3.9
	Injury to spinal cord	1	2.0
	Spine fracture	1	2.0
Front Passenger	Soft tissue injury of the neck	6	20.7
	Whiplash injury lower back at level L4, L5, S1	1	3.4
	Laceration at neck	3	10.3
	Pain at neck	2	6.9
	Vertebra body fracture C3, L4, C3, C2, C5/C6, compression fracture L1, L2, burst fracture- T12, T3/T4	10	31.0
	Facet joint subluxation C5/C6	1	3.4
	Lamina fracture C3	1	3.4
	Cervical spine spondylolisthesis C4/C5	1	3.4
	Prolapsed intervertebral disc C5-C7	1	3.4
	Sacrum fracture	1	3.4
Rear Passenger	Soft tissue injury of the neck	5	22.7
	Abrasion over neck	1	4.5
	Vertebra body fracture C2, C4, C6-C7, compression fracture - L1, L1, L1, L4, T12,	9	27.3
	Lamina fracture C6	1	4.5
	Spinous process fracture C2, C4	2	9.1
	Transverse process fracture C7, L2-L4, T1	3	13.6
	Paraplegia on L side	1	4.5

Perceived the possibilities for secondary gains were minimal, the crash victims had likely dismissed the symptoms as benign, not needing medical attention, and unlikely to associate the condition with their earlier crash injury. The study in Lithuania demonstrated that none of the 202 rear-end collision crash subjects had disabling or persistent complaints linked to their preceding accident (Schrader et al, 1996) while in Greece, 180 crash victims found their symptoms to be brief, self-limiting, and didn't develop into whiplash syndrome (Partheni et al., 2000). Thus, many researchers like Carroll et al. (2009) and Ozegovic et al. (2009) concluded that expectations and beliefs of recovery (or conversely, of additional chronic complications) to be an essential factor for the outcome following whiplash injury. A low prevalence of chronic WAD in some countries is then associated with correspondingly low community expectations for long-term complications (Ferrari et al., 2003a; Ferrari, 2003b; Ferrari & Lang, 2005). Fracture and dislocation of the vertebra are the most common type of spine injuries among passenger cars. Correspondingly, our finding showed that the most common vertebra level affected was the cervical spine, especially C5-C6, and this can be seen across all passenger car positions from driver to rear passenger (Table 2). Thoracic vertebra fracture was scarce, with only four occupants sustained the injury.

3.4 Spine Injury Pattern

Figure 2 shows the distribution of injuries according to spine vertebra level and seating position. Cervical vertebra section (C1-C7) accounted for 68% of the total injured spine section, followed by 20% from lumbar (L1-L5), 7% from thoracic (T1-T12) and 5% from sacral (S) section. Overall, drivers mostly sustained the injury in C5 vertebra level; front passengers typically get injured at C3, C5 and C6 section, while rear passengers mostly get injured at the L1 section. It can be concluded that different seating positions in a car resulted in different injuries to the spine vertebra level.

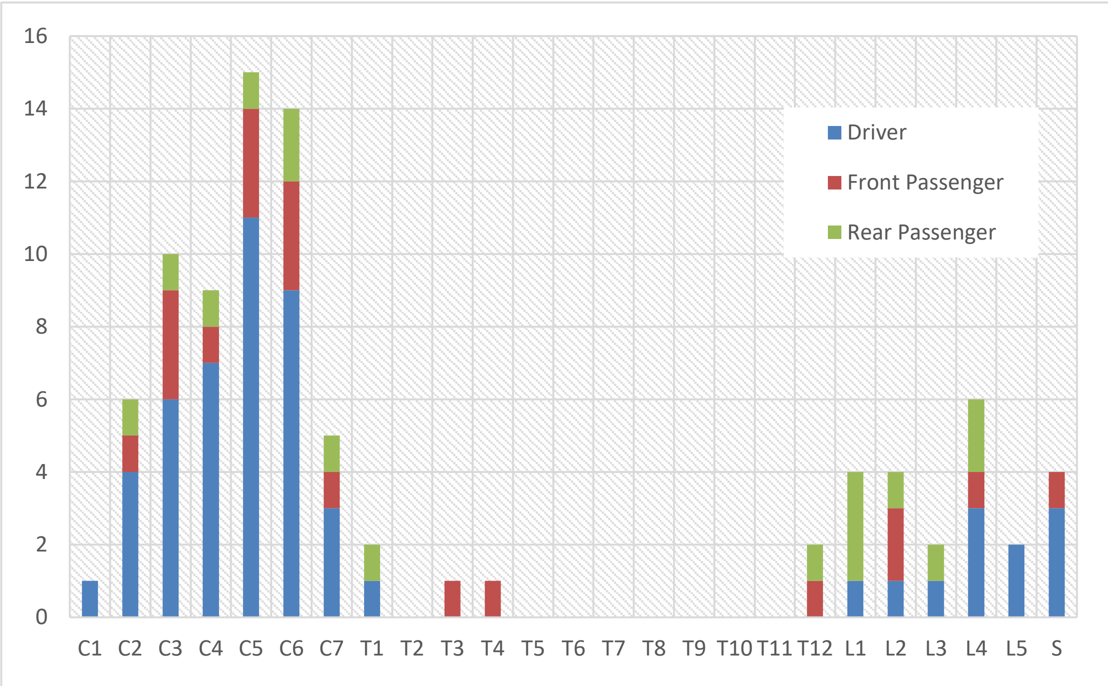

Figure 2: Spine vertebra level and occupant seating position

Though our findings confirmed the previous study on the high frequency of cervical incidence among car occupants (Skold & Voigt, 1977; Robertson et al., 2002), our result contradicted the finding by Heidari et al. (2010) that indicated front occupants had more lumbar spine injury compared to the rear occupants. It was not surprising to see the high cervical spine injury for car occupant as the biomechanics cervical spine made it susceptible to acceleration-deceleration type traumas (Mackay & Hill, 1995).

Seat belt restraint may also cause spine injuries; specifically, cervical vascular injury, cervical spine fracture, or clavicle fracture may be caused/contributed by seatbelt impact to the neck, while lumbar spine fracture may be attributed in part to the abdomen portion of seat belt restraint (Huecker & Chapman, 2020). In our study, the front passenger and driver had a higher occurrence of upper spine injury are consistent with the expected pattern of neck seat belt injury; the lower prevalence of this injury among rear passengers can be attributed to lower adherence of rear seat belt practice among rear passengers (Ng et al., 2013). Note, however, that our study's data source didn't specifically indicate whether seat belt restraint was being used or not thus we are not able to correlate between seat belt usage and spine injury patterns.

3.5 Injury Severity and Outcomes

The frequency of each body region's injury severity is shown in Table 3. Most of the injuries to the neck and spine were minor (MAIS 1) and moderate (MAIS 2). Only 1 out of 33 neck injuries resulted in MAIS 3, while only 8 out of 53 spine injuries had MAIS 3 and above. High proportions of severe injuries were observed at lower extremities, thorax and head. Of all the occupants with spinal injuries, neurological deficit occurred in 9 (10.2%) cases. Rear passengers were found to have the highest proportion of neurological deficits, with 3 cases out of 16, followed by drivers with 5 cases out of 45 (11.1%).

For associated injury, usually, the head and lower and upper extremities are the most common body regions injured together with the spine. This corresponded the previous studies (Robertson et al., 2002; Heidari et al., 2010; Moradi-Lakeh et al., 2010). When compared to other seating positions, only the driver with spine injury had a concomitant severe injury thorax injury. Thus, the driver's severe thorax injury could serve as an indicator of a possible spine injury.

Table 3: Distribution of injury severity according to the body region

Body Region	Injury Severity					Total
	MAIS 1	MAIS 2	MAIS 3	MAIS 4	MAIS 5	
Head	196	49	20	6	-	271
Face	175	25	2	0	-	202
Neck	32	-	1	-	-	33
Thorax	65	24	30	-	-	119
Abdomen	27	8	2	1	2	40
Spine	5	40	4	2	2	53
Upper	124	131	1	1	-	257
Lower	154	100	70	1	-	325
External	51	1	-	-	-	52
Total	829	378	130	11	4	1,352

3.6 Limitations

An important potential limitation is that this study was retrospectively performed thus, information was limited to the only available records. Moreover, due to practical constraints, the sampling size was restricted to 500 randomly selected records. While the records provide more than 800 injured occupant records, the numbers of spine injury cases were very small, causing the analysis in some subcategories improbable. Although the record contains information about the crash, variables such as seat belt usage, airbag deployment and interior car damage details are not available to relate the mechanism of injury for the occupant. As children represent a significant proportion of those rear occupants in this study, the results may have been influenced due to different injury patterns in this population. Lastly, the distribution of seating positions in rear occupants, centre seat versus outboard seat was also not available for us to deduce the risk.

4.0 CONCLUSION

This study demonstrated that spine injuries have very low occurrence in Malaysia relative to other injury types, and whiplash-specific injuries are even rarer among occupants of a passenger car crash in Malaysia. Even when considered together (neck, spine and whiplash injuries) the number of occupants sustained the injuries still would only add up to about 10% out of the total injured occupants in car crashes. The most common vertebra level to be affected was the cervical spine, especially the C5-C6 level vertebra compared to others.

The low occurrence of spine injury is comparable to other countries, but the rare whiplash injury may indicate the lack of 'whiplash culture' in Malaysia. The 'whiplash culture' theory shows that in countries wherein the population generally accepts chronic whiplash as being a real condition, a substantial proportion of persons with whiplash injuries develop chronic symptoms after injury. On the other hand, in countries that lack a whiplash culture, wherein the people do not generally accept chronic whiplash as being a real condition, very few people develop chronic symptoms.

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