*Journal of the Society of Automotive Engineers Malaysia*
*Volume 5, Issue 3, pp 476-489, September 2021*
*e-ISSN 2550-2239 & ISSN 2600-8092*

# An Analysis of Injury Patterns for Drivers Based on Police Reported Frontal Crashes in Malaysia

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**ORIGINAL ARTICLE** *Open Access*

**Article History:**

Received
*22 Aug 2020*

Accepted
*30 Apr 2021*

Available online
*1 Sep 2021*

**Abstract** – *Most Southeast Asian countries including Malaysia have a relatively high number of traffic fatalities involving occupants of 4-wheel vehicles. The frontal impact collisions have been identified as the cause of most passenger vehicle occupant deaths. Therefore, a better understanding of real-world frontal crashes is needed in support of decision-making processes for future frontal crash test programs. One of the important elements to examine is the occupant injury patterns based on real-world crashes. Furthermore, different frontal crash configurations may result in different levels of injury severity. The objective of this study is to analyze the driver injury and body part injury levels based on police-reported frontal crashes in Malaysia. Road crash cases from 2015 to 2019 were obtained from Bukit Aman Traffic Investigation and Enforcement Department (JSPT), Royal Malaysia Police (PDRM). 81% of the cases comprised frontal crashes (full width & offset) while the rest involved sideswipe cases. Most of the drivers sustained no injury (70.77%) whereas 11.11%, 8.77%, and 6.87% suffered fatal injury, injury, and severe injury, respectively. The most frequent fatal cases among drivers involved injuries to multiple body regions for both configurations. The chi-square test revealed a significant association between the frontal crash configuration and driver injury level. The average odds ratio for fatality in frontal crashes compared to sideswipe configurations was 6.29. The rate of driver fatality per one crash has also increased marginally over the years. The study findings provide some information to support the recommendation that a full-width configuration is considered in future ASEAN NCAP frontal crash tests. Further research is also needed to fully understand real-world frontal crash impacts in Malaysia.*

**Keywords:** Frontal crashes, driver injury, Malaysia

## 1.0 INTRODUCTION

From 2007 to 2016, Malaysia's motor vehicle crashes recorded more than 5.3 million cases resulting in 67,721 fatalities and over 180,000 injuries (MOT, 2017). Car crashes make up most of these figures, which have constantly increased over the years (Figure 1). Most Southeast Asian countries have also seen a high percentage of road traffic fatalities involving drivers and passengers of 4-wheel vehicles (WHO, 2015).

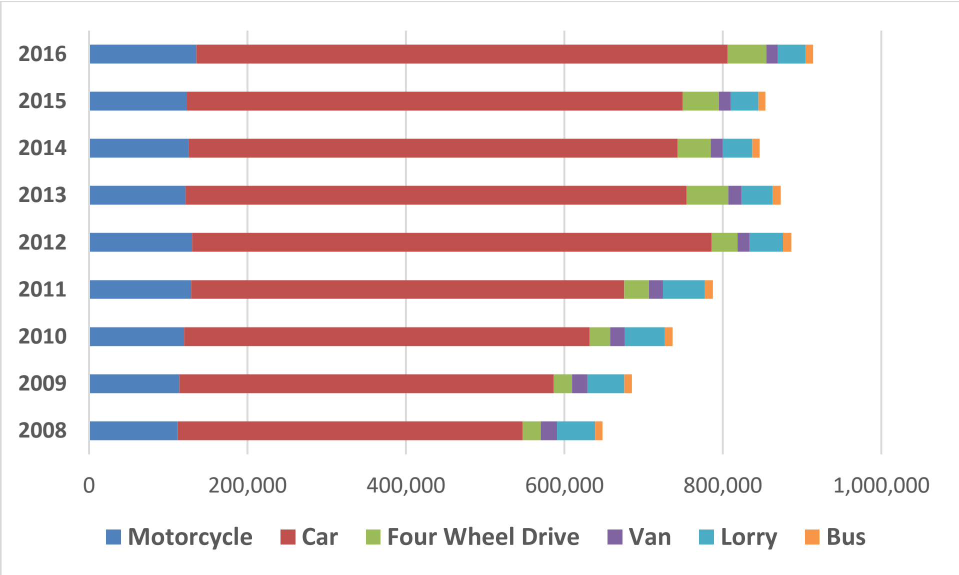


**Figure 1**: Motor vehicles involved in road crashes by type of vehicles in Malaysia, 2007-2016 (MOT, 2017)

Malaysia's in-depth crash data between 2007 and 2012 also revealed 90.4% of frontal impact crashes involved passenger vehicles (Syukri et al., 2015). In the USA, the Insurance Institute for Highway Safety (IIHS) has analyzed passenger vehicle occupant deaths in single and multiple vehicle real-world crashes. The initial impact points include frontal, side, rear, and others (mostly rollover). The vehicle types that have been studied include cars, pickups, and SUVs. Based on the 2018 crash data, 53% of vehicle occupant deaths in single crashes were due to frontal impact collisions. A similar situation was identified for vehicle occupant deaths in multiple-vehicle crashes, with 59% of the cases resulting from frontal impact crashes (IIHS, 2020). Findings from IIHS directly suggest that avoidance of frontal crashes and mitigation of their impacts are crucial.

Given the situation, the New Car Assessment Programme for Southeast Asian Countries (ASEAN NCAP) remains committed to ensuring the safety of vehicle occupants in the Southeast Asian region. ASEAN NCAP provides consumers with the information they require to buy the safest car they can afford. Since 2012, ASEAN NCAP has been awarding safety star ratings for the ASEAN automotive market. In parallel, the Malaysian Government has taken the lead by imposing the most important United Nations (UN) vehicle safety standards in the country. ASEAN NCAP has recently announced its Roadmap 2021-2025 with a more inclusive assessment protocol as shown in Figure 2. Specifically, for the Adult Occupant Protection (AOP) pillar, three categories shall be assessed, namely offset frontal crash test, side-impact test, and Head Protection Technology (HPT). In the assessment protocol, the frontal crash impact test contributes the most points under the Adult Occupant Protection (AOP) pillar (ASEAN NCAP, 2018; ASEAN NCAP, 2020). ASEAN NCAP frontal offset crash test uses hybrid III 50% dummies for adults (placed on the driver and front passenger seats) and P1.5 and P3 dummies to represent children in the back seat. The test car will impact the 40% ODB (Offset Deformable Barrier) at a traveling speed of 64 km/h (ASEAN NCAP, 2019a; ASEAN NCAP, 2019b; Jawi et al., 2013). The total score of the ODB frontal impact test depends on the scoring for each relevant body area including the head, neck, chest, knee, femur-pelvis, lower leg, and foot/ankle of the driver and the front passenger. The score of the side impact test depends on four individual body regions, namely the head, chest, abdomen, and pelvis. On the other hand, HPT is to ensure adequate head protection is offered; for example, by encouraging the fitment of more curtain airbags in cars sold in the Southeast Asian region (ASEAN NCAP, 2019b; ASEAN NCAP, 2020).

| ASEAN NCAP 2021-2025 | AOP | | COP | | Safety Assist | | Motorcyclist Safety | |
|---|---|---|---|---|---|---|---|---|
| | Item | Max | Item | Max | Item | Max | Item | Max |
| | Frontal | 16 | Frontal | 16 | *EBA* | 6 | *BSD / BSV* | 8 |
| | Side | 8 | Side | 8 | *SBR(Fr.)* | 3 | *Rear View Technology* | 4 |
| | *HPT Evaluation* | 8 | CRS Installation | 12 | *SBR(Rr.)* | 1.5 | *AHB* | 2 |
| | | | Vehicle Based Assessment | 13 | *SBR(Rr.) Advanced* | 1.5 | Pedestrian Protection | 2 |
| | | | *Child Presence Detection* | 2 | *AEB City* | 2.5 | | |
| | | | | | *AEB Inter Urban* | 3.5 | *[Advanced MST]** | 2* |
| | | | | | *Advanced SAT* | 3 | **BONUS POINT* | |
| Score | | 32 | | 51 | | 21 | | 16 |
| Weighting | | 40% | | 20% | | 20% | | 20% |

*Slanting = Fitment Rating System*   ** To add 2 points MAX to total MS point*

| | AOP (%) | COP (%) | Safety Assist (%) | Motorcyclist Safety (%) |
|---|---|---|---|---|
| 5 ★ | 80 | 75 | 70 | 50 |
| 4 ★ | 70 | 60 | 50 | 40 |
| 3 ★ | 60 | 30 | 40 | 30 |
| 2 ★ | 50 | 25 | 30 | 20 |
| 1 ★ | 40 | 15 | 20 | 10 |

**Figure 2**: ASEAN NCAP Roadmap 2021-2025 (ASEN NCAP, 2018)

There are several studies on the impact of a frontal crash to body part injuries including head injury (Mueller et al., 2015), thoracic injury or chest injury (Chen & Gabler, 2014; Cormier, 2008), lumbar spinal injury, or low back (Adolph et al., 2013; Shaikh et al., 2020; Sivasankari & Balasubramanian, 2021) and lower limb injury (Crandall et al., 1998; Kuppa & Fessahaie, 2003; Rudd, 2009). Presently, risk factors of lumbar spine fractures in frontal crashes have been investigated through parametric simulations. An occupant with reclined posture, severe crush pulse, early pulse peak, and vehicle pitch angle may also increase lumbar forces in a frontal crash (Tang et al., 2020). Based on the opinions of experts in both medical and automotive fields, it is believed that frontal collisions in Malaysia may severely injure the head, neck, and chest areas of the vehicle front occupants (Sukadarin et al., 2020). Studying the impact and injury patterns in frontal crashes of vehicles with a good rating for crash protection in the US, Brumbelow & Zuby (2009) found that programs promoting structural designs to absorb energy across a wider range of impacts, such as small overlap, could reduce serious injuries in frontal crashes. To improve vehicle safety in frontal collisions, the crash compatibility between the colliding vehicles is crucial. By using a deformable element in the full-width test, the test conditions represent real-world situations concerning acceleration pulse, restraint system, triggering time, and deformation pattern of the front structure (Johannsen et al., 2013).

ASEAN NCAP star rating is given based on the simulation of crash tests and performance assessments. Research that determines the pattern of car occupant injury in real-world frontal crashes may be able to consolidate the assessment program or detect any potential gaps in its present protocol. Thus, a better understanding of real-world frontal and sideswipe crashes in the region including Malaysia is highly recommended. In view of this, the current study has been conducted to analyze the driver injury and body area injury levels based on police-reported road crashes in Malaysia between 2015 and 2019. The main objective of this study is to determine the injury patterns in both frontals (full width & offset) and sideswipe crashes, respectively.

## 2.0 METHODOLOGY

The methodology of the study includes the data source and data analysis.

### 2.1 Source of Data

Data pertaining to police-reported road crashes between 2015 and 2019 were obtained from Bukit Aman Traffic Investigation and Enforcement Department (JSPT), Royal Malaysia Police (PDRM). Only passenger vehicles and two crash configurations (first impact) were selected including (1) frontal crash (full width and offset) and (2) sideswipe (Figure 3) cases. Nevertheless, full width and offset crashes were recorded under the same configuration (front crash) and the percentage of offset was also not defined in the JSPT database. Data for injury level and body part injury were also obtained as recorded in the JSPT database. The injury level was categorized as (1) fatal, (2) severe injury, (3) injury, and (4) no injury. Meanwhile, body part injuries included (1) head, (2) neck, (3) chest, (4) back, (5) pelvis, (6) hand, (7) lower leg, (8) multiple injuries, and (9) no injury.

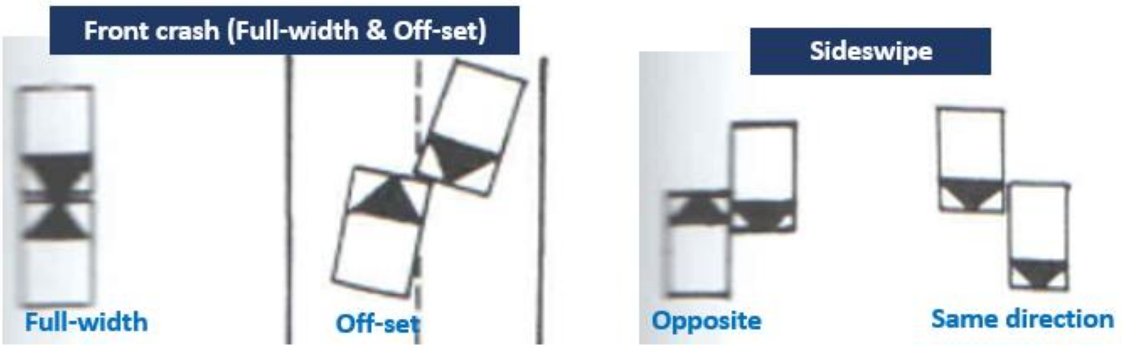


**Figure 3**: Crash configuration (first impact), Bukit Aman Traffic Investigation and Enforcement (JSPT) Royal Malaysia Police

### 2.2 Data Analysis

Descriptive analysis was performed to analyze the distribution of road crash cases, passenger vehicles type, injury category, and body part injury according to the crash configurations (whether frontal or sideswipe crashes). The Chi-square test was performed to investigate the significant relationship between crash configuration and injury category. In addition, an odd ratio test was performed to identify the likelihood of crash configuration that contributes to the driver fatality. The result analysis was performed in the Minitab statistics package.

## 3.0 RESULTS AND DISCUSSION

The results include frontal and sideswipe crashes in Malaysia between 2015 and 2019, distribution of vehicle types, distribution of injury level, distribution of body part injury, and crash configuration and category of injury association

### 3.1 Frontal and Sideswipe Crashes in Malaysia between 2015-2019

Table 1 shows the reported cases and the number of vehicles involved in frontal (full width and offset) and sideswipe crash in Malaysia from 2015 to 2019. A total of 5,761 cases were reported involving 8,166 vehicles between the years 2015 and 2019. In 2015, 1,340 cases were reported which increased to 1,508 cases in 2016. A decrease was recorded in 2017 with 1,313 cases. Positively, the number of cases decreased to 599 cases in 2018. In the following year, the number increased to 1,001 cases. Since 2013, ASEAN NCAP has provided consumers with safety ratings of new cars entering the ASEAN automotive market. ASEAN NCAP has conducted over 79 collision tests with 100 safety ratings (ASEAN NCAP, 2018). The authors believe this initiative has increased new car safety standards that generally suit the ASEAN context and may be able to contribute to a decrease in frontal crashes.

**Table 1:** Total of cases, vehicles involved, and crash configuration

| Year | No. of Cases | No. of Vehicles Involved | Crash Configuration | | |
|---|---|---|---|---|---|
| | | | **Front Crash** (A) | **Sideswipe (B)** | **Ratio (A/B)** |
| 2015 | 1,340 | 1,855 | 1,446 | 409 | 3.53 |
| 2016 | 1,508 | 2,173 | 1,741 | 432 | 4.03 |
| 2017 | 1,313 | 1,917 | 1,564 | 353 | 4.43 |
| 2018 | 599 | 897 | 772 | 125 | 6.18 |
| 2019 | 1,001 | 1,324 | 1070 | 254 | 4.21 |
| **Grand Total** | **5,761** | **8,166** | **6,593** | **1,573** | **4.19** |

Figure 4 shows the distribution of frontal and sideswipe crashes between 2015 and 2019. 81% (6,593) of the vehicles were involved in frontal crashes while the sideswipe cases contributed only 19% (1,573). The distribution of vehicles involved in the five consecutive years is shown in Figure 5. The percentage was fairly consistent from 2015 to 2017 with 22.7%, 26.6%, and 23.5% of vehicles involved, respectively. However, there was a sharp downward trend with only 11% of vehicles recorded in 2018; followed by a certain increment of 16% of vehicles involved in the ensuing year.

Nevertheless, the ratio of vehicles involved in frontal crashes compared to sideswipe accidents showed an increment over the years (Table 1). The ratio rose from 3.53 to 4.03 and later 4.43 between 2015 and 2017. The highest ratio was in 2018, with a ratio of 6.18 even with the less number of crashes and vehicles recorded. Overall, the ratio of vehicles involved in frontal cases compared to sideswipe cases was 4.19. This indicated the prevalence of frontal crashes in Malaysia. Therefore, the most points in the frontal crash impact test, or 50% for the AOP pillar in the ASEAN NCAP protocol, is deserved. In addition, a comprehensive rating protocol is also seen as a prerequisite for the AOP pillar. The vehicle must score more than 12.5 points over 16 in the frontal offset test to qualify for a 5-star rating. The vehicle that scores less than 12.5 points will be awarded a 4-star rating and below (ASEAN NCAP, 2020).

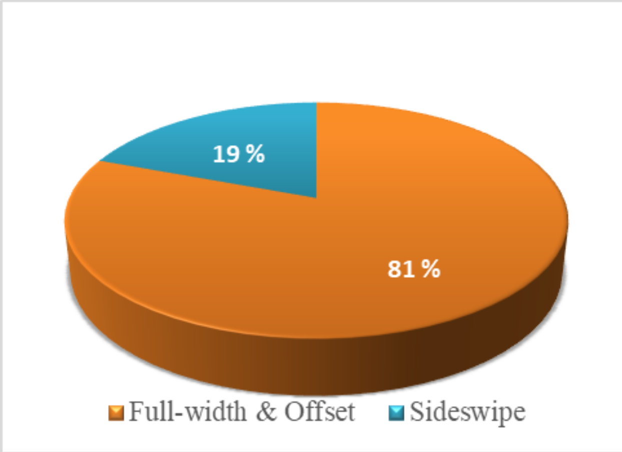


**Figure 4**: Percentage of frontal crash configuration

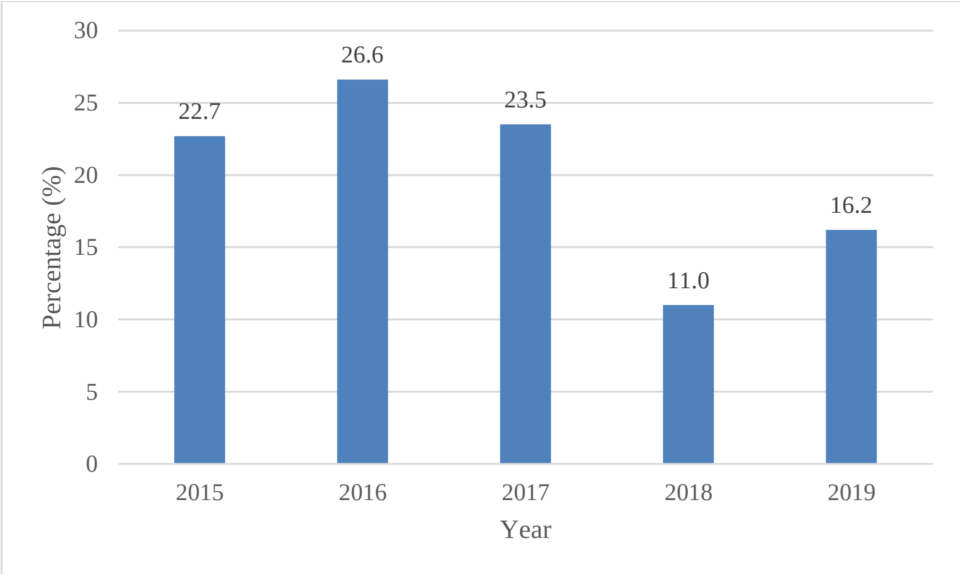


**Figure 5**: The percentage of vehicles involved in a frontal crash, 2015-2019

## 3.2 Distribution of Vehicle Types

Three types of passenger vehicles were recorded as shown in Table 2, including the car, 4-wheel drive, and taxi. Car crashes registered the highest frequency with 90% of the vehicle type involved in frontal crashes. On the other hand, only 9.58% and 0.53% of the vehicles were categorized as 4-wheel drive and taxis, respectively. Each year, car crashes occur most frequently due to their growing number (MOT, 2017). Apart from that, the ratio for frontal crashes compared to sideswipe cases for the car was 4.15; whereas, the ratio for the 4-wheel drive was 4.79. These values signal that both vehicles (car and 4-wheel drive) require a better driver and front occupant protection. ASEAN NCAP has amended the score for the side impact test in the sense that it will be reduced by 50%. On the other hand, additional points will be rewarded for Head Protection Technology (HPT) (ASEAN NCAP, 2020). Such a change will encourage more curtain airbags in new cars for the ASEAN market. This revision is deemed an appropriate reactive measure to reduce the consequences of head collision risk in frontal and sideswipe crashes.

**Table 2**: Distribution and ratio of vehicle types involved in frontal crashes

| Type of vehicle | Crash Configuration | | Frequency | Percentage | Ratio (A/B) |
|---|---|---|---|---|---|
| | Frontal (A) | Sideswipe (B) | | | |
| Car | 5,915 | 1,426 | 7,341 | 90 | 4.15 |
| 4-wheel drive | 647 | 135 | 782 | 9.58 | 4.79 |
| Taxi | 31 | 12 | 43 | 0.53 | 2.58 |
| **Total** | **6,593** | **1,573** | **8,166** | **100** | **4.19** |

### 3.3 Distribution of Injury Level

The driver injury level in a road crash comprised fatal, severe injury, injury, and no injury (Table 3). Overall, 70.7% of the drivers sustained no injury, whereas 11.11%, 8.77%, and 6.83% of the drivers suffered a fatal injury, injury, and severe injury, respectively. For instance, the recorded frontal crashes showed 13% fatalities, 8% cases of severe injury, 10% cases of injury, while 66% recorded no injury cases (Figure 6). Fatalities and severe injuries were recorded for 2% and 5% of the drivers involved in sideswipe crashes (Figures 7). An injury was more unlikely to happen in the reported cases as sideswipe crashes had a percentage of 89% compared to full width frontal and offset crashes with 66%.

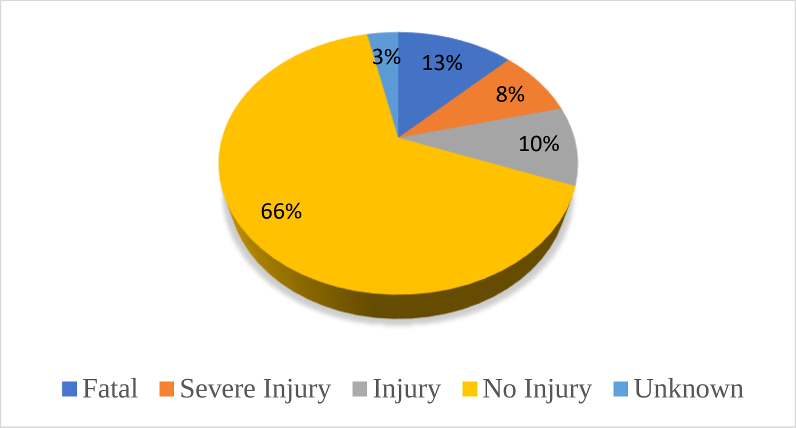


**Figure 6**: Percentage of the driver injury based on full-width and off-set crash configuration

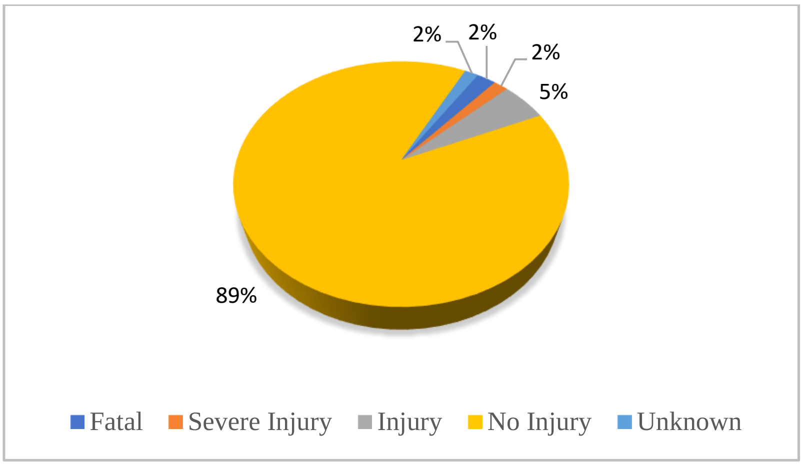


**Figure 7**: Percentage of the driver injury based on sideswipe crash configuration

**Table 3**: Distribution of driver injury

| Injury level | Crash Configuration | | Total | Percentage |
|---|---|---|---|---|
| | Frontal (Full-width & Off-set ) | Sideswipe | | |
| Fatal | 870 | 38 | 908 | 11.11 |
| Severe Injury | 533 | 25 | 558 | 6.83 |
| Injury | 638 | 78 | 716 | 8.77 |
| No Injury | 4,362 | 1,411 | 5,773 | 70.70 |
| Unknown | 190 | 21 | 211 | 2.58 |
| **Overall** | **6,593** | **1,573** | **8,166** | **100** |

Based on the data (Table 3), 908 drivers died, 716 drivers were injured, and 558 drivers sustained severe injuries due to frontal crashes within the five-year period. These figures require our attention and immediate actions to prevent and reduce the impact of frontal and sideswipe crashes. Consumers must be offered the safest car they can afford. Therefore, car manufacturers are also responsible for producing affordable cars with good safety standards in developing countries including Malaysia. To become a market leader, car manufacturers not only have to focus on aesthetic features and fuel efficiency but also emphasize good safety aspects.

### 3.4 Distribution of Body Part Injury

Table 4 shows the frequency of injury category based on driver body parts for frontal and sideswipe crashes. The following analysis and interpretation were derived after disregarding the ‘no injury’ and ‘no information’ cases.

The total number of injured drivers between frontal and sideswipe crashes revealed a slightly contrasting pattern. In the former, most drivers suffered from multiple injuries (414 drivers), whereas in the latter, injury to the lower leg (23 drivers) dominated the situation. It was not uncommon for drivers to suffer from multiple injuries in crashes. Hence, observations after omitting these cases produce the top three ‘lower leg – head – chest’ most prevalent patterns in frontal crashes, while the ‘lower leg – head – hand’ pattern was most frequent in sideswipe crashes.

Focusing exclusively on fatal cases, multiple injuries, head, chest, neck, lower leg, and pelvis injuries contributed to driver fatalities in frontal crashes. Meanwhile, overrepresentation of ‘no information’ limits any interpretation of body part injuries for fatal cases in the sideswipe configuration.

Moreover, multiple body injuries recorded the highest frequency for fatal (104 drivers) and severe injuries (178 drivers) in frontal cases. Also in this configuration, the second-highest number of driver fatalities was caused by head injury (75 drivers) followed by chest injury (19 drivers). According to the National Highway Traffic Safety Administration (NHTSA) report, fatal crashes involving head-on collisions contributed the second-highest percentage compared to other collision types such as rear-end and sideswipe crashes (III, 2021). A study of the pattern of injuries caused by road traffic crashes involving 4-wheel drive (4WD) vehicles and passenger cars in the United Arab Emirates (UAE) discovered that head injury was more common among occupants in 4WD vehicles than those in small cars (Bener et al., 2006). Many cases worldwide showed that car drivers or front passengers or both were killed due to the high impact against the car interior or intrusion of part of the car into the driver or front passenger compartment (Hitosugi & Takatsu, 2000).

**Table 4:** Distribution of injury level based on body parts

| | Body Part Injury | Injury Category | | | | |
|---|---|---|---|---|---|---|
| | | **Fatal** | **Severe Injury** | **Injury** | **No Injury** | **Total** |
| Frontal (Full-width and Off-set) | Back | 0 | 3 | 9 | 0 | 12 |
| | Chest | 19 | 36 | 41 | 0 | 96 |
| | Hand | 0 | 17 | 54 | 0 | 71 |
| | Head | 75 | 81 | 99 | 0 | 255 |
| | Lower leg | 2 | 144 | 133 | 0 | 279 |
| | Multiple | 104 | 178 | 132 | 0 | 414 |
| | Neck | 9 | 4 | 13 | 0 | 26 |
| | Pelvis | 1 | 11 | 6 | 0 | 18 |
| | No Injury | 0 | 0 | 0 | 4,362 | 4,362 |
| | No information | 660 | 44 | 109 | 0 | 813 |
| | Total | 870 | 518 | 596 | 4,362 | 6,346 |
| Sideswipe | Back | 0 | 1 | 2 | 0 | 3 |
| | Chest | 0 | 2 | 3 | 0 | 5 |
| | Hand | 0 | 3 | 12 | 0 | 15 |
| | Head | 2 | 4 | 13 | 0 | 19 |
| | Lower leg | 0 | 11 | 12 | 0 | 23 |
| | Multiple | 2 | 3 | 9 | 0 | 14 |
| | Neck | 0 | 0 | 1 | 0 | 1 |
| | Pelvis | 0 | 0 | 1 | 0 | 1 |
| | No Injury | 0 | 0 | 0 | 1,411 | 1,411 |
| | No information | 34 | 1 | 22 | 0 | 57 |
| | Total | 38 | 25 | 75 | 1,411 | 1,549 |
| | Grand Total | 908 | 490 | 606 | 4,814 | 7,895[a] |

[a] *Excluding 271 unknown cases*

Furthermore, lower leg injury had the highest contribution to severe injury and injury of the drivers in frontal crashes. Meanwhile, 44% (11) of the drivers involved in sideswipe crashes sustained severe injury to the lower leg (Table 4). Other works revealed the threat-to-life hierarchy and the body region, which indicated that the lower leg injury (including injuries to femur and pelvis) was at "Number 3" after spinal cord injury and brain injury (Martin, 2000). A study of the Taiwan population found that male and older drivers faced a greater risk of fatality in a single car and truck crash. The driver was generally associated with lower injury rates but higher fatality rates (Chang et al., 2020). An analysis of the UK in-depth crash data revealed that older car occupants involved in frontal impacts were significantly more prone to serious chest injury than their younger counterparts (Welsh et al., 2006). Overall, all the critical body parts are covered in the ODB frontal impact test (ASEAN NCAP, 2019b).

### 3.5 Crash Configuration and Category of Injury Association

The Chi-square Test of Independence was used to investigate the association between crash configurations (frontal vs sideswipe) and the level of injury. The hypothesis is as follows:

$H_0$: There is no significant effect between frontal crash configuration and level of injury.

$H_1$: There is a significant effect between frontal crash configuration and level of injury.

The result provided evidence to reject the $H_0$: $X^2(4) = 296.18$, $p < .0001$. This suggests a significant association between crash configurations and level of injury based on police-reported cases in Malaysia.

We continued the analysis by computing the odds ratio for fatality in frontal crashes relative to the sideswipe configuration over the five years to provide a trend. The cross-tabulation of fatal and non-fatal drivers for frontal and sideswipe crash configurations is shown in Table 5. The trends are consistent across the five years, with higher cases of frontal crashes than sideswipe crashes. These observations are apparent for both fatal and non-fatal conditions. There was a significant association between the crash configuration and the level of injury for each year.

**Table 5**: Cross-tabulation of fatal and non-fatal drivers based on configurations

| Year | Crash Configuration | Injury Level | | Statistical Analysis | |
|---|---|---|---|---|---|
| | | Fatal Frequency (%) | Non-Fatal Frequency (%) | Chi-square | Odds ratio |
| 2015 | Full-width and Off-set | 169 (96) | 1223 (75) | Reference | |
| | Sideswipe | 7 (4) | 401(25) | *0.00 | 7.92 |
| | **Total** | 176 (100) | 1624 (100) | | |
| 2016 | Full-width and Off-set | 220 (95) | 1444 (78) | Reference | |
| | Sideswipe | 11 (5) | 412 (22) | *0.00 | 5.71 |
| | **Total** | 231 (100) | 1856 (100) | | |
| 2017 | Full-width and Off-set | 204 (95) | 1324 (80) | Reference | |
| | Sideswipe | 10 (5) | 335 (20) | *0.00 | 5.16 |
| | **Total** | 214 (100) | 1659 (100) | | |
| 2018 | Full-width and Off-set | 105 (99) | 647 (84) | Reference | |
| | Sideswipe | 1 (1) | 121 (16) | *0.00 | 19.64 |
| | **Total** | 106 (100) | 768 (100) | | |
| 2019 | Full-width and Off-set | 172 (95) | 895 (79) | Reference | |
| | Sideswipe | 9 (5) | 245 (21) | *0.00 | 5.23 |
| | **Total** | 181(100) | 1140 (100) | | |

Note: *sig < 0.001

In 2015, the odds were OR = 7.92 (95% CI [3.68 – 16.97], $X^2(3) = 94.37$, $p < .0001$) and decreased to OR = 5.71 (95% CI [3.09 – 10.58], $X^2(3) = 94.81$, $p < .0001$) in 2016. In the following year, the decrease was marginal to OR = 5.16 (95% CI [2.71 – 9.87], $X^2(3) = 71.07$, $p < .0001$), before making a big jump to OR = 19.64 (95% CI [2.71 – 142.06], $X^2(3) = 26.49$, $p < .0001$) in 2018. In 2019, the odds returned to OR = 5.23 (95% CI [2.63 – 10.38], $X^2(3) = 59.51$, $p < .0001$). On average, across the five years, the likelihood of fatality was OR = 6.26 (95% CI [4.52 – 9.61], $X^2(3) = 339.31$, $p < .0001$) in frontal crashes as compared to sideswipe crashes. While all of the odds were significantly higher than one across the years (i.e. the likelihood of fatality was always bigger in the frontal than sideswipe crashes), its value for 2018 was surprisingly high, warranting an explanation.

A potential explanation of this would be the characteristics of the 2018 data. In 2018, the data showed a decrease in crashes with 599 cases involving 897 vehicles or drivers compared to the other years (Table 1). Apart from this, only 2% (23 drivers) were found with no information/under-reporting about the injury category, which is considered marginal. However, the ratio of the fatal drivers was 105 times concerning frontal crashes relative to sideswipe crashes in 2018. Meanwhile, the ratios of the other years were only between 19 and 21. The huge difference of these values contributed to the odds in 2018, which were significantly bigger than the other years being studied. Nevertheless, without comprehensive data (e.g. the traffic exposure, collision partners, vehicle protection technology, and impact speed, *inter-alia*) a more extensive explanation was outside the scope of the study.

Further analysis was conducted to determine the rate of driver fatalities per single crash. The higher the number, the more severe it was. Based on the data tabulated in Table 6, the trends consistently showed a little increment year by year. A Chi-Square Goodness of Fit Test on fatalities per 1,200 cases ratio across the years produced significant results, $X^2(4) = 11.24$, $p = .024$. This suggested the increasing trend was systematic and critical. Therefore, the introduction of the new ASEAN NCAP roadmap is timely indeed especially with its addition of a safety assist technology pillar to address this issue. The results of the current study further support the idea that a full-width configuration is considered in the future ASEAN NCAP frontal crash test. Such a practice will ensure safer cars on the market and thereby result in safer roads.

**Table 6**: Ratio of fatality over frontal and sideswipe crashes

| **Year** | **Frontal and Sideswipe Crashes** | | **Fatality per case (A/B)** | **Fatalities per 1.2k crashes** |
|---|---|---|---|---|
| | **Fatal driver (A)** | **Total Cases (B)** | | |
| 2015 | 176 | 1,340 | 0.13 | 195 |
| 2016 | 231 | 1,508 | 0.15 | |
| 2017 | 214 | 1,313 | 0.16 | |
| 2018 | 106 | 599 | 0.17 | |
| 2019 | 181 | 1,001 | 0.18 | |
| **Overall** | **908** | **5,761** | **0.15** | |

*Note: Denominator of 1,200 was selected after considering the average of total cases for the five years*

## 4.0 STUDY LIMITATION

A clear limitation of the present study was the missing information pertaining to body part injuries and the underreporting of cases in Malaysia. Huge missing data and underreported cases may obscure the overall burden of road crash injuries. Studies comparing Malaysian road crash statistics with Sweden recommended that analysis should examine hospital databases, and not only police crash databases (Kamaluddin et al., 2019; Abdul Manan & Várhelyi, 2012). Patterns of crashes and injuries that exist in the sample may vary from the bigger data of frontal crashes. Additionally, the frontal full width and offset configurations were recorded under the same configuration. Thus, there was a limitation to determine the different injury risks between the configurations as described in ASEAN NCAP 40% frontal-offset and full-width crashes.

## 5.0 CONCLUSION

In Malaysia, a total of 5,761 cases and 8,166 vehicles were reportedly involved in frontal and sideswipe crashes between 2015 and 2019. 81% of the cases involved frontal crashes while another 19% involved sideswipe crashes. The ratio of vehicles involved in both frontal and sideswipe crashes has shown an increment over the years. All types of cars demand better protection for the driver and the front occupant. Besides the multiple injuries, the lower leg, head, chest, and hand were the other prominent body parts sustaining injuries in frontal and sideswipe crashes. Meanwhile, the head, chest, neck, lower leg, and pelvis were the most significantly injured body parts in fatal frontal (full width and offset) crashes. Compared to the sideswipe crashes, fatalities in frontal crashes were 6.26 times more likely to occur. Another noteworthy observation across the same period was the marginal increment in the rate of driver fatality per a single frontal and sideswipe crash case. There was limited information whereby the frontal full width and offset configurations were recorded under the same configuration in the police database. Further research is also needed to fully understand real-world frontal crash impacts in Malaysia.

## ACKNOWLEDGEMENTS

The authors wish to thank Universiti Malaysia Pahang (www.ump.edu.my) and ASEAN NCAP Collaborative Holistic Research (ANCHOR) III for funding the project (No. A3-C1X1).

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