Characteristics of heavy goods vehicles (HGV) accidents in Malaysia

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Abstract. An increasing trend of freight road traffic in Malaysia resulted in more than a thousand fatal accidents involving heavy goods vehicles (HGV) every year. Of these fatal accidents involving HGV, more than 80% resulted in deaths for other road users. This situation creating a significant need to better understand the accident characteristics of this vehicle group. Utilizing five years of historical accidents data from the year 2011 to 2015, this study attempt to examine the factors associated with HGV accident resulted in fatalities. Results from the binary logistic regression indicated that the smaller vehicles have significantly higher odds of resulting fatal outcome. Comparing other vehicles with the bus, fatality odds ratio for the car, motorcycle and cycle are 1.929, 2.423 and 3.626 respectively. The likelihood of being fatal in an accident involving HGV is significantly higher on the straight road as compared to the T/Y junction or others (interchange & roundabout). Accidents involving HGV on expressway were also found to have higher odds compared to other road hierarchies. The result of this study can aid safety planners to plan safety management for HGV transport.

1. Introduction
Heavy goods vehicles (HGVs) are referred to large vehicles that used to transport goods by road. In Malaysia, the HGV can be classified into three main class, including trailer (articulated lorries), rigid lorry (2 or more axles lorry with over than 2.5 ton’s permissible gross weight) and small lorry (2 axles small lorry or pick-up with less than 2.5 ton’s permissible gross weight). The Malaysia fleet of HGV is composed of almost million units (data in 2016) cumulating a total of 200 kilometres of travelled distance per day as well as an Average Annual VKT (AAKT) of approximately 70,000 km [1]. Travelled distance by HGV is expecting to be grow in line with the growth of the ecommerce market in Malaysia.

The evolution of HGV accidents in Malaysia has shown a continuous up-and-down trend. Figure 1 below show the five years’ trend of road accidents involving HGV in Malaysia. Despite of a small numbers of HGV in traffic volume, accident involving HGV results in more than 1000 deaths each year in Malaysia. Out of that numbers, involvement of HGV in accident resulting more than 80% of second vehicle fatalities. This shows that HGV accident has a substantial impact on the safety of other road users.
In Europe, accident involving HGV resulted 4,500 deaths or about 18% of road accident fatalities in year 2013 [2]. Road accident fatalities involved HGV is also become a concern in Sweden since it contribute half of car occupant deaths [3]. In related to fatality risk, study conducted by Buddhavarapu, Banerjee, & Prozzi (2013) proved that the probability of fatal accident is higher at location with a higher percentage of truck traffic.

The large dimensions of these HGV, and their big masses contribute enormously to the severity of their impact with other vehicles involved in the road accidents [2]. Since HGV often travel at lower speeds than other vehicles, the differential of speed may potentially lead to rear‐end accidents [6].

Study focus on the risk of motorcyclist by turning lorries conducted by [7] concluded that lorry drivers perceived that they drive more cautiously when a motorcyclist was riding nearby the lorry. However, in terms of the location of blind spots, most drivers perceived that the rear is the blind spot area of a lorry without knowing that the front and both sides of a lorry are also blind spots. Improve design of rear view mirror in HGV could reduce the blind spot which in turns leads to reduce the possibility of the road accidents [8].

Due to large dimension, HGV have operating limitations such as large blind spots, long stopping distances, and limited manoeuvrability that make it essential for other vehicles to put extra focus on safety. HGV involvement in fatal accidents creating a significant need to better understand the impact of this vehicle group to other road user. Thus, this study attempt to examine the characteristic HGV accidents and its associated factors resulted in fatalities to other road users.

2. Method
Road accident data obtained from Royale Malaysia Police (RMP) extracted from MROADS (MIROS Road Accidents Database System) were used to examine the characteristics of HGV accidents in Malaysia. The five years’ accident data related to HGV for the years 2011-2015 were analysed quantitatively using SPSS. HGV accident data for the five years is then filtered to select a subsample of 7026 cases involving HGV versus other vehicles, which classified into four main categories as shown in Figure 2. These four categories of vehicles namely bus, car/van, motorcycle and bicycle. Accident cases involving lorry versus lorry and single lorry accidents were also excluded for analysis.

The effect of the variables on the likelihood of fatality outcome were explored using the binary logistics model. Dichotomous level of injury severity (fatal vs non-fatal) for accidents involving HGV in Malaysia is used as the dependent variable in the model analysis. The odds ratio (OR) were used as the model outcome to indicate the probability that the categorical variable to a predictive factor. The greater value of OR (more than 1) indicate that the variable is related with higher odds of the outcome, and vice versa.
Variables with large amount of missing data such as type of traffic system, type of light condition, type of location and type of collision were dropped for model analysis. The final model considered 7026 accident cases involving HGV without any missing values for all independent variables considered for analysis.

3. Results and Discussion
3.1. Accident involving HGV with other vehicles
Out of 7026 accident analysed, there were 3787 fatal and 3239 non-fatal cases, which include serious and slight injury of the driver/s or passenger/s of the vehicles. Table 1 shows that majority of HGV accidents involved motorcyclists, which contribute for 2311 motorcycle fatalities. Involvement of HGV also causing about 1372 fatalities in car accidents, 56 fatalities in cycle accidents and 48 fatalities in bus accidents. Motorcycle fatalities in accidents involving HGV is the highest in Malaysia which constitute of 61% fatalities. As comparison to other countries such Europe, involvement of heavy vehicles resulted 47% of car occupants killed in road accidents that involved HGV and buses [2].

| Vehicle types | Fatal cases (n=3787) | Non-fatal cases (n=3239) |
|---------------|----------------------|--------------------------|
|               | n  | %     | n  | %     |
| Bus           | 48 | 1.3   | 68 | 2.1   |
| Car           | 1372 | 36.2 | 1275 | 39.4 |
| Motor         | 2311 | 61.0 | 1864 | 57.5 |
| Cycle         | 56  | 1.5   | 32  | 1.0   |
| Total         | 3787 | 100.0 | 3239 | 100.0 |

The distribution of accident for three different types of HGV (trailer, rigid, small) involving other types of vehicles is summaries in Table 2. Based on data obtained, the most frequent type of HGV collide with other vehicles is the rigid lorry, which having permissible gross weight of over than 2.5 ton’s. From 5058 of the rigid lorry accident, 3047 cases involved motorcycle, 1852 cases involved car/van, 77 cases involved bus and the rest 62 cases involved bicycle.
Table 2. Type of lorry and other vehicles cross tabulation

| HGV types | Other vehicles | Total |
|-----------|----------------|-------|
|           | Bus | Car | Motor | Cycle |       |
| Trailer   | 36  | 640 | 776   | 18    | 1470  |
| Rigid     | 77  | 1852| 3047  | 62    | 5038  |
| Small     | 3   | 155 | 352   | 8     | 518   |
|           | 116 | 2647| 4175  | 88    | 7026  |

The HGV accidents by type of collision with other vehicles were summarised in Table 3. Cross tabulation of collision type by vehicle types show that the high percentage of HGV accident experienced rear end collision with buses and motorcyclists. Head on collision are the most common type of collision for HGV accident involving car/van. While angular and side swipe collision contribute the majority for HGV accident involving motorcycles.

Table 3. Collision type and other vehicles cross tabulation

| Collision type   | Other vehicles (%) | Total |
|------------------|--------------------|-------|
|                  | Bus | Car/Van | Motorcycle | Bicycle |       |
| Head on          | 0.2 | 13.2    | 8.4       | 0.1     | 21.9  |
| Rear end         | 0.9 | 11.6    | 16.1      | 0.2     | 28.8  |
| Right angle      | 0.0 | 2.0     | 3.7       | 0.1     | 5.9   |
| Angular          | 0.2 | 7.7     | 17.2      | 0.4     | 25.6  |
| Side swipe       | 0.1 | 2.1     | 10.4      | 0.4     | 13.0  |
| Others           | 0.0 | 0.3     | 0.5       | 0.0     | 0.8   |
| Hitting          | 0.1 | 0.7     | 0.7       | 0.0     | 1.5   |
| Out of control   | 0.0 | 1.1     | 1.4       | 0.0     | 2.5   |
| Total            | 1.7 | 38.8    | 58.3      | 1.2     | 100   |

Table 4. Road type and other vehicles cross tabulation

| Road Type    | Other vehicles | Total |
|--------------|----------------|-------|
|              | Bus | Car/Van | Motorcycle | Bicycle |       |
| Expressway   | 56  | 464     | 430       | 0       | 950   |
| Federal      | 43  | 1325    | 1600      | 29      | 2997  |
| State        | 13  | 622     | 1296      | 31      | 1962  |
| Municipal    | 3   | 151     | 571       | 19      | 744   |
| Other        | 1   | 85      | 278       | 9       | 373   |
| Total        | 116 | 2647    | 4175      | 88      | 7026  |

For a period of 2011 to 2015, most of the HGV accident involving bus occurred at expressway with 56 cases (refer Table 4). For the HGV accident involving car, majority of cases occurred at federal road. A large amount of HGV accident involving motorcycles occurred at federal and state road. While for the HGV accident involving cyclist, about 31 cases occurred at state road and none at expressway. Overall, federal road had been recorded the highest number of HGV accident involving other vehicles.
The distribution of HGV accident involving other types of vehicles as shown in Table 5 allows identification of the types of vehicles most likely to be involved in the HGV accidents at different set of road geometry. Analysis indicate that 65.5% of the HGV accident occurred at straight road where majority of the accident involving motorcyclist and car. At bending road, HGV accident involving car contribute the highest percentage (8.2%) as compared to other types of vehicles. Apart from this, HGV accident involving motorcycles are frequently occurred at T/Y junction (9.9%).

Table 5. Road geometry and other vehicles cross tabulation

| Road geometry    | Other vehicles (%) | Total |
|------------------|--------------------|-------|
|                  | Bus    | Car/Van | Motorcycle | Bicycle |       |
| Straight         | 1.4    | 25.7    | 37.6       | 0.8     | 65.5  |
| Bend             | 0.2    | 8.2     | 7.3        | 0.1     | 15.8  |
| Cross junction   | 0.0    | 1.3     | 4.1        | 0.1     | 5.6   |
| T/Y junction     | 0.0    | 2.4     | 9.9        | 0.2     | 12.6  |
| Other            | 0.0    | 0.2     | 0.4        | 0.0     | 0.6   |
| Total            | 1.7    | 37.7    | 59.4       | 1.3     | 100   |

Looking to the type of road and geometry, most of the HGV accident occurred on a straight section of the federal road (27.3%), followed by state road (16.8%) and expressway (12.5%). For other type of road geometry (bend and junctions), HGV accident is most likely to occurred on the federal road, see Table 6.

Table 6. Road geometry and other vehicles cross tabulation

| Road geometry    | Road type (%) | Total |
|------------------|---------------|-------|
|                  | Expressway | Federal | State | Municipal | Other |       |
| Straight         | 12.5       | 27.3    | 16.8  | 6.1       | 2.8   | 65.5  |
| Bend             | 0.9        | 7.6     | 5.2   | 1.1       | 1.0   | 15.8  |
| Cross junction   | 0.0        | 2.3     | 1.5   | 1.2       | 0.5   | 5.6   |
| T/Y junction     | 0.2        | 5.3     | 4.3   | 1.9       | 0.9   | 12.6  |
| Other            | 0.0        | 0.2     | 0.1   | 0.2       | 0.1   | 0.6   |
| Total            | 13.5       | 42.7    | 27.9  | 10.6      | 5.3   | 100   |

3.2. Model result
Logistic regression analysis was used to quantify the fatality risk factors associated with HGV accident with other vehicles. The effect of variables that influence the likelihood of fatal accidents involving HGV is represented by the odds ratio. The fatality odds ratio from model analysis is summarised in Table 7.

The likelihood of being fatal in an accident involving HGV is significantly higher on the straight road as compared to the T/Y Junction or others (interchange & roundabout). In related to the road geometry, it was also found that bend section was a statically significant factor of HGV accident fatality at 10% when comparing to straight section (OR=1.134).
Accident involving HGV on the expressway is more likely to result in fatalities compared to other road types including federal road, state road, municipal and others. This could be due to the higher speed operated by vehicles when travelling on the expressway, as compared to other types of road. HGV with heavy mass when travelling with higher speed would create big momentum. When collide with other vehicle, an energy from this big momentum transform into big impact that resulted in higher fatality odds.

The likelihood of fatality for other vehicles except for bus is significantly higher when involve in HGV accidents. Car had odds of fatality that were 1.929 (p-value < 0.05) times higher than bus. Motorcycle and cycles had more odds of fatality, OR = 2.423 (p-value < 0.05) and OR = 3.626 (p-value < 0.05) compared to bus respectively. This indicates that the risk of fatality is higher for the smaller vehicles involved in the HGV accidents. Sharing traffic system with HGV could be dangerous for other smaller vehicles due to greater collision impact [3]. In addition, involvement of heavy vehicles would increase 5.6 times fatality odds to pedestrians [9].

4. Conclusion
This study focus on the analysis of the HGV accident in Malaysia. Accident involving HGV would have resulted more than 80% fatalities to other vehicles. Of those vehicles involved in fatal cases, motorcycle is the most common vehicle become a victim in HGV accident. Majority of HGV accident involving motorcycles experience angular and rear end collision.

Based on the 5 years' accident data, association between selected variables and the odds of fatality for HGV accidents were analysed using logistics regression. Results from model analysis indicate that accident involving HGV is significantly higher on the expressway. As the highest hierarchy of road, vehicles traveling on the expressway are operating with higher speed. Heavier vehicles like HGV traveling in higher speed would having greater momentum to cause greater injury to other vehicles occupant. In addition, a collision of HGV with smaller vehicles would resulted in higher fatality odds.

### Table 7. Model summary

| Attributes     | Odds ratio | (95% CI)       | Sig.  |
|----------------|------------|----------------|-------|
| **Road geometry** |            |                |       |
| Straight       | Reference  |                |       |
| Bend           | 1.134      | 0.991-1.299    | 0.068** |
| Cross Junction | 0.908      | 0.735-1.123    | 0.374  |
| T/Y Junction   | 0.617      | 0.531-0.716    | 0.000* |
| Other          | 0.529      | 0.281-0.995    | 0.048* |
| **Road types** |            |                |       |
| Expressway     | Reference  |                |       |
| Federal        | 0.494      | 0.422-0.579    | 0.000* |
| State          | 0.486      | 0.411-0.575    | 0.000* |
| Municipal      | 0.800      | 0.649-0.987    | 0.038* |
| Other          | 0.468      | 0.364-0.602    | 0.000* |
| **Vehicle types** |          |                |       |
| Bus            | Reference  |                |       |
| Car            | 1.929      | 1.310-2.841    | 0.001* |
| Motor          | 2.423      | 1.646-3.566    | 0.001* |
| Cycle          | 3.626      | 2.024-6.498    | 0.000* |

* statically significant at 5% level
** statically significant at 10% level
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