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The Effect of Road Characteristic on Motorcycle Fatal Crashes Involving Heavy Goods Vehicle (HGV): A Case Study in Malaysia

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ABSTRACT

Road characteristic is one of the main contributing factors for fatality to the motorcycle when involve in HGV crash. In particular, the studies related to HGV and motorcycle crashes affecting by the road characteristics have been relatively limited. This article provides eight road characteristics that were identified in the crash between HGV and motorcycle. The purpose of this article is to examine the severity of a motorcycle crash when it is engaged in the HGV crash. This study intends to evaluate the road characteristics which are significantly giving effect to the fatal crashes between HGV and motorcycle. The data acquired from RMP crash database for the past three years was cleaned and filtered then analysed statistically through descriptive and simple logistic regression analysis using SPSS software. The result reveals that eight main risk factors of road characteristics are associated to contributing to HGV-motorcycle crash fatality. Descriptively, fatality occurrence is higher in unexpected road characteristic as per common assumption; more fatalities in straight road as compared to other road geometry characteristic. Furthermore, not every characteristic is statistically significant towards the probability of fatality to occur in HGV-motorcycle crash, such as the bend and the sloppy road. Hence, findings in this study are expected to provide a new insight in evaluating the road characteristics factor affecting the HGV-motorcycle crash fatality.

1. Introduction

Heavy goods vehicle (HGV) is difficult to control due to their big blind spots, long stopping distances, and lack of agility. Due to their size, the other vehicles must exercise greater caution around them. Shaadan [1] reported that the majority of fatalities involve motorcyclists, regardless of the fact that more motorcar crashes happen. There have been several studies in the literature reporting on a high number of motorcycle fatalities in Malaysia occurring on straight road sections, highlighting the danger of road geometry such as bends or straight road sections.

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Elliot [2] indicated that the motorcycle riders may be injured by slippery surfaces, repaired sections on the road, unevenness, road markings, longitudinal parallel grooves, cobbles, drain covers, and gratings, and found that the rider is probably vulnerable to bitumen, a substance used to fill and fix road fractures that can cause the road to become slippery.

HGV can cause serious damage and even fatality when collides with motorcycle. A thorough analysis of HGV crash factors was necessary because these vehicles contribute more to the severity of crashes than other types of vehicles, particularly motorcycles. Abdul Manan [3], summarized that the majority of road crash fatalities involve motorcyclists, constituting more than 50% of the total number of fatalities and the motorcycle fatalities has reached 4070 cases in 2019, which is the highest for the last 10 year. Crashes on dry surfaces which closely connected to the road friction, are more likely to be severe when the driver have greater confidence in envisioning the dry condition [4]. However, the study by Mohammed [5] indicated that speed was the only factor influencing the crash severity. Gong [6] added that the severity of the crash can be reduced if the driver is more cautious and conservative in adverse weather conditions. Furthermore, it was found that the safety of motorcycle can be affected by the road defect such as rutting, water ponding, potholes, corrugation, and others [7].

One of the factors that contributes to crashes between HGVs and motorcycles is the characteristic of the road. However, studies specifically related to the road characteristic have been relatively limited. Therefore, this study was carried out through statistical analysis towards the road characteristic affecting the HGV-motorcycle crash fatality based on real data acquired from Royal Malaysia Police (RMP) crash database in order to provide a better understanding of the traffic conditions in Malaysia. The purpose of this paper is to evaluate the road characteristics which are significantly giving effect to the fatal crashes between HGV and motorcycle, hence strengthening the base of Malaysian road safety program.

2. Literature Review

The difference in speed between HGV and small vehicles increases the likelihood of traffic conflicts because the relationship between HGV interactions and related crash risk was found to be positively associated with the crash risk of other vehicles and because the relationship between HGV interactions and related crash risk may vary with traffic volume. There have been several studies in the literature reporting the large size and the mass of HGV contributing significantly to the severity when crashing with other vehicles in traffic crash. Despite the comparatively low percentage of HGVs in Malaysia's overall traffic flow which is 20% in 2011 and 2016, crashes involving these vehicles cause the fatalities of over 1000 people each year and according to those statistics, HGV responsible for more than 80% of all fatalities involving secondary vehicles [8]. As a result, it has been discovered that HGVs have caused numerous fatalities when involved in crashes.

A heavy vehicle's involvement in a crash increases the probability by 2.3 to 4.5 which increase the severity of the crash [9]. Therefore, crash involving heavy trucks are more likely to result in fatalities or serious injuries. Hence, the performance and efficiency of Malaysia's traffic would be significantly affected by the increased number of HGVs [10]. Moreover, the crash involving HGVs have a greater impact than those involving other types of vehicles since the HGV is larger in dimension and weight, resulting to more injuries and fatalities. In addition, according to Marwan [11], due to the rising number of goods transported by road, it is anticipated that HGV will remain a familiar sight in the future years. Motorcycle riders are more vulnerable to injury than car drivers since they only have their balance while riding [12]. It has been conclusively shown that motorcycle riders account for 23% of all crash-related deaths worldwide, and more than 24% of motorcycle crashes are caused by

maneuvers or lane changes, indicating the rider is unable to detect any cars in the area [13]. It has been found that this occurrence is caused by a number of causes, one of which is the road itself, which is uneven, cracked, and full of potholes [14].

Road structure is among the contributing factors in motorist fatalities. Potholes and uneven roads may hinder vehicle tire from gripping the road's surface, causing the vehicle to lose control, and some drivers may attempt to avoid faulty road structures by unexpectedly entering the path of another driver, resulting in collisions with other vehicles [15]. Numerous studies on truck-involved incidents focused heavily on route design and operating factors. Miaou [16] in 1994 discovered that geometric highway design features such as horizontal curvature, vertical grade, and shoulder were related to truck-involved crashes and Harkey in 1996 indicated that operating features of longer combination vehicles and geometric design affected safety, while Harwood in 1999 discovered that lengths of horizontal curves were significantly affected by larger and more massive trucks.

Therefore, the road traffic crashes are not a new subject of research in the field of traffic safety, and controlling traffic crashes has been crucial in identifying defects in traffic management and the transportation system. According to previous studies, identifying factors influencing road collisions collected from crash investigations can be used to prevent future crashes on a road stretch in a certain state [17]. The improvements slightly reduce the possibility of severe injury, and downgrades slightly increase the risk [18].

3. Methodology

This study utilized secondary traffic data crash reports by the RMP crash record database, that were extracted by the Institute of Road Safety Research (MIROS). The collaboration with MIROS helped to facilitate data sharing and improve the completeness of the dataset because the HGV crash data came from an in-depth database research and needed to be examined and treated with a data cleaning and filtration process. The data related to HGV and motorcycle crashes used in this paper are within years 2015–2017. RMP crash reports consist of various information including different factors and causes of the crash. Data filtration and cleaning process are utilized to segregate the accidents reports data in accordance to factors and causes, which is important in catering the study limitation. Hence, other influencing factors than road characteristic have been eliminated from being taken into further analysis.

A total of 2309 HGV-motorcycle crashes were successfully drawn from the RMP traffic crash reports after filtering all the discrepancies. These discrepancies, such as overlapping case numbers, inaccurate incident location, mismatched road hierarchy to road geometry and incomplete data, were eliminated. There are ninety different types of categories for each crash record, such as route number, road type, rider's age, motorbike type, time of crash, weather condition, crash severity, road geometry, vehicle type and others. This study focuses on fatality cases involving road characteristic only including road geometry, road defect, shoulder type, road condition, quality of surface, road surface type, road surface condition, and lane marking.

The data cleaning procedure was conducted for blank data which generally involves imputing missing values, smoothing down noisy data, identifying inaccurate data, and correcting inconsistencies. Numerous datasets were needed to undergo the data cleaning process, and the step started by sorting the raw data. The data was extracted by row referring to the report number. Then, data entry errors such as the wrong figure being used and data being entered incorrectly, not being updated, or being exclude or happen for many different reasons, was checked by using Statistical Package for Social Science (SPSS) software. Errors that are not taken care of, could affect the result of the statistical analysis.

Descriptive analysis and simple logistic regression were conducted on the crash fatality data to determine the pattern of road characteristics being the factor to HGV-motorcycle crash. The analysis consists of the summarization, collection, and presentation of data obtained from the sample. The descriptive analysis is used to describe the trend of HGV-motorcycle crash fatality and summarize the data points in constructive way. In this hypothetical data, to identify which road characteristic may associate with the crash fatality, a simple logistic regression is used in this study as univariable analysis to screen for important variables. Only variables with p-values less than 0.25 are considered significant in affecting the HGV-motorcycle crash.

4. Results and Discussion

4.1 Data Overview

Table 1 shows the crash severity related to road factors affects generated from the record of RPM accident reports. The crash severity is divided into two categories, fatal and non-fatal. Fatal indicates crashes that include death while non-fatal includes other than death; major or minor or no injury at all. A total of 2,309 HGV-motorcycles crashes with 1457 being the fatal cases and 852 non-fatal were acquired as sample. The result shows that more than 60% of fatalities occur when a motorcycle is involved in a crash with HGV, indicating that motorcycles are more fragile and riskier crashing into HGVs.

Table 1
Total crash severity of crashes between HGV and motorcycle in year 2015 to 2017

	Crash severity		
	Non-fatal (%)	**Fatal (%)**	**Total (%)**
Number of crashes	852 (36.9)	1457 (63.1)	2309 (100)

The lower value of non-fatal crash could presumably be a result of unreported cases, especially crashes does not involve fatality. Fatality involves death while non-fatality includes others than death; major/minor injury or not injured at all. The likelihood of non-fatal crashes not being reported accordingly is indisputable. However, as the data was drawn from the RMP accidents database, the study has limitation in addressing those unreported cases and taking only the available data into account. Furthermore, road safety matter is commonly addressed by the fatality scenario of any crash condition as it involves death. Hence, this study, without neglecting the non-fatal crashes, but considering more to the fatal cases in evaluating road characteristic factor contributing to the HGV-motorcycle crash fatality.

4.2 Descriptive Analysis

Figure 1 illustrates the trend of fatal and non-fatal crashes in Malaysia from 2015 to 2017. The trend indicates that the year2016 recorded the highest 549 fatal cases, increasing from 440 cases in 2015 and decreasing to 468 cases in 2017. It is apparent from this figure that non-fatal cases also show the same trend with 270 cases in 2015 increasing to 327 cases in 2016 and decreasing to 255 cases in 2017. This trend implies that HGV-motorcycle crash results to more fatality than non-fatal.

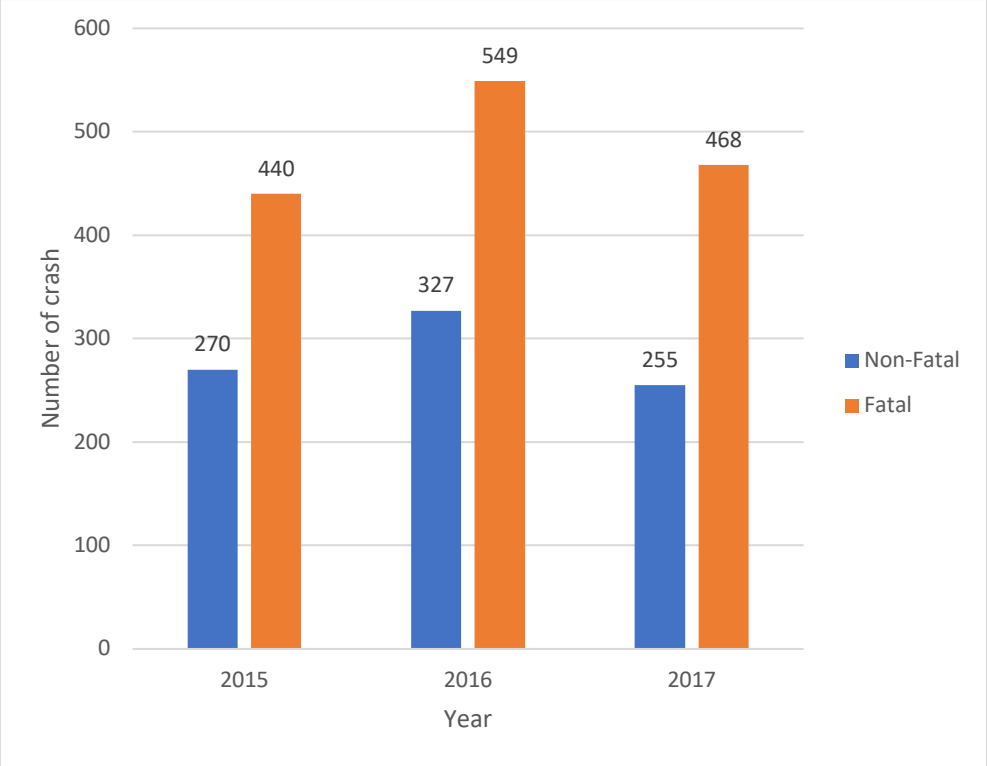

Fig. 1. Trend of crash severity

Table 2 shows the descriptive statistics of the crashes by the eight (8) risk factors covering road characteristics, which in turn becoming the independent variables for the logistic regression. These risk factors range from the type of the road such as road geometry, road defect, shoulder type, road condition, quality of surface, road surface type, road surface condition and lane marking contributing to the fatal crashes. The police records specified that road surface quality is the description of the road surface after it was developed or maintained, since a period of the road commission. While the road surface condition describes the road surface after the crash, after it has been exposed to the elements or has been subjected to the spillage of hazardous materials that may alter driving behavior, such as oil and sand.

The results indicate that the quality of the surface is the factor that contributes to the majority of fatalities involving motorcycles and HGV in these occurrences; (E1) smooth surfaces account for 60.3% of the total number of fatalities. The finding is consistent with finding of past studies by [19], which the rider tends to be bolder when riding on a smooth road surface as they consider the risk to be lower, which can lead to a crash. The finding also indicates that flat road condition (D1) is the second leading factor towards HGV-motorcycle crashes, accounting to 59.6% of the total number of fatal crashes. This implies that HGV occurrence in flat areas is frequent, which was consistent with the finding from Manap [20]. On flat mainline sections, where drivers are most likely to exceed the speed limit and cause crashes, drivers become less cautious and more tempted to indulge in risky behaviors [21]. Despite the road condition appearing to be in good condition, the neglected road safety hides potential dangers that can pose a serious threat to unaware users.

In the event of an HGV crash, the smooth and flat surface are the most often encountered variables. According to the factors, each factor with the most variable occurs in crashes between HGV and motorcycles, including straight road (44.7%), paved road (38.8%), flat surface (59.6%), smooth surface (60.3%), bitumen road (46.2%), dry surface condition (56.4%), and single lane (34.8%) for fatal cases with an average involvement of 30% to 60%. According to these figures, road conditions may enhance the likelihood of crashes between HGVs and motorcyclists. The emphasis on smooth

and flat surfaces, as well as the other criteria listed, highlights the significance of infrastructure and road design in ensuring the safety of all road users.

Table 2
Total number of crash severity in HGV crash with motorcycle involving road factors.

			Crash Severity		
			Non-fatal (%)	**Fatal (%)**	**Total (%)**
Road Geometry	A1	Straight	549 (23.8)	1033 (44.7)	1582 (68.5)
	A2	Bend	85 (3.7)	182 (7.9)	267 (11.6)
	A3	Roundabout	55 (2.4)	80 (3.5)	135 (5.8)
	A4	Cross Junction	155 (6.7)	146 (6.3)	301 (13.0)
	A5	T/Y Junction	8 (0.3)	16 (0.7)	24 (1.0)
		Total	852 (36.9)	1457 (63.1)	2309 (100.0)
Road Defect	B1	Shoulders Low/High	15 (0.6)	19 (0.8)	34 (1.5)
	B2	Manhole Low/High	1 (0.0)	2 (0.1)	3 (0.1)
	B3	Loose Gravel	3 (0.1)	11 (0.5)	14 (0.6)
	B4	Dusty Roads	4 (0.2)	12 (0.5)	16 (0.7)
	B5	Pothole	7 (0.3)	11 (0.5)	18 (0.8)
	B6	Slippery	8 (0.3)	21 (0.9)	29 (1.3)
	B7	Defective Traffic Lights	1 (0.0)	2 (0.1)	3 (0.1)
	B8	Narrow Bridge	4 (0.2)	5 (0.2)	9 (0.4)
	B9	No Guard Rails	3 (0.1)	9 (0.4)	12 (0.5)
	B10	No/Insufficient Streer Lights	17 (0.7)	53 (2.3)	70 (3.0)
	B11	Not Relevant	789 (34.2)	1312 (56.8)	2101 (91.0)
		Total	852 (36.9)	1457 (63.1)	2309 (100.0)
Shoulder Type	C1	Paved	470 (20.4)	897 (38.8)	1367 (59.2)
	C2	Unpaved	382 (16.5)	560 (24.3)	942 (40.8)
		Total	852 (36.9)	1457 (63.1)	2309 (100.0)
Road Condition	D1	Flat	813 (35.2)	1376 (59.6)	2189 (94.8)
	D2	Slope	39 (1.7)	81 (3.5)	120 (5.2)
		Total	852 (36.9)	1457 (63.1)	2309 (100.0)
Quality of Surface	E1	Smooth	830 (35.9)	1392 (60.3)	2222 (96.2)
	E2	Pothole	3 (0.1)	10 (0.4)	13 (0.6)
	E3	Rutted	4 (0.2)	12 (0.5)	16 (0.7)
	E4	Corrugation	15 (0.6)	43 (1.9)	58 (2.5)
		Total	852 (36.9)	1457 (63.1)	2309 (100.0)
Road Surface Type	F1	Crasher Run	5 (0.2)	20 (0.9)	25 (1.1)
	F2	Brick	204 (8.8)	358 (15.5)	562 (24.3)
	F3	Bitumen	636 (27.5)	1066 (46.2)	1702 (73.7)
	F4	Concrete	4 (0.2)	6 (0.3)	10 (0.4)
	F5	Earth	3 (0.1)	7 (0.3)	10 (0.4)
		Total	852 (36.9)	1457 (63.1)	2309 (100.0)
Road Surface Condition	G1	Dry	766 (33.2)	1302 (56.4)	2068 (89.6)
	G2	Wet	74 (3.2)	132 (5.7)	206 (8.9)
	G3	Oily	1 (0.0)	2 (0.1)	3 (0.1)
	G4	Sandy	10 (0.4)	19 (0.8)	29 (1.3)
	G5	Reconstruction work	1 (0.0)	2 (0.1)	3 (0.1)
		Total	852 (36.9)	1457 (63.1)	2309 (100.0)
Lane Marking	H1	Double	222 (9.6)	254 (11.0)	476 (20.6)
	H2	Single	465 (20.1)	804 (34.8)	1269 (55.0)
	H3	One Way	33 (1.4)	133 (5.8)	166 (7.2)
	H4	Divider	81 (3.5)	210 (9.1)	291 (12.6)
	H5	U Turn	4 (0.2)	3 (0.1)	7 (0.3)
	H6	No Marking	47 (2.0)	53 (2.3)	100 (4.3)
		Total	852 (36.9)	1457 (63.1)	2309 (100)

The data suggests that non-fatal cases exhibit a similar trend to fatal cases but with less severity. Results show that the smooth and flat surface are also the most variable in HGV crashes for non-fatal cases, with 35.9% and 35.2%, which is related to 830 cases and 813 cases out of total cases. For period of 2015 to 2017, most variable of HGV crash involving motorcycle occurred were A1 (Straight), C1 (Paved), D1 (Flat), E1 (Smooth), F3 (Bitumen), G1 (Dry), and H2 (Single).

4.3 Simple Logistic Regression (Univariable Analysis)

Table 3 shows the result of simple logistic regression analysis which important in analyzing the significance of each road characteristic that contribute to fatality in HGV-motorcycle crashes. The p-value in the result of lesser than 0.25 indicates the significance of the specific road characteristic being the factor to HGV-motorcycle fatality crashes. The lower the p-value of the specific road characteristic, the greater the significance of particular road characteristic in predicting the effect on the crash fatality. The lower the standard error, indicates the prediction for the specified variable affecting the HGV-motorcycle crash is more precise. While the odd ratio measures the association of variables with the first variable in each road characteristic. Odd ratio represents the constant effect of predictor (road characteristic variable) on the likelihood that one outcome will occur (crash fatality).

The significance of a factor is determined by its effect on the dependent variable; the crash fatality. A factor's significance is determined not only by the magnitude of its odds ratio, but also by the level of statistical evidence supporting its impact. The table compares various road characteristic in accordance to road factors. The data in road geometries shows straight road, roundabout and cross junction are the significant factor in observing the risk of fatal crash. According to the odd ratio with straight road as references, roundabout and cross junction has 23% and 50% less odds of crash fatality. The roundabouts, in particular, are known for their traffic-calming effects because they exert drivers to slow down and yield to other vehicles. Lower speeds within roundabouts can help to minimize crash severity and lower the fatality rates. This demonstrates that, rather than a truly substantial correlation, the observed differences in fatality rates between roundabouts and cross junctions with the straight road may be the result of other unaccounted causes.

The road defect in the Table 3 shows that loose gravel, dusty roads, slippery, no guard rail and no/insufficient steer lights are the significant factors and has more than 2 times the odds to crash fatality, compared to shoulder high/low characteristic. It is apparent that visibility issues, a lack of lighting, and slippery pavement are the leading causes of severity in motorcycle crashes [22-24]. Loose gravel, dusty roads and slippery pavement would decrease the tire grip hence affecting the vehicle control. Due to their greater vulnerability to such conditions, motorcyclists are particularly at risk of skidding, losing control, and facing subsequent crashes.

As for shoulder type, the paved and unpaved road show to be the significant variable in affecting the HGV-motorcycle crash fatality. The paved road has 30% more odds of fatality to happen in crash compared to unpaved road. Based on the result, paved roads may acquire surface imperfections, potholes, or deteriorated pavement, especially older or in need of maintenance roads, which may impair vehicle stability and control. On the other side, unpaved roads might have a more lenient surface that promotes greater traction and control, lowering the probability of collisions and their severity.

Table 3
Summary of result simple logistic regression analysis

Variable Road Factor	Road Characteristic	Regression coefficient (b)	Crude odds ratio (95% CI)	P value	Odds ratio	Standard Error
Road geometry	Straight	0	1	0.000		
	Bend	0.129	(0.862,1.502)	0.361*	1.138	0.142
	Roundabout	-0.257	(0.540,1.106)	0.159	0.773	0.183
	Cross Junction	-0.692	(0.390,0.642)	0.000	0.501	0.127
	T/Y Junction	0.061	(0.452,2.499)	0.889*	1.063	0.436
Road defect	Shoulders Low/High	0	1	0.427*		
	Manhole Low/High	0.457	(0.130,19.122)	0.720*	1.579	1.273
	Loose Gravel	1.063	(0.682,12.279)	0.149	2.895	0.737
	Dusty Roads	0.862	(0.634,8.854)	0.200	2.368	0.673
	Pothole	0.216	(0.387,3.976)	0.717*	1.241	0.594
	Slippery	0.729	(0.719,5.975)	0.177	2.072	0.540
	Defective Traffic Lights	0.457	0.130,19.122)	0.720*	1.579	1.273
	Narrow Bridge	-0.013	(0.225,4.330)	0.986*	0.987	0.755
	No Guard Rails	0.862	(0.544,10.317)	0.250	2.368	0.751
	No/Insufficient Street Lights	0.901	(1.031,5.874)	0.042	2.461	0.444
	Not relevant	0.272	(0.663,2.598)	0.435*	1.313	0.348
Shoulder type	Paved	0	1	0.000		
	Unpaved	-0.264	(0.647,0.912)	0.003	0.768	0.087
Road condition	Flat	0	1	0.000		
	Slope	0.205	(0.829,1.816)	0.306*	1.227	0.200
Quality of surface	Smooth	0	1	0.162		
	Pothole	0.687	(0.545,7.243)	0.298*	1.988	0.660
	Rutted	0.582	(0.575,5.564)	0.315*	1.789	0.579
	Corrugation	0.536	(0.944,3.096)	0.077	1.709	0.303
Road surface type	Crasher Run	0	1	0.497*		
	Brick	-0.824	(0.162,1.122)	0.105	0.439	0.508
	Bitumen	-0.870	(0.156,1.122)	0.083	0.419	0.503
	Concrete	-0.981	(0.076,1.858)	0.230	0.375	0.816
	Earth	-0.539	(0.110,3.099)	0.527*	0.583	0.852
Road surface condition	Dry	0	1	0.995*		
	Wet	0.048	(0.779,1.414)	0.751*	1.049	0.152
	Oily	0.163	(0.107,12.998)	0.894*	1.177	1.226
	Sandy	0.111	(0.517,2.416)	0.777*	1.118	0.393
	Reconstruction work	0.163	(0.107,12.998)	0.894*	1.177	1.226
Lane marking	Double	0	1	0.000		
	Single	0.413	(1.221,1.870)	0.000	1.511	0.109
	One Way	1.259	(2.311,5.370)	0.000	3.523	0.215
	Divider	0.818	(1.657,3.100)	0.000	2.266	0.160
	U Turn	-0.422	(0.145,2.961)	0.583*	0.656	0.769
	No Marking	-0.015	(0.640,1.518)	0.948*	0.986	0.220
			* p-value>0.25 is not significant			

The results also pointed that flat road condition is the significant affecting factor to the crash fatality. Though slope condition has 22.7% more odds to have crash fatality compared to flat condition, the downward slope and curve were found to contribute to the crash severity flat condition itself is more significant in terms of its contribution to the crash factor [25]. As much as slope is related to a higher probability of crash fatalities based on the data occurrence implied by the odd ratio, flat condition gives the statistically significance impact towards the probability of crash fatality to occur based on the p-value.

Single lane markings, one-way markings, and divider markings, are significant to crash fatalities, with more than 50% odds compared to double lane marking. It emphasizes the importance of lane markings as road characteristics that contribute to crash fatalities, indicating that proper lane marking design and maintenance are crucial for road safety.

5. Conclusions

This study was conducted to evaluate the road characteristic that gives effect to the crash fatality between HGV and motorcycle. Data cleaning and filtration allowed road characteristic factors being segregated from other influencing factors, dedicating to the main focus of the study. Hence, according to the RPM accident reports database, there are more than 60% cases involving fatal between HGV and motorcycle crash. The descriptive analysis summarizes the occurrence of road characteristic being the variable to the crash fatality. While simple logistic regression is performed to determine the significant variables affecting the probability of crash fatality to occur.

Altogether there are eight (8) main variables being the risk factors towards the HGV-crash fatality; road geometry, road defect, shoulder type, road condition, quality of surface, road surface type, road surface condition and lane marking, drawn and classified from the data cleaning and filtration process. Each variable consists of specific related road characteristic affecting the HGV-motorcycle crash fatality. In conclusion, the results imply that all main variables generally have significant probability for HGV-motorcycle crash fatality to occur. However, going into detail, not all of the road characteristics from each main variable are significant to be taken into account. The result also reveals that specific characteristic which is of common interest in connecting to the factor of crash occurrence, for instance bend road, is actually not statistically significant to relate to the riskier condition of HGV-motorcycle crash fatality specifically, but the roundabout and T/Y junction does. Similar condition occurs to sloppy road which is statistically insignificant towards the probability of crash fatality, but the flat road does. This result might provide a new insight to the common perception towards the connection between road characteristic as factors to HGV-motorcycle crash-fatality. Nonetheless, further analysis towards determining the main key factor of road characteristic contributing to higher risk of HGV-motorcycle crash fatality is advisable. Determination of the main affecting road characteristic key factor is important in ensuring significant dedicated mitigation for road safety will be taken care of.

This study is hope to assist academics and industrial key players improving the motorcycle safety not only in Malaysia, but also in other nations facing comparable challenges [26]. HGV-motorcycle safety could be planned better by predicting specific road characteristic key factors affecting the crash fatality. The finding of the study is also expected to assist authorities in implementing targeted interventions and assessing the effectiveness of existing measures and infrastructure.

Based on the findings of this study, several recommendations for future research are made. More comprehensive research on HGV-motorcycle crashes involving other influencing factor is required to reduce the number of fatal and other types of severe incidents. To examine the elements that lead to crash severity, combined study on HGV crashes and other factors, such as human behaviour and

vehicle factors would be beneficial. Researchers and practitioners might work together to develop preventative strategies centred on the best road design for motorcycles and HGVs.

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