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Differences Level of Injury Severity for Male and Female Drivers in Traffic Crashes in Sabah

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ABSTRACT

Road traffic crash has become a big issue around the world because it has recorded a higher number of fatalities each year. Previous research has found many factors influencing injury severity between male and female drivers. However, these factors might be different in complex driving condition like mountainous areas and different vehicle composition. The main objective of this study is to examine the differences between male and female driver's injury severity in a passenger car, four-wheel drive vehicle and van. In order to investigate the effect of topography and vehicle composition, Sabah has been selected as the study area. Separate logistics regression model for injury severity of male and female drivers were examined using traffic crash data from 2008 to 2012. The results showed that the crashes at night times and wet season were more severe than crashes on day time and dry season for male drivers only. Crashes on cross junction were more severe for female drivers. Dangerous turning behaviours that cause the crashes also contributed to the increasing severity level of female drivers. Factors which have the same effect on male and female drivers were collision type, road type, road geometry, driver age, driver errors and type of vehicle. This study gives an insightful understanding about the different factors influencing injury severity level, which involved male and female drivers in crashes in areas that are mountainous and the effect of different vehicle composition on the road.

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1. Introduction

The road safety issue is one of major concern around the globe because have a higher number of fatalities. In 2018, a total of 2.3 million people died worldwide because of traffic crash (World Health Organization [WHO], 2018). Low and middle-income countries are the highest contributors to this statistic. Malaysia as a developing and middle-income country also facing this problem where recorded 24 death per 100,000 population and ranked as second in South East Asia documented higher fatalities in road traffic crash. To counter this problem, more research in road safety are needed to increase our understanding of the crash occurrence and injury severity related to road traffic crashes, especially in Malaysia and particularly in middle-income countries.

There are many studies on road safety has been conducted in Malaysia. Most of them are focus to traffic crash on the federal road in Peninsular Malaysia (Mohamad et al., 2019; Hosseinpour et al., 2016; Khaidir et al., 2016). Sabah is one of the states located in Borneo attached with Sarawak, Brunei and Kalimantan, Indonesia. This state is different from the other states in Malaysia because more than 60% of the topography is mountainous areas (Rusli et al., 2015, 2018). In addition, the composition of traffic is unique compared to Peninsular. Passenger car is a dominant type of vehicle registered in both Sabah and Peninsular over the years. However, heavy vehicle and motorcycle are the second type of vehicle registered in Sabah and Peninsular, respectively. These differences might create a different driving style and influenced the crash occurrence and injury severity in the road traffic crash. Figure 1 shows the trend of traffic crashes involved male and female drivers in Sabah from 2008 to 2012.

The previous study found the differences in crash occurrence and injury severity involved male and female drivers. Compared to female, male is more aggressive (Lajunen & Parker, 2001), risk-taking (Grabowski & Morrisey, 2001), attention-seeking (Clarke et al., 2005), higher degree of acceptable in driving (Evans, 2001; Deery, 1999), speeding (Krahé & Fenske, 2002) and more confidence to drive under worse scenario such as driving in difficult weather and late-night (Parker et al., 1995). However, the male also found more exposure and experience in driving than female (Harré et al., 1996). Besides that, female drivers are more cautious and safe drivers (Yagil, 1998; Li et al., 1998).

In term of injury severity, there are few differences factors found influencing injury severity of male and female drivers (Islam & Mannering, 2006; Qu et al., 2015; Jones, 2017; Yazdani et al., 2019). Abdel-Aty & Abdelwahab (2004) found that female drivers tend to suffer more severe than male drivers for traffic crashes in the Central Florida area. Evans (2001) compared severity of female and male drivers on crashes involved passenger car, light truck and motorcycle in the US. He found that the probability of fatality among female drivers was higher compared to male drivers for these types of vehicle. Female drivers on the impact of crashes have a higher fatality risk than male drivers (Evans & Gerrish, 2001). Parenteau et al. (2013) analyzed the impact of the frontal crashes towards male and female occupants

and found the relative injury of the female is higher than male for crashes during speed more than 65km/h. In addition, the risk of serious injury in all body is higher for female compared to male except for the head and abdomen. Lardelli-Claret et al. (2009) researched passenger on the front seat aged more than 17 years involved in traffic crashes in Spain. They have identified that the risk of death associated with the severity of the crash was slightly higher in men. Agbelie (2016) examined the injury severity of 1,503 two-passenger vehicle crash along 150 highway segments in Washington state. They found on average, the largest differences between male and female for five parameters including the average annual daily combination of truck volume, presence of vertical curve, number of lanes, the presence of left-hand shoulder and speed limit were less than 89km/h. In other studies, Wu et al. (2016) found female drivers more likely to be injured severely in single-vehicle crashes on rural and urban roadways in New Mexico. A study along mountainous roads in Sabah also identified that female driver were less likely to involve in injury-producing crashes compared to males (Rusli et al., 2018). Due to the high number of road crashes, many countries and cities have initiated many transportation safety countermeasures including the use of urban and intercity railway transportation as means to reduce road crashes (Masirin et al., 2017).

The objective of this paper is to examine the differences between male and female driver's injury severity in a passenger car, four-wheel drive vehicle and van. In achieving the objective, two different models represent male and female are estimated and compared with each other.

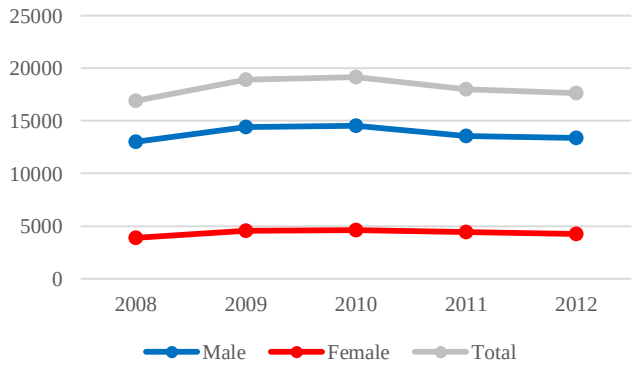

Figure 1: Number of drivers involved in crash by gender (MIROS, 2012).

2. Method

2.1. Data Description

Five-year traffic crash data (2008-2012) were obtained from the Malaysian Institute of Road Safety Research – Road Accident Analysis and Database System (M-ROADS). Should be noted that the main source of this data is from Malaysian Royal Police. Road users who involved in road traffic crash are needed to make a police report for insurance claim purpose. In the POL27 form, 63 pieces of information need to report by a police officer in every road traffic crash. To make a study is more comparable between male and female drivers, only three types of vehicles have been selected in this study, passenger car, four-wheel drive and van. After the data cleaning process, there were respectively 68,932, and 21,754 crashes involved male and female drivers in Sabah during that period.

Driver injury severity in Malaysia was classified into four categories; fatal, serious injury, slight injury and property damage only (PDO). Due to small observations on fatal, serious and slight injury compared to PDO, only two severity level were considered in this study; severe (fatal, serious and slight injury) and non-severe (PDO). Driver severe injuries for male represent 5% of total crashes, and 95% represents non-severe injuries. For female drivers, 3% of them were severe and 97% were non-severe.

2.2. Methodology

The logistic regression analysis has been used in many road safety studies to identify significant risk factors influencing crash occurrence and injury severity. As mentioned before, due to large differences between four categories of injury severity, the response variable was classified into two categories; severe and non-severe. Therefore, binary logistic regression was used to examine the relationship between explanatory variables with the response variable. This type of regression has been used by researcher in road safety to identify factors influencing crash occurrence (Harb et al., 2008; Jiang et al., 2016; Mohamed et al., 2017) and injury severity (Dissanayake & Lu, 2002; Yuan et al., 2017; Kelarestaghi et al., 2017). The logit was the natural logarithm of the odds that the response variable Y was severe (Y=1) versus non-severe (Y=0) as shown by Eq.1:

$$Logit(P) = ln\left(\frac{P}{1-P}\right) = \beta_0 + \beta_1 x_1 + \cdots + \beta_i x_i \quad (1)$$

where P is the probability of driver injury severity involved in crashes, $x_i$is the independent variable and $\beta_i$is the model coefficient directly determining the odds ratio.

3. Results

Table 1 and Table 3 show the number of observations and percentage distribution across injury severity for male and female drivers, respectively. There are eleven explanatory factors were available from M-ROADS for further analysis which include time of day, day of the week, a season of the year, school seasons, collision type, crash type, road type, road geometry, driver age, driver errors and vehicle type.

Table 1: Summary statistics of explanatory variables for male drivers.

Variables	Categories	Injury Severity (%)		
		Severe	Non-severe	Total
Time of day	Day time	2089(58.6)	42864(65.6)	44953(65.2)
	Night time	1474(41.4)	22505(34.4)	23979(34.8)
Day of week	Weekdays	2489(69.9)	45764(70.0)	48253(70.0)
	Weekend	1074(30.1)	19605(30.0)	20679(30.0)
Season of year	Dry season	2628(73.8)	49112(75.1)	51740(75.1)
	Wet season	935(26.2)	16257(24.9)	17192(24.9)
School seasons	School days	2802(78.6)	51543(78.8)	54345(78.8)
	School holidays	761(21.4)	13826(21.2)	14587(21.2)
Collision type	Rear-end	377(10.6)	26494(40.5)	26871(39.0)
	Angle and right-angle side	1054(29.6)	16298(24.9)	17352(25.2)
	Out-of-control	418(11.7)	11283(17.3)	11701(17.0)
	Other	1714(48.1)	11294(17.3)	13008(18.9)
Crash type	Multi-vehicle	2121(59.5)	47187(72.2)	49308(71.5)
	Single-vehicle	1442(40.5)	18182(27.8)	19624(28.5)
Road type	State road	1560(43.8)	30786(47.1)	32346(46.9)
	Federal road	1710(48.0)	27516(42.1)	29226(42.4)
	Municipal road	138(3.9)	4631(7.1)	4769(6.9)
	Other	155(4.4)	2436(3.7)	2591(3.8)
Road geometry	Straight	2165(60.8)	37936(58.0)	40101(58.2)
	Bend	660(18.5)	9043(13.8)	9703(14.1)
	Roundabout	61(1.7)	3828(5.9)	3889(5.6)
	Cross junction	62(1.7)	1258(1.9)	1320(1.9)
	T/Y junction	381(10.7)	6935(10.6)	7316(10.6)
	Other	234(6.6)	6369(9.7)	6603(9.6)

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Table 2 – *Continued from previous page.*

Variables	Categories	Injury Severity (%)		
		Severe	Non-severe	Total
Driver age	<25	617(17.3)	8755(13.4)	9372(13.6)
	25-44	1918(53.8)	36841(56.4)	38759(56.2)
	45-64	937(26.3)	18045(27.6)	18982(27.5)
	>64	91(2.6)	1728(2.6)	1819(2.6)
Driver errors	Not at fault	2185(61.3)	30454(46.6)	32639(47.3)
	Speeding	412(11.6)	11770(18.0)	12182(17.7)
	Driving too close	62(1.7)	10998(16.8)	11060(16.0)
	Other offences	362(10.2)	5280(8.1)	5642(8.2)
	Dangerous turning	259(7.3)	3533(5.4)	3792(5.5)
	Dangerous overtaking	106(3.0)	1701(2.6)	1807(2.6)
	Careless driving	113(3.2)	1250(1.9)	1363(2.0)
	Traffic light violation	64(1.8)	383(0.6)	447(0.6)
Vehicle type	Passenger car	2154(60.5)	42045(64.3)	44199(64.1)
	Four-wheel drive	1069(30.0)	19170(29.3)	20239(29.4)
	Van	340(9.5)	4154(6.4)	4494(6.5)

Referring to Table 1 and 2, crash on day time was dominant for both male and female drivers, with 58.6% of male and 67.6% of female drivers were severe. Compared to the weekend, severe crash during weekdays was higher for male and female drivers. Percentage of the severe crash was higher on the dry season than a wet season for male dan female drivers. About 78.6% of severe crashes occur on school holidays for male and 80.8% for female drivers.

Out of 13 types of collision, only three were available for modelling due to a smaller number of observations; rear-end, angle and right-angle side and 'out-of-control'. Other types of collision were grouped into others. Angle and right-angle side collisions recorded a higher number of severe crashes than another group, with 29.6% for male drivers and 30.8% for female drivers. There are 59.5% of severe crashes involved more than one vehicle for male drivers and 54.6% for female drivers.

Federal and state road respectively represents a higher percentage of severe crashes for male drivers (48.0%) and female drivers (49.0%). In terms of road geometry, the straight road was recorded a higher percentage of severe crashes compare to bend, roundabout, cross junction, T/Y junction and other types of road geometries for both male and female drivers.

Drivers aged 25–44 years were dominant involved severe crashes followed by age group 45–64 years for both male and female drivers. Male and female drivers not-at-fault were the higher group involved in severe crashes. In terms of behaviours, male drove more than speed limit found to have a higher percentage to be severe (11.6%) while a higher percentage of severity among female drivers involved with dangerous turning (11.5%). Results also indicated that 77.8% of female drove passenger car was severe when involved in crashes while only 60.5% of male drivers. However, female drivers found have less percentage to be severe in crash involved four-wheel drive and van.

Table 3: Summary statistics of explanatory variables for female drivers.

Variables	Categories	Injury Severity (%)		
		Severe	Non-severe	Total
Time of day	Day time	478(67.6)	15284(72.6)	15762(72.5)
	Night time	229(32.4)	5754(27.4)	5983(27.5)
Day of week	Weekdays	498(70.4)	14771(70.2)	15269(70.2)
	Weekend	209(29.6)	6267(29.8)	6476(29.8)
Season of year	Dry season	519(73.4)	15614(74.2)	16133(74.2)
	Wet season	188(26.6)	5424(25.8)	5612(25.8)

Continued on next column.

Table 3 – *Continued from previous column.*

Variables	Categories	Injury Severity (%)		
		Severe	Non-severe	Total
School seasons	School days	571(80.8)	17134(81.4)	17705(81.4)
	School holidays	136(19.2)	3904(18.6)	4040(18.6)
Collision type	Rear-end	71(10.0)	8896(42.3)	8967(41.2)
	Angle and right-angle side	218(30.8)	5931(28.2)	6149(28.3)
	Out-of-control	81(11.5)	2537(12.1)	2618(12.0)
	Other	337(47.7)	3674(17.5)	4011(18.4)
Crash type	Multi-vehicle	386(54.6)	16078(76.4)	16464(75.7)
	Single-vehicle	321(45.4)	4960(23.6)	5281(24.3)
Road type	State road	349(49.4)	11349(53.9)	11698(53.8)
	Federal road	295(41.7)	7241(34.4)	7536(34.7)
	Municipal road	47(6.6)	1749(8.3)	1796(8.3)
	Other	16(2.3)	699(3.3)	715(3.3)
Road geometry	Straight	424(60.0)	11814(56.2)	12238(56.3)
	Bend	86(12.2)	1908(9.1)	1994(9.2)
	Roundabout	22(3.1)	1714(8.1)	1736(8.0)
	Cross junction	12(1.7)	394(1.9)	406(1.9)
	T/Y junction	100(14.1)	2749(13.1)	2849(13.1)
	Other	63(8.9)	2459(11.7)	2522(11.6)
Driver age	<25	129(18.2)	2585(12.3)	2714(12.5)
	25-44	434(61.4)	13539(64.4)	13973(64.3)
	45-64	137(19.4)	4656(22.1)	4793(22.0)
	>64	7(1.0)	258(1.2)	265(1.2)
Driver errors	Not at fault	433(61.2)	10932(52.0)	11365(52.3)
	Speeding	56(7.9)	2656(12.6)	2712(12.5)
	Driving too close	8(1.1)	3047(14.5)	3055(14.0)
	Other offences	72(10.2)	1835(8.7)	1907(8.8)
	Dangerous turning	81(11.5)	1554(7.4)	1635(7.5)
	Dangerous overtaking	17(2.4)	473(2.2)	490(2.3)
	Careless driving	22(3.1)	409(1.9)	431(2.0)
	Traffic light violation	18(2.5)	132(0.6)	150(0.7)
Vehicle type	Passenger car	550(77.8)	17390(82.7)	17940(82.5)
	Four-wheel drive	116(16.4)	2938(14.0)	3054(14.0)
	Van	41(5.8)	710(3.4)	751(3.5)

Table 4 presents the estimation results of the logistics regression for male driver injury. From eleven variables included in the model, only nine of them were found statistically significant influencing crash severity of male drivers. Nighttime crashes had higher odds of being severe than day time crashes *(OR=1.179, 95% CI:1.096-1.269)*. Crashes during wet season were 1.1 times *(OR=1.084, 95% CI:1.000-1.175)* more likely to severe than crashes during the dry season. Compared to multi-vehicle crashes, the odds of severe single-vehicle crashes were about 87% *(OR=1.867, 95% CI:1.699-2.051)* higher than non-severe crashes.

Compared to rear-end crashes, the odds of angle and right-angle side, 'out-of-control' and other crashes were significantly severe, with the corresponding odds respectively about 4.5 times *(OR=4.453, 95% CI: 3.891-5.096)*, 2.5 times *(OR=2.421, 95% CI: 2.021-2.899)* and 8.9 times *(OR=8.878, 95% CI: 7.779-10.132)* higher.

The odds of severe crashes on the federal road were about 1.3 times *(OR=1.299, 95% CI: 1.206-1.399)* higher than on state road. In contrast, the municipal road had lower odds recorded severe crash *(OR=0.454, 95% CI: 0.379-0.545)*. In term of road geometry, injury severities were not significantly different across the bend and straight road segments. However, straight road segment had a higher odds of severe crash than roundabout *(OR=0.244, 95% CI: 0.188-0.317)*, cross junction *(OR=0.627, 95% CI: 0.479-0.820)*, T/Y junction

(OR=0.625, 95% CI: 0.549-0.712) and other types road geometries *(OR=0.370, 95% CI: 0.321-0.427).*

Male drivers less than 25 years had higher odds of being involved in a severe crash than male drivers aged 25-44 years. Other age groups were not significantly different in injury severity compared to 25-44 years driver. The odds of severe crashes were lower involving speeding *(OR=0.242, 95% CI: 0.212-0.275)*, 'driving too close' *(OR=0.230, 95% CI: 0.175-0.301)*, 'dangerous overtaking' *(OR=0.607, 95% CI: 0.494-0.747)*, careless driving *(OR=0.622, 95% CI: 0.505-0.766)* and other offences *(OR=0.570, 95% CI: 0.505-0.645)* than not-at-fault. In contrast, the odds of traffic light violation were about 2.2 times *(OR=2.208, 95% CI: 1.664-2.929)* higher.

Compared to passenger car, the odds of severe crashes involved four-wheel drive and van were about 1.2 times *(OR=1.157, 95% CI: 1.069-1.253)* and 1.5 times (*OR=1.546, 95% CI: 1.364-1.752)* higher, respectively.

Table 4: Binary logistics model for male driver injury.

Variable	Reference Category	Odds Ratio (OR)	Confidence Interval (95%)	*p*-value
Time of day				
Night time	Day time	1.179	1.096-1.269	0.000***
Season of year				
Wet season	Dry season	1.084	1.000-1.175	0.050*
Crash type				
Single-vehicle	Multi-vehicle	1.867	1.699-2.051	0.000***
Collision type				
Angle and right-angle side	Rear-end	4.453	3.891-5.096	0.000***
Out-of-control		2.421	2.021-2.899	0.000***
Other		8.878	7.779-10.132	0.000***
Road type				
Federal road	State road	1.299	1.206-1.399	0.000***
Municipal road		0.454	0.379-0.545	0.000***
Other		0.854	0.716-1.019	0.080
Road geometry				
Bend	Straight	1.028	0.932-1.134	0.579
Roundabout		0.244	0.188-0.317	0.000***
Cross junction		0.627	0.479-0.820	0.001**
T/Y junction		0.625	0.549-0.712	0.000***
Other		0.370	0.321-0.427	0.000***
Driver age				
<25	25-44	1.489	1.349-1.643	0.000***
45-64		0.970	0.892-1.055	0.480
>64		0.992	0.793-1.241	0.944
Driver errors				
Speeding	Not at fault	0.242	0.212-0.275	0.000***
Driving too close		0.230	0.175-0.301	0.000***
Other offences		0.571	0.505-0.645	0.000***
Dangerous turning		1.055	0.907-1.228	0.489
Dangerous overtaking		0.607	0.494-0.747	0.000***
Careless driving		0.622	0.505-0.766	0.000***
Traffic light violation		2.208	1.664-2.929	0.000***
Vehicle type				
Four-wheel drive	Passenger car	1.157	1.069-1.253	0.000***
Van		1.546	1.364-1.752	0.000***

*significant at 0.05 level
**significant at 0.01 level
***significant at 0.001 level

The binary logistic model identified seven variables influencing injury severity of female drivers including crash type, collision type, road geometry, driver age, driver errors and vehicle type. The estimate of the odds ratio for each of them for severe crashes involved female drivers, and its 95% confidence interval (CI) were reported in Table 5.

Table 5: Binary logistics model for female driver injury.

Variable	Reference Category	Odds Ratio (OR)	Confidence Interval (95%)	*p*-value
Crash type				
Single-vehicle	Multi-vehicle	3.035	2.479-3.717	0.000***
Collision type				
Angle and right-angle side	Rear-end	4.373	3.225-5.931	0.000***
Out-of-control		3.490	2.327-5.235	0.000***
Other		9.055	6.746-12.153	0.000***
Road type				
Federal road	State road	1.397	1.182-1.650	0.000***
Municipal road		0.635	0.461-0.874	0.005**
Other		0.491	0.293-0.823	0.007**
Road geometry				
Bend	Straight	1.004	0.778-1.296	0.974
Roundabout		0.319	0.204-0.498	0.000***
Cross junction		0.624	0.340-1.144	0.127
T/Y junction		0.665	0.508-0.869	0.003**
Other		0.394	0.297-0.522	0.000***
Driver age				
<25	25-44	1.769	1.432-2.185	0.000***
45-64		0.895	0.731-1.095	0.282
>64		0.792	0.365-1.715	0.554
Driver errors				
Speeding	Not at fault	0.153	0.110-0.214	0.000***
Driving too close		0.175	0.084-0.365	0.000***
Other offences		0.488	0.372-0.640	0.000***
Dangerous turning		1.373	1.029-1.833	0.031*
Dangerous overtaking		0.615	0.369-1.024	0.061
Careless driving		0.423	0.267-0.672	0.000***
Traffic light violation		3.466	2.017-5.956	0.000***
Vehicle type				
Four-wheel drive	Passenger car	1.302	1.051-1.612	0.000***
Van		1.935	1.371-2.731	0.000***

*significant at 0.05 level
**significant at 0.01 level
***significant at 0.001 level

The odds of severe single-vehicle crashes were 3.0 times *(OR=3.035, 95% CI: 2.479-3.717)* higher than multi-vehicle crashes. In terms of collision type, the odds of severe crashes for angle and right-angle side, out-of-control and other types of collisions respectively about 4.4 times *(OR=4.373, 95% CI: 3.225-5.931)*, 3.5 times *(OR=3.490, 95% CI: 2.327-5.235)* and 9.1 times *(OR=9.055, 95% CI: 6.746-12.153)* higher than rear-end collision.

Compared to the state road, the odds of severe crashes on the federal road were about 40% (OR=1.397, 95% CI: 1.182-1.650) higher than non-severe crashes. However, the odds of severe crashes on municipal *(OR=0.635, 95% CI: 0.461-0.874)* and other types of roads *(OR=0.491, 95% CI: 0.293-0.823)* were lower than state road, respectively. Driver injury severity was not statistically significantly different for crashes along the horizontal curve and cross junction with

a straight road segment. Non-severe crashes on roundabout, T/Y junction and other types of road geometries were about 3.1 times *(OR=0.319, 95% CI: 0.204-0.498)*, 1.5 times *(OR=0.665, 95% CI: 0.508-0.869)* and 2.5 times *(OR=0.394, 95% CI:0.297-0.522)* higher than straight road segment.

Female drivers aged less than 25 years had higher odds being involved in severe crashes *(OR=1.769, 95% CI: 1.432-2.185)* than 25-44 years drivers. The odds of severe crashes for speeding *(OR=0.153, 95% CI: 0.110-0.214)*, driving too close *(OR=0.175, 95% CI: 0.084-0.365)*, dangerous overtaking *(OR=0.615, 95% CI: 0.369-1.024)*, careless driving *(OR=0.423, 95% CI: 0.267-0.672)* and other offences *(OR=0.488, 95% CI: 0.372-0.640*) were lower than not-at-fault. Crashes related to other risky driving behaviours like 'dangerous overtaking' and traffic light violation were more likely to severe compared to not-at-fault, with the corresponding odds respectively 1.4 times (OR=1.373, 95% CI: 1.029-1.833) and 3.5 times (OR=3.466, 95% CI: 2.017-5.959) higher.

In term of vehicle type, the four-wheel drive and van had a higher odd of being involved in severe crashes than a passenger car, with corresponding odds respectively 30% *(OR=1.302, 95% CI: 1.051-1.612)* and 94% *(OR=1.935, 95% CI: 1.371-2.731)*.

4. Discussion

Out of eleven explanatory factors selected for the forward selection logistic regression, nine explanatory factors were found statistically significant with 95% confidence interval for injury severity involved male drivers and seven factors found influencing injury severity of female drivers. The nine significant factors in male driver model were a time of day, a season of the year, crash type, collision type, road type, road geometry, driver age, driver errors and vehicle type. The same factors also found to be statistically significant for female driver model except for the time of day and season of the year.

4.1. Environmental Factors

The results showed that the probability of severe crashes involved male drivers was higher during night time compared to day time. However, injury severity level for female drivers was not statistically significantly different between night and day crashes. Alvaro et al. (2018) tested twenty-four participants in a driving simulator to improving decision making in young drivers. They found that male less likely to stop driving due to sleepiness during the time. The same observation also found for a season of the year. Crash during wet season found to be severe compare to crash during the dry season for male drivers. Wet pavement will reduce the skid resistance of vehicle tires and increase the probability of severe when crash occur. Wu et al. (2016) also reported that driving in rainy condition increase the probability of involvement in severe crashes in rural areas. However, Chen et al. (2016) identified that drivers tend to be more cautious on wet pavement conditions and drive at relatively low speed. Li et al., (2019) found wet and male drivers among the factors decreasing the probability of incapacitating injuries and fatalities for drivers. These factors found not statistically significant in the female driver model.

4.2. Crash Characteristics

The influence of crash type on driver injury severity was significant for both male and female driver models. A single-vehicle crash could be more severe for male and female drivers compared to a multi-vehicle crash, with corresponding odds were 1.9 times and 3.0 times higher, respectively. Other research also found that single-vehicle crashes have a higher fatality rate compared to multi-vehicle crashes (Zhou & Chin, 2019; Wu et al., 2016).

Compared to rear-end collision, angle and right-angle side, out-of-control and other types of collisions had higher odds of a fatal outcome. The same finding also found in female driver model. This finding shows that collision between the vehicle in the same direction is less severe compared to other direction. Hosseinpour et al. (2014) found the percentage of fatalities in rear-end collision was lower compared to head-on, angular and out-of-control. The most severe crashes happen when two vehicles involved in head-on. Cumulative speed of two vehicles in opposite directions is higher and increase the probability of severity level when the head-on crash happens. In addition, reaction time for the driver to avoid a collision from the oncoming vehicle also not enough. However, the observation for a head-on collision in this study was small and grouped with other types of collisions.

4.3. Road Characteristics

Road type was found to affect the severity of the drivers significantly. Compared to the state road, crash occurring on the federal road had higher odds of a severe outcome for both male and female drivers. Nevertheless, crashes on municipal roads were lower odds involved both types of drivers. The odds of severe crashes on other types of roads higher for female drivers and not statistically different for male drivers compared to the state road. One should be noted that the management of these roads is from different authorities. For example, the Malaysian Public Works Department under the Ministry of Works Malaysia has a responsibility to manage and maintain all the federal roads in Malaysia except for Sabah and Sarawak. State roads were under the supervision of the State Public Works Department while municipal roads under local authorities. Different sources of budget and local act might influence different strategies taken in reducing the crash occurrence and injury severity from traffic crashes. However, comparing crash risk on these roads could be a worthwhile future research topic.

A crash occurring on straight roads were more severe than on roundabout, T/Y junction and other types of road geometries for both types of drivers, except the crash on the cross junction that were only significant in female drivers' model. There was no significant difference in severity level for crashes occurring along the straight segment compared to the bend segment for both male and female drivers. This finding is in line with previous research in Malaysia (Darma et al., 2017), where it was found that straight road segments recorded the highest number of traffic deaths compared to other types of geometries. They explain that the length of the straight road in Malaysia is significantly higher and increase the probability of a crash. Different from study by Darma et al. (2017) where analyzed crashes involved with all type of vehicles, the recent study focus to passenger car, four-wheel drive and van only. In the other hand, Lee & Li (2014) found that drivers are more likely to severe on crashes along curve section compared to the straight section due to out-of-control and hitting roadside objects.

4.4. Driver Characteristics

For both male and female models, driver aged less than 25 years were more severe in the crashes than 25-44 years. Kockelman & Kweon (2002) found that young drivers are driving much recklessly compared to middle-age drivers and leading to more severe in single-vehicle crashes. Other groups of age were not significantly different in driver injury severity compared to the reference category.

Traffic light violation was significant behaviour that increases the probability of severe among male and female drivers in traffic crashes. Red-light running is the main issue for drivers when approaching a traffic light. To counter this problem, road authorities have installed a red light camera on the selected signalized intersection to record vehicles whose drivers run red lights. This enforcement type has been identified, reduced the number of crashes at an intersection in Malaysia (Jamil et al., 2014; Kabit et al., 2016). Dangerous turning was found significant in female drivers' model only. Female drivers need more times to decide while driving compared to male drivers. This situation created last minutes decision and finished with dangerous turning. In addition, differences in driving behaviour may

arise from different driving conditions between male and female from size, weight and position.

4.5. Vehicle Characteristics

The results show that the type of vehicle influencing the severity level of the drivers. The odds of four-wheel drive and van respectively were 1.2 and 1.5 times higher compared to passenger car for male drivers and 1.3 and 1.9 times higher for female drivers. Compared between male and female, female drivers are more severe when involved with four-wheel drive and van crashes. Obeng (2011) found safety features of vehicle react differently on injury severity risky of male and female drivers. Differences in physiological (size and weight) might affect a difference in interaction with vehicle safety for male and female drivers. Bener et al. (2008) found that female drivers drove SUV in Qatar commit more errors than male drivers.

5. Conclusion and Recommendations

This study applied binary logistics model to examine the differences between male and female driver's injury severity in a passenger car, four-wheel drive vehicle and van. Results of estimation show that both models are different regarding to the level of significance and odd ratio. Out of eleven explanatory variables included in the model, nine of them were statistically significant influencing severity of male drivers where only seven factors are influencing the severity of female drivers.

The estimation model reveals that crash on night time and wet season was severe than day time and dry season. However, these factors not statistically significant in the female driver model. The magnitude of the odds ratio for single-vehicle crashes compared to multi-vehicle crashes involved female drivers was higher than male drivers.

Angle and right-angle side, 'out-of-control' and other collisions type were more severe than rear-end collision. The odds of these factors almost same between male and female drivers. Crashes on the federal road were severe than crashes on the state road for both male and female models. In contrast, crash occurring on municipal roads were less severe. Crash on other types of roads also was severe than on the state road, however this only significant on female drivers only.

Crash on straight road segment had a higher probability of severe than on roundabout, cross junction, T/Y junction and other types of road geometries. However, the cross junction was statistically significant for female drivers only.

Young drivers (<25 years) more probability to severe than older people in a crash for both types of drivers. Traffic light violation was the only risky behaviour that influencing the severity of male and female drivers. In addition, dangerous turning also found influencing the severity of female drivers. Finally, in terms of vehicle type, driver of four-wheel drive and van were severe compared to the driver of a passenger car for both male and female drivers. The magnitude of odds ratio for four-wheel drive and van higher in female driver model than male driver model. Identification of risk factors on male and female drivers provides useful information to road authorities in designing countermeasure or road safety program to road users.

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