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Causation of Road Traffic Crash Severity on Malaysian Expressways

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ABSTRACT

The economic growth of a country is dependent on its transportation facilities. However, over the past few years, issues related to the safety of roads users have gained more attention. According to the World Health Organization (WHO), in most countries, road traffic crashes cost up to 3% of the gross domestic product and are the leading cause of death among those aged 15 to 29 years old. Hence, to prevent further loss due to road traffic crashes, more emphasis should be placed on reducing the occurrence of road crashes by understanding the causative factors of road traffic crashes and take remedial measures. In this study, crash reports obtained from the Malaysia Highway Authority (MHA) were utilized to identify the causation factors of crash severity in road traffic crashes on Malaysian intra-urban expressways. Data was coded based on the critical events, critical reasons and associated factors of each crash. A relative risk analysis was conducted to evaluate the effect of each factor on the road traffic crash outcome. Findings from this study indicated that only the critical events of a crash are associated with certain crash outcomes while critical reasons and associated factors are not.

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1. Introduction

Each year, more than 1.35 million lives are scarified due to road traffic crashes, making it the 8th leading cause of death globally (WHO, 2018). Statistics have shown that children aged 5–14 and young adults aged 15–29 years old are mostly being killed due to road traffic crashes. The number of deaths recorded due to road traffic crashes can be alarming, as 92% of the total road traffic deaths recorded worldwide occur in low-middle income countries. In 2016, it was estimated that more than 113,000 people died due to road traffic crashes in ASEAN countries.

Studies have shown that road traffic crashes are complex events and usually involve two or more vehicles in an event. Elements influencing the occurrence of a crash may take place hours, days, or months before the crash (Starnes, 2006). They include driver training and experience, highway condition and traffic signaling, vehicle design and manufacture, and weather conditions (DOT, 2006). Crash reconstruction experts rarely conclude that crashes are the result of a single factor. Fatigue, speeding and driving under influence are major factors in motor vehicle crashes overall (DOT, 2006; Armstrong et al., 2008). Although their presence does not always result in a crash, these three factors, as well as other drivers, road and environmental, as well as vehicle factors, can increase the risk that a crash will occur.

Extensive literature can be found on risk factors influencing road traffic crashes and how they affect the outcome severity of the road traffic crashes. A study conducted by Al-Ghamdi (2002) found that crash location and cause of crash have a significant effect on the severity of a crash. Findings from Delen et al. (2006), revealed that the demographic or behavioural characteristics of the person, technical characteristics of the vehicle itself as well as environmental factors and roadway condition at the time of occurrence are some of the factors that affect the risk of higher crash severity in an event of a road crash. Results from a study conducted by Chang and Wen (2006) indicated that vehicle type is the most important variable associated with crash severity. According to Christoforou et al. (2010), increased traffic volume has a consistently positive effect on the severity, while speed has a differential effect on severity depending on flow conditions.

It should be noted that previous studies were mostly carried out in developed countries such as North America, Canada and Europe. Findings from these studies have provided some insight on the cause and severity outcome of road traffic crashes, however, their findings may not be applicable to Malaysia due to the difference in the conditions and problems faced. Moreover, differences in the road and driving conditions, as well as traffic and regulatory characteristics may also result in different outcomes and do not explain the issues encountered locally, leaving some questions unanswered. Therefore, it is necessary to examine the environmental aspects as well as involved vehicles, drivers and roadway characteristics to identify the factors and their interactions that may contribute to an increase or decrease in the severity of road traffic crashes in Malaysia. This would be needed for implementing beneficial road safety measures.

2. Method

The study is divided into three main phases; 1) coding of road crash report, 2) site verification and 3) relative risk analysis and multiple regression (as shown in Figure 1). Crash reports for intra-urban expressways within Malaysia from 2013 to 2015 obtained from the Malaysia Highway Authority (MHA) were fully utilized within

this study. In total, 24,781 crash cases were coded according to DOT 2006 and the critical event, critical reason and associated factor for each crash report were identified prior to analysis. This set of data was chosen as it contains a detailed crash description and the chain events leading to a crash.

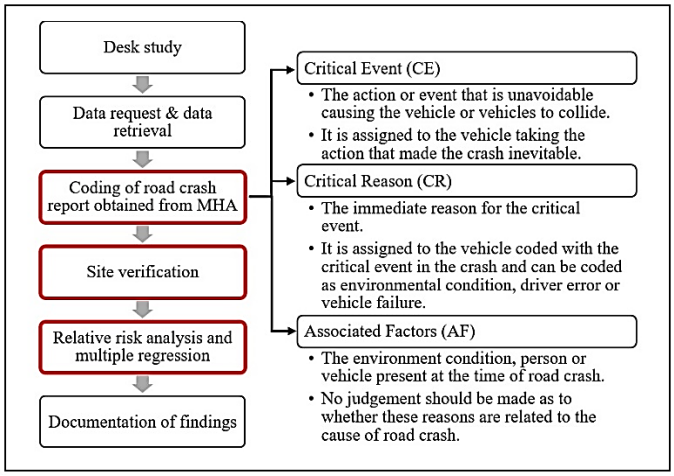

Figure 1: Research flowchart.

3. Results

3.1. General Findings

The number of crash cases and victims recorded by the type of expressway is as shown in Table 1. In total, 24,781 crash cases and 37,027 crash victims were observed on open and closed tolling system between the year 2013 and 2015. Out of this total, 33.3% of crash cases occurred on expressways with open tolling system and 66.7% on expressways with closed tolling system. The trend in the percentage of crash victims recorded is similar to the percentage of crash cases for each type of expressway.

Table 1: Number of crash cases and crash victims by type of expressway.

Type of expressway	Crash case		Crash victim	
Open tolling system	8,251	33.3%	12,220	33.0%
Closed tolling system	16,530	66.7%	24,807	67.0%
Grand total	24,781		37,027	

Based on the data obtained from MHA, crash cases were then analyses by the type of severity for each type of expressway, as shown in Table 2. With more than 61%, the damaged only category recorded the highest percentage of severity, whereas fatal had the lowest percentage among all severity type (less than 3%). This pattern was observed for both types of expressways, open and closed tolling system.

Table 2: Number of crash cases by type of expressway and severity.

Type of expressway	Fatal	Severe	Slight	Damage only	Total
Open tolling system	218 (2.6%)	1,492 (18.1%)	1,463 (17.7%)	5,078 (61.5%)	8,251
Closed tolling system	487 (2.9%)	2,289 (13.8%)	2,479 (15.0%)	11,275 (68.2%)	16,530
Grand total	705	3,781	3,942	16,353	24,781

Based on figures shown in Table 2, a total of 66.7% (16,530) of crashes recorded occur on closed tolling system expressway. This finding is expected as expressways with open tolling systems are usually designed with more access points as compared to those with closed tolling systems. The density of access points will tend to affect the design speed and traffic volume of the expressway. Thus, encouraging short trips and diversion of traffic from the expressway. However, as the exposure data were not analysed in this study, no further conclusion can be made on this finding.

3.2. Critical Event and Severity

The action or event that causes a vehicle or vehicles on a course, making the collision unavoidable is identified as the critical event of a crash. It is assigned to the vehicle making the action that caused the crash inevitable. Based on the analysis conducted and as shown in Table 3, it was found that approximately 63% of the total crash cases recorded throughout the observation period were due to lost control of vehicle, making it the most common type of critical event in occurrence of a crash. This is then followed by rear-end collision between vehicles with 19%.

Table 3: Critical event by severity.

Critical event	Fatal	Severe	Slight	Damage only	Total
Head on collision	14 (15.7%)	30 (33.7%)	20 (22.5%)	25 (28.1%)	89
Hit object on road – Animal/ carcass	4 (0.8%)	29 (5.7%)	58 (11.5%)	414 (82.0%)	505
Hit object on road – Debris	7 (0.4%)	93 (5.2%)	121 (6.8%)	1,571 (87.7%)	1,792
Hit object on road – Infrastructure	2 (0.6%)	9 (2.7%)	19 (5.7%)	303 (91.0%)	333
Hit object on road – Static vehicle	4 (9.8%)	15 (36.6%)	13 (31.7%)	9 (22.0%)	41
Hit object on road – Temporary infra	- (0.0%)	1 (5.3%)	2 (10.5%)	16 (84.2%)	19
Hit pavement defect – Pot hole	- (0.0%)	1 (14.3%)	2 (28.6%)	4 (57.1%)	7
Hit pedestrian/crash victim on road	24 (34.3%)	34 (48.6%)	10 (14.3%)	2 (2.9%)	70
Lost control of vehicle	420 (2.7%)	2,288 (14.6%)	2,645 (16.9%)	10,343 (65.9%)	15,696
Rear-end collision between vehicles	177 (3.7%)	885 (18.3%)	703 (14.6%)	3,066 (63.5%)	4,831
Evasive manoeuvre	1 (2.6%)	7 (18.4%)	8 (21.1%)	22 (57.9%)	38
Side collision between vehicles	12 (3.6%)	78 (23.6%)	77 (23.3%)	164 (49.5%)	331
Side swipe between vehicles	38 (3.9%)	298 (30.3%)	255 (25.9%)	394 (40.0%)	985
Squeezed by vehicle	2 (4.5%)	13 (29.5%)	9 (20.5%)	20 (45.5%)	44
Grand total	705	3,781	3,942	16,353	24,781

According to the crash record obtained from RMP (2014), approximately 14% of road traffic crashes are due to head-on collision. However, findings within this study indicate that only a small percentage of head-on collisions are recorded for expressways with open or closed tolling system. This finding is associated the type of carriageway of the roads. Most expressways within Malaysia are designed to have separation of directional flow, with or without the usage of median barriers, and based on previous studies conducted by Prentkovskis et al. (2009) and Martin et al. (2013), the separation of directional flow can prevent or reduce the occurrence of road traffic crashes due to head-on collisions.

Based on further analysis to evaluate the relationship between critical event and crash severity, it is found that a significant relationship between the critical event of crash and crash severity was obtained.

3.3. Associated Factors and Severity

The associated factors of a crash include the person, vehicle, and environmental conditions present at the time of the crash. Determining the associated factors of a crash is essential as it provides enough information to describe the circumstances of the crash. Based on the data obtained, most crash reports only state the critical event of a crash. Therefore, in such cases, the associated factor is categorized as unknown.

Based on the coded data, as shown in Table 4, approximately 46% of the crash reports recorded have unknown associated factors. Apart from this fact, 30% of crashes recorded are due to visibility issues and 18% are due to slippery roads. This finding complements the findings of a study conducted by the Monash University Accident Research Centre. According to the study, delineation improvements will generally reduce road traffic crashes by about 28% (Oxley et al., 2004). With reference to iRAP Road Safety Toolkit, street lighting can reduce approximately 50% of pedestrian crashes as well as help people feel safe and reduce crime.

To further understand how the associated factors related to the severity outcome, a multilevel regression analysis was conducted. However, results show that there is no significant relationship between associated factors relate to the severity outcome.

Table 4: Associated factors by severity.

Associated factor	Fatal	Severe	Slight	Damage only	Total
Pavement – bad surface	- (0.0%)	- (0.0%)	5 (35.7%)	9 (64.3%)	14
Pavement – pothole	1 (3.7%)	- (0.0%)	7 (25.9%)	19 (70.4%)	27
Pavement – slippery	42 (0.9%)	338 (7.6%)	531 (11.9%)	3,562 (79.6%)	4,473
Pavement – water ponding	- (0.0%)	3 (6.3%)	2 (4.2%)	43 (89.6%)	48
Presence of animal	1 (0.3%)	25 (6.9%)	34 (9.4%)	303 (83.5%)	363
Presence of debris – fallen goods	- (0.0%)	3 (8.8%)	3 (8.8%)	28 (82.4%)	34
Presence of debris – misc. objects	- (0.0%)	7 (13.5%)	10 (19.2%)	35 (67.3%)	52
Presence of debris – oil slick	- (0.0%)	3 (33.3%)	6 (66.7%)	- (0.0%)	9
Presence of debris – rock	- (0.0%)	4 (7.5%)	4 (7.5%)	45 (84.9%)	53

Continued on next column.

Table 4 – *Continued from previous column*.

Associated factor	Fatal	Severe	Slight	Damage only	Total
Presence of debris – steel	2 (0.5%)	22 (5.9%)	23 (6.2%)	324 (87.3%)	371
Presence of debris – tire	- (0.0%)	13 (6.3%)	15 (7.3%)	177 (86.3%)	205
Presence of debris – wood	- (0.0%)	7 (8.9%)	14 (17.7%)	58 (73.4%)	79
Presence of pedestrian	15 (40.5%)	16 (43.2%)	5 (13.5%)	1 (2.7%)	37
Presence of unknown object	- (0.0%)	6 (2.1%)	6 (2.1%)	271 (95.8%)	283
Visibility – limited	145 (3.2%)	646 (14.3%)	696 (15.4%)	3,043 (67.2%)	4,530
Visibility – no lighting	142 (5.0%)	490 (17.4%)	495 (17.6%)	1,692 (60.0%)	2,819
Unknown	357 (3.1%)	2,198 (19.3%)	2,086 (18.3%)	6,743 (59.2%)	11,384
Grand total	705	3,781	3,942	16,353	24,781

3.4. Critical Reason and Severity

The immediate reason for the critical event (i.e., the failure leading to the critical event) is said to be the critical reason of a crash and is assigned to the vehicle coded with the critical event in the crash. However, it should be noted that in some crash reports, the critical reason is unstated. Therefore, for this study, the critical reason for such cases are classified as unknown.

As shown in Table 5, results from this study show that reckless driving is identified as the main critical reason of a crash on Malaysian intra-urban expressways. As indicated in previous studies on this matter (Kloeden et al., 1997; Walsh et al., 2004), factors related to human behaviour are said to be the main contributor to road traffic crashes. Only a small percentage of crashes are recorded due to unfit drivers.

Table 5: Critical reason by severity.

Critical reason	Fatal	Severe	Slight	Damage only	Total
Incompetence	90 (3.8%)	430 (18.1%)	515 (21.7%)	1,336 (56.3%)	2,371
Mechanical failure	22 (1.5%)	186 (12.4%)	277 (18.4%)	1,017 (67.7%)	1,502
Negligent	28 (1.5%)	199 (10.3%)	239 (12.4%)	1,463 (75.8%)	1,929
Not at fault	26 (5.8%)	74 (16.4%)	42 (9.3%)	308 (68.4%)	450
Reckless	346 (3.0%)	1,800 (15.4%)	1,707 (14.6%)	7,815 (67.0%)	11,668
Unfit to drive	- (0.0%)	1 (16.7%)	2 (33.3%)	3 (50.0%)	6
Unknown	189 (2.8%)	1,092 (15.9%)	1,162 (17.0%)	4,412 (64.4%)	6,855
Grand total	611	3,352	3,429	15,018	24,781

4. Discussion and Conclusion

This study aims to identify the causation factor of crash severity in road traffic crashes on Malaysian intra-urban expressways. Crash reports obtained from the Malaysia Highway Authority (MHA) were coded according to DOT 2006 and the critical event, critical reason and associated factor for each crash report were identified prior to analysis.

The critical event of a crash is the action or event that causes the vehicle or vehicles on a course, making the collision unavoidable. It is assigned to the vehicle making the action that caused the crash inevitable. In this study, lost control and rear-end collision are critical events with the highest percentage. When analysing the relationship between the critical event and crash outcome, a significant relationship was observed, indicating that each critical event is associated with certain crash outcome.

Critical reason of a crash is defined as the immediate reason for the critical event (i.e., the failure leading to the critical event) and is assigned to the vehicle coded with the critical event. In this study, reckless is the common critical reason of a crash. However, when further analysis was conducted, no significant relationship was obtained between the critical reason and severity of a crash.

The person, vehicle, and environmental conditions present at the time of the crash is noted and is defined as the associated factors of a crash. Limited visibility and slippery roads are the main associated factors coded from the crash reports obtained. When analyzing the effect of associated factors with severity, no significant relationship was obtained.

5. Recommendations

Findings from this study are beneficial in determining the appropriate countermeasures to be implemented in order to reduce the number of crashes and the severity outcome of crashes occurring on Malaysian expressways. Based on findings from this study, emphasis should be given on issues related to visibility and slippery roads. However, it should be noted that no exposure analysis was included in this study. Therefore, to obtain a full understanding of the current situation in Malaysia, more value can be added to this study by including such analysis.

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