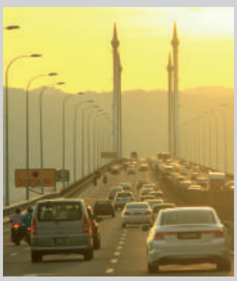
MRR No. 326

Research Report

Motorcyclists' Crash Causation Factors Associated with Lane Filtering and Splitting



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Published by:
Malaysian Institute of Road Safety Research (MIROS)
Lot 125-135, Jalan TKS 1, Taman Kajang Sentral,
43000 Kajang, Selangor Darul Ehsan, Malaysia.

Perpustakaan Negara Malaysia Cataloguing-in-Publication Data

Mohd. Khairul Alhapiz Ibrahim
Motorcyclists' Crash Causation Factors Associated with Lane Filtering and
Splitting / Mohd Khairul Alhapiz Ibrahim, Mohd Firdaus Mohd Siam,
Low Suet Fin, Khairil Anwar Abu Kassim.
(Research Report ; MRR No. 326)
ISBN 978-967-2078-73-9
1. Motorcycling accidents--Research--Malaysia.
2. Traffic accidents--Research--Malaysia.
3. Motorcycling injuries--Research--Malaysia.
4. Government publications--Malaysia
I. Mohd Firdaus Mohd Siam. II. Low, Suet Fin.
III. Khairil Anwar Abu Kassim. VI. Title. VII. Series.
363.12590720595

Printed by:
Malaysian Institute of Road Safety Research (MIROS)

Typeface: Calibri
Size: 11 pt.

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Acknowledgements

The author would first like to express heartfelt gratitude to former Director-General of MIROS, Dr Siti Zaharah Ishak for extending her full support throughout the project. Acknowledgement is also due to Dr Low Suet Fin, the former Director of Road User Behavioural Change Research Centre (RUBC) for her support and invaluable inputs. Thanks are due to the research assistants, especially Mr Muhammad Hafidz Basir for his help in the preparation of the instruments, data collection and data analysis for this project. The author would also like to thank the members of RUBC and Research Management and Commercialization Unit (RMC) for all the help in the facilitation and management of this research project. Last, but not least, special thanks to our family members and friends who have supported us during the duration of this project.

Abstract

This study was conducted to determine motorcycle crash causation factors related to lane filtering and splitting movements. Four motorcyclists were recruited and supplied with a Garmin VIRB XE action camera to record their riding data for a month. The camera was mounted on the helmet and was capable of recording the front view, riding speed, distance of travel, positioning data and acceleration data. The analysis of the recorded riding data had resulted in the classification of 258 crash relevant events, with a staggering 96.5% of them occurred while the participants were filtering or splitting in between lanes. A binary logistic regression was conducted to determine the factors influencing the likelihood of a near miss during a crash relevant event. The results revealed that the odds of the motorcyclists to experience a near-miss while filtering or splitting in between lanes was 8.5 times higher when the conflict partner was another motorcycle, as compared to a heavy vehicle. Further, lane splitting or lane filtering movements on the non-highway roads were 2.2 times more likely to result in a near miss, compared to highways. No other factors were found to be significant based on the current dataset. The results were discussed in terms of the way to mitigate the associated crash risk facing the motorcyclists in Malaysia.

1. Introduction

In Malaysia, motorcycle is a popular alternative to a four-wheeled vehicle for motorists to avoid traffic congestion, especially in large urban areas. Ability to evade traffic congestion by weaving through traffic and filtering between stopped vehicles is an advantage of the powered two-wheelers that contributes to the high number of their ownership (Burge, Fox, Kouwenhoven, Rohr, & Wigan, 2007; Clabaux, Fournier, & Michel, 2017). Lane filtering is defined in the literature as the act of overtaking stationary or slow-moving vehicles by using the space within a lane (Sperley & Pietz, 2010). On the other hand, using the space within one or more lanes to get ahead of traffic moving at high speed is called lane splitting (Federation of European Motorcyclists' Associations (FEMA), 2009). In Malaysia, both types of overtaking maneuvers are commonly practiced by motorcyclists. Their legal status is unclear and to the best of our knowledge, no summons has ever been issued for a motorcyclist for such practices. Based on the reviewed literature, the available regulatory provision was described as lacking and unsupportive (Hamzah, Solah, & Paiman, 2018). The overtaking related offenses under the Road Transport Act 1987 and Road traffic ordinance 1958 are overtaking from the left side of the road, crossing double solid white lines and preventing others from overtaking (Jabatan Pengangkutan Jalan (JPJ), 2014). However, these offenses are mostly related to four-wheelers under the subject of 'drivers of motor vehicles'. In short, the lane positioning and overtaking conducts for motorcyclists are relatively unclear in the available legal documents. At present, the impact of lane filtering practices on the risk of crash is understudied in Malaysia, particularly through a collection of empirical evidence in actual traffic. This study set out to investigate the crash causation factors related to lane filtering and lane splitting manoeuvres. Analyses of critical riding events that were captured through GPS-based action camera were conducted to determine the factors.

1.1 Research Objectives

Two objectives were set for this research, namely:

i. To collect motorcycle riding data in actual traffic conditions using a GPS-based action camera.
ii. To determine the crash causation factors related to lane filtering and splitting movements based on crash-relevant events.

2. Literature Review

At present, a review of the literature indicates a lack of systematic research on the potential risks (and benefits) of lane filtering and lane-splitting in Malaysia. A recently published study by Hamzah et al. (2018) provides an overview of the issue and discuss the idea of allocating a dedicated travel lane for motorcyclists through ‘keep-left’ order. The impact of such dedicated lane positioning on the safety of motorcyclists in mixed traffic has yet to be investigated. On the other hand, in-depth studies conducted elsewhere are easier to find, albeit not as many as expected. Lane filtering by the motorcyclists is considered risky by car drivers due to safety concerns related to difficulties in perceiving the motorcyclists (Beanland, Pammer, Sledziowska, & Stone, 2015). In a crash study by Clarke, Ward, Bartle and Truman (2004), lane filtering was found to increase the risk of motorcycle crash. The researchers reported that a case of motorcyclist filtering through traffic was recorded in one out of twenty motorcycle crashes in Great Britain. A direct link between lane filtering and crash causation among motorcyclists has never been established in the local crash study. However, incidents related to lane changing or overtaking maneuvers were reported in a local study to have 7.81 times higher odds of causing a near miss to a motorcyclist compared to incidents related to braking or sudden stopping (Ibrahim, Ab Rashid, Mohd Jawi, & Mohamed Jamil, 2018).

Most of the previous studies highlighted the adverse effects of lane filtering and lane-splitting for motorcyclists, although a few of them did report a limited safety benefit for such practices. For example, Rice and Troszak (2015) reported that lane-splitting could potentially lower the risk of injury if done cautiously. The researchers analyzed 5,569 motorcycle crash cases recorded from June 2012 through August 2013 in California, USA to examine the prevalence of lane splitting and its effect on the extent of injuries sustained during a crash. They suggested that a lane splitting practice done in traffic moving under 80 km/h without exceeding the speed of other vehicles by more than 24 km/h could reduce the extent of the injury sustained during a crash. The dataset also show that lane-splitting motorcyclists injured much less frequently and were less likely to suffer head injury (9% vs 17%), torso injury (19% vs 29%), extremity injury (60% vs 66%), and fatal injury (1.2% vs 3.0%) compared with other motorcyclists. However, the prevalence of lane-splitting cases was low (17%) in the dataset being analyzed. In addition, compared to Malaysian traffic, motorcyclists were a minority in (2.53%) in California (Department of Motor Vehicles California, 2017). Another purported safety benefit of lane filtering reported previously is the reduction in the risk of rear-end collisions (ACEM, 2009). However, it lacks support from other studies.

In contrast, a study conducted by Clabaux et al. (2017) reported a higher risk of crash involvement among lane-splitting motorcyclists on urban roads. The study was based on a set of motorcycle crash data for the city of Marseille, France, collected on sections of urban roads from the year 2007 through 2009. Motorcycle engine displacement, space used when filtering, and a motorcyclist's visibility in a traffic queue were the factors being considered in the study. The study found that the risk of involving in injury crashes was 3.94 times higher for motorcyclists who practiced lane filtering or lane splitting compared to those who did not, regardless of motorcycle categories or the spaces used (e.g., along the axis of the carriageway, along bus lanes, or in between traffics). The act of filtering was discussed as a cause for a motorcyclist to be less cognitively conspicuous and less expected by other motorists. In addition, motorcyclists' age, experience and riding style were also postulated as the confounding factors to the crash risks while filtering. The study recommends curbing the lane filtering and lane splitting to improve the safety on urban roads.

Riding error committed by motorcyclists like riding too fast for conditions and right-of-way violations (ROWV) by other motorists are two main leading causes of multi-vehicle motorcycle crashes. In many cases, a driver reported to have looked but did not see a motorcyclist with whom he or she collided. Inadequate visual conspicuity of a motorcyclist is reported to have contributed to this situation (Washington Traffic Safety Commission, 2017). When a motorcyclist filter through lanes, a conflict may arise with an unsuspected collision partner due to a limited perceptual exploration of the areas the motorcyclist was at, thus increasing the risk of a collision (Salmon, Young, & Cornelissen, 2013). Collisions due to drivers turning across the path of filtering motorcyclists were previously reported by Crundall, Clarke, Ward and Bartle (2008). Thus, many related motorcycle studies have suggested the use of reflective or fluorescent clothing and daytime headlights to reduce the risk of collision (Abdul Manan, Várhelyi, Çelik, & Hashim, 2017; Wells et al., 2004). Further, Mulvihill et al. (2013) suggested that lane filtering or splitting could affect the motorcyclists' perception of surrounding traffic and hazards, which increase the risk of a collision.

Another study by Nguyen, Hanaoka and Kawasaki (2014) explored the impact of a 'safety space' on motorcyclists safety during a non-lane based motorcycle movement. The non-lane based movements included lane filtering and splitting in a zigzag movement. Motorcyclists were assumed to increase and decrease their riding speed based on the threat to their safe space. This threat was influenced by variation in speeds, traffic density, proximity to the most influential vehicle (or a conflict partner) and the width of available clearances. Based on the literature review, a motorcyclist's risk of a crash during a lane filtering or splitting manoeuvre could be influenced by many factors. These factors are the riding speed, traffic density, the magnitude of speed differential between a motorcyclist and the surrounding traffic, motorcycle engine displacement, the types of roads, the types of space used when filtering, a motorcyclist's visibility, and a motorcyclist's perception of surrounding traffic and hazards.

Except for a number of recently published studies, the practice of motorcycle lane filtering has not been examined from the motorcyclists' point of view in actual traffic conditions. Thus, key information is yet to be found to support the risks and benefits of lane filtering outlined in previous literature. This shortcoming is detrimental to motorcycle crash mitigation. In Malaysia, the lack of previous studies on this subject is surprising, considering the numbers of motorcycles on the road and the annual road fatalities involving them. Thus, the present study set out to collect the naturalistic riding data to examine the factors influencing the crash risk related to lane filtering and lane splitting. A profile of the crash risk is valuable for risk identification and mitigation. In addition, naturalistic driving data in real traffic environment is expected to increase the external validity of the findings on the effective countermeasures.

3. Methodology

This section describes the data recording equipment, selection of participants, data coding and analysis approach, and the overall implementation of the study.

3.1 Data Recording Equipment

The principal data for this study is the footage of riding scenarios captured from the point of view of the motorcyclists. A GPS-based Garmin VIRB XE action camera (Figure 1) was used to record this data. The camera was mounted on the helmet and was capable of recording the front view, riding speed, a distance of travel, positioning data and acceleration data. The camera was approximately 3.0" (W) x 1.6" (D) x 1.4" (H) (77.0 x 40.6 x 36.8 mm) in size, weighed around 151.7g and powered by a rechargeable 980mAh Lithium-polymer battery. The battery lasted for about two hours on a single charge with high definition image recording (1080 pixels, 30 frames per seconds). The camera was equipped with an image stabilization mechanism and was designed to be waterproof. These two (2) specifications were much needed for this type of study due to the inherent vibration of motorcycle and the high possibility of rainy condition during the recording session. All recorded data were stored temporarily in a micro SD card before being transferred to an external hard drive for permanent storage. The recorded data were analysed for any crash relevant events or traffic conflict based on their movement in the lane.

Figure 1 Garmin VIRB XE action camera used in this study

3.2 Selection of the Participants

A convenience sampling method was used to select the participants in this study. Four consenting motorcyclists were recruited and were supplied with the data recording equipment. The selected participants used their motorcycle to travel to and from their place of work. For each participant, data recording was scheduled for a month. Apart from recording all of their riding trips, the participants were also tasked with the charging of camera's battery and replacing the micro SD card, when it is full. Due to the naturalistic nature of the data collection method, the journey profiles of a participant was not controlled. However, the inclusion of a participant in the study was filtered based on certain criteria such as the frequency of using motorcycle to travel, distance from participants' residence to their workplace and the routes they usually used. Participants were tasked to record all of their trips on the motorcycle, including weekend and night travel.

3.3 Data Coding and Analysis Approach

This study set out to investigate the crash causation factors related to lane filtering and lane-splitting manoeuvres. The factors being considered in the present study were engine displacement, riding speed, types of road, number of lanes, travel distance, types of conflict partner, weather conditions and time of day. In order to achieve the objective of this study, the recorded riding data were analyzed to determine any crash relevant events experienced by the participants. The movement of the participants in each of the events was coded as either a lane filtering, a lane-splitting or a normal (in a lane) movement. A near-miss resulted from a crash relevant event was used as a surrogate measure of a crash occurrence. A crash relevant event was coded as a near miss if a participant made an evasive manoeuvre to avoid a collision with a conflict partner. Thus, the crash causation factors related to lane filtering and lane splitting manoeuvres were determined by analyzing the influence of each factor on the likelihood of a near-miss during a crash relevant event experienced by the participants. The description and categories of variables related to the crash causation factors are listed in Table 1.

Table 1 The description and categories of variables included in the analysis

Variable name	Definition	Categories
Near-miss	A crash relevant event, in which the participants made an evasive maneuver to avoid a collision	0. No 1. Yes
Types of a conflict partner	Other parties that are most influential in a crash relevant events experienced by the participants	0. Motorcycle 1. Car 2. Heavy vehicle
Trip category	The purpose of the trips	0. Trip from home to work 1. Trip from work to home 2. Other trips
Travel distance	The distance in kilometre (km) travelled by a participant in a single trip	0. Less than 15 km 1. 15 – 30 km 2. More than 30 km
Types of road	Types of roads traversed by a participant in a single trip	0. Other roads 1. Highway

Number of lanes	The number of lanes available in the direction of travel where a crash relevant event occurred	Continuous
Riding speed	The recorded GPS speed of the motorcycle during a crash relevant event	0. Less than 80 km/h 1. 80 km/h or more
Motorcycle engine displacement	Category of a motorcycle based on the size of the engine	0. 150 cc and above 1. Less than 150 cc
Weather	The condition of the atmosphere in the area where a crash relevant event occurred	0. Fine/clear 1. Rainy

4. Results

4.1 Descriptive Data

Table 2 lists the description of the participant's demography, their trips and motorcycle model used during the data collection. Participants were all male with an average age of 39.8 years old (SD = 11.23), and average motorcycle riding experience of 21.8 years (SD = 8.69). On average, they travel 25.5 km (SD = 13.9) for each trip taken during the data collection period. Three of them used a similar motorcycle model with 135 cc engine capacity. Only one (1) participant used motorcycles with more than 150 cc engine capacity. Most of the recorded trips were commuting to and from work with main routes used were a mix of highway and federal roads.

Table 2 Description of participants' trip and types of motorcycle used

Participant code	Age	Riding experience (years)	Place of residence	Routes most travelled	Motorcycle used	Average trip distance
P-1	55	31	Bukit Damansara	• Sprint Expressway (E23) • North-South Expressway (E2) • Sungai Besi Expressway (E9) • Kajang Silk Highway (E18)	Yamaha NMax 155cc BMW G310 GS 310cc	32.7 km

P-2	39	23	Labu	• LEKAS Highway (E21) • Federal route 362 (formerly state route N38)	Yamaha 135LC 135cc	41.7 km
P-3	37	23	Seri Kembangan	• Kajang Silk Highway (E18) • Federal route 3215 (formerly state route B16)	Yamaha 135LC 135cc	13.9km
P-4	28	10	Seri Kembangan	• Kajang Silk Highway (E18) • Federal route 3215 (formerly state route B16)	Yamaha 135LC 135cc	13.9 km

4.2 Lane Movements and Crash Relevant Events

The movement of participants when the events occurred were coded as lane-based and non-lane-based. A movement was coded as a lane-based movement only if a participant was moving in platoon with other traffic, inside the boundary of a lane. A movement was coded as a non-lane-based if a participant positioned himself inside the space in between cars on adjacent lane, or if a participant moved from a lane to another by weaving. The analysis of the recorded riding data had resulted in the classification of 258 crash relevant events. Table 3 displays the descriptive statistics of crash relevant events and cases of a near-miss based on the motorcyclists' movements. We found that only nine crash relevant events (3.5%) occurred while the participants were moving in a lane. Other events were associated with non-lane-based movements of either lane filtering or lane splitting. Eighty-six of all crash relevant events (33.3%) were classified as a near-miss. Of all the cases of a near-miss, 79 cases (91.9%) were recorded when the participants performed a non-lane-based movement of either splitting or filtering. Further, 55.8% of near-misses occurred when the participants were filtering through lanes, compared to lane splitting (36.0%) and normal lane movement (8.1%).

Table 3 The descriptive statistics of the crash relevant events

		Crash-relevant events	**Near-miss**		**Total**	**% Within crash-relevant events**
			No	**Yes**		
Motorcyclists movements	Filtering	Count	85	48	133	51.6%
		% within filtering	63.9%	36.1%	100.0%	
		% within near-miss	49.4%	55.8%		
	Splitting	Count	85	31	116	45.0%
		% within splitting	73.3%	26.7%	100.0%	
		% within near-miss	49.4%	36.0%		
	Normal (in a lane)	Count	2	7	9	3.5%
		% within normal (in a lane)	22.2%	77.8%	100.0%	
		% within near-miss	1.2%	8.1%		
Total		Count	172	86	258	
		% within crash-relevant events	66.7%	33.3%	100.0%	

4.3 Likelihood of a Near-Miss during Lane Filtering and Lane Splitting Movements

A binary logistic regression was conducted to determine the effects of each factor on the likelihood of a near-miss during a crash relevant event. Logistic regression is a more suitable regression method in this case because the outcome variable (near-miss) is binary and there is a mix of numerical and categorical variables in the list of the factors. Compared to a linear regression method, the assumption of a normal distribution and equal variance of explanatory variables is not required for logistic regression analysis.

Since the analysis concerned only the non-lane-based movements, the events related to the normal (in a lane) movements were filtered out from the dataset. The logistic regression model was found to be statistically significant, $\chi^2(11) = 27.41$, $p < 0.01$, which showed that the set of factors in the model was reliable to distinguish between events with near-miss and no near-miss. The results of Hosmer and Lemeshow (1980) test indicated that the data fit the model sufficiently. The model explained 16.9% (Nagelkerke R^2) of the variance in instances of a near-miss. The model correctly classified 73.2% of the cases (96.6% for no near-miss and 23.5% for near-miss cases). The Wald criterion indicated that types of road and types of a conflict partner made a significant contribution to the prediction of a near-miss (See Table 4). Exponentiated B (e^B) value indicates that the odds of the motorcyclists to experience a near-miss was 8.5 times higher when the conflict partner was another motorcycle, as compared to a heavy vehicle. Further, lane-splitting or lane filtering movements on the non-highway roads were 2.2 times more likely to result in a near-miss, compared to highways. No other factors were found to be significant based on the current dataset. The descriptive statistics of all the factors relative to the cases of a near-miss are included in the Appendixes.

Table 4 Summary of logistic regression analysis for variables predicting likelihood of a near-miss

Factors	B	SE (B)	z-ratio	Sig.	Odds ratio, Exp(B)	95% C.I. for Exp(B)	
						Lower	Upper
Travel distance				.435			
Less than 15 km	.060	.667	0.090	.928	1.062	.287	3.925
15 – 30 km	-.375	.520	-0.721	.471	.687	.248	1.904
More than 30 km				Reference			
Engine displacement	-.295	.512	-0.576	.565	.744	.273	2.031
Riding speed	.017	.390	0.044	.966	1.017	.474	2.184
Types of roads							
Non-highway	.773*	.386	2.003	.045	2.166	1.016	4.617
Highway				Reference			
Conflict partner				.001			
Motorcycle	2.136*	.669	3.193	.001	8.462	2.280	31.409
Car	-.123	.376	-0.327	.744	.884	.423	1.849
Heavy vehicle				Reference			
Weather	.482	.502	0.960	.337	1.620	.605	4.336
Trip category				.276			
Trip from home to work	-.602	.434	-1.387	.165	.548	.234	1.282
Trip from work to home	.067	.449	0.149	.882	1.069	.443	2.578
Other trips				Reference			
Number of lanes	.296	.236	1.254	.209	1.344	.847	2.133
Constant	-1.969	1.075	-1.832	.067	.140		

Summary statistics
Model χ^2 = 27.41 (df = 11; p < 0.01)
Pseudo R^2 = 0.169
Hosmer and Lemeshow test χ^2 = 10.37 (df = 8; p =0.240)
N = 249

*p < 0.05. **p < 0.01. ***p < 0.001.

5. Discussion

The results of the present study show that the majority (96.5%) of the crash relevant events occurred when the motorcyclists were filtering or splitting on the roads, compared to when they stayed in the traffic flow in the lanes. This finding is consistent with that obtained by Clabaux et al. (2017). In addition, the motorcyclists found themselves in a near-miss situation more often when they were filtering, compared to splitting. This finding should be explored further to determine whether there is indeed a different risk level or potential safety benefits related to both non-lane-based movements. For example, as pointed out by Rice and Troszak (2015), a cautious lane splitting could reduce the extent of injuries sustained by a motorcyclist in the event of a crash. On the other hand, the higher odds of a near-miss associated with a motorcycle as the conflict partner could be explained by the fact that the other motorcycle was also filtering or splitting in between lanes. As pointed put by Salmon et al. (2013), both of the motorcyclists were at a higher risk of not seeing each other due to the limited perceptual exploration of the areas they were at and unsuspecting each other while filtering and splitting in between lanes. This study also found out that the likelihood of a near-miss was significantly higher on non-highway roads compared to highways. One of the possible reasons is due to the higher frequency of interruption in traffic flow and vehicle operating speeds on the non-highways roads. More frequent congestion points and access points could also increase the likelihood of a near-miss.

This study found that lane filtering and splitting are indeed risky for motorcyclists. For instance, 96.5% of all crash relevant events were recorded when a participant was moving either by filtering through lanes or splitting across different lanes. In contrast, only nine (9) crash relevant events were recorded when a participant was moving in a normal lane movement. In addition, 91.9% of all cases of a near miss recorded in the present study was associated with filtering or splitting movements.

6. Conclusion

The present study set out to collect the naturalistic riding data to examine the factors influencing the crash risk related to lane filtering and lane splitting. The use of a GPS-based action camera was found to be very feasible and has resulted in an invaluable database that can be translated into a risk profile for crash causation and mitigation analysis. The objectives of this study were successfully achieved with the experimental methodology employed in this study. Two potential crash causation factors were found to significantly influence the likelihood of a near miss during lane filtering or splitting. In addition, the analysis of the naturalistic riding has increased the depth of rider behaviour study, especially on the risk associated with lane splitting and filtering. The analysis of the crash relevant events and risky riding behaviours has also broadened the scope of the analysis previously not achievable.

7. Recommendation

The work that we have presented here needs to be explored further with a larger sample and a higher degree of variation across the explanatory variables. This is due to the relatively small dataset available in the present study and the encouraging results presented based on the present dataset. Nevertheless, the findings presented in this study can be used as a basis to highlight the high risk of a road crash related to the practice of lane filtering and splitting among motorcyclists in Malaysia. It is especially important to increase the awareness of this risk among both motorcyclists and other motorists. For instance, the Variable Message Sign (VMS) should be used to warn the motorists of the risk and remind them of the presence of the motorcyclists in between lanes. In addition, the risk of lane filtering and splitting movements should be highlighted during rider training and licensing stage. The training curriculum should include a specific section to train the new riders on how to mitigate the risk of a crash when moving within a mix-traffic environment.

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Appendixes

A1: The descriptive statistics of near-misses based on motorcyclists' movement

			Near-miss		Total
			No	Yes	
Motorcyclists movements	Filtering	Count	85	48	133
		% within motorcyclists movements	63.9%	36.1%	100.0%
		% within near-miss	49.4%	55.8%	51.6%
	Splitting	Count	85	31	116
		% within motorcyclists movements	73.3%	26.7%	100.0%
		% within near-miss	49.4%	36.0%	45.0%
	Normal (in a lane)	Count	2	7	9
		% within motorcyclists movements	22.2%	77.8%	100.0%
		% within near-miss	1.2%	8.1%	3.5%
Total		Count	172	86	258
		% within motorcyclists movements	66.7%	33.3%	100.0%
		% within near-miss	100.0%	100.0%	100.0%

A2: The descriptive statistics of near-misses based on riding speeds

			Near-miss		Total
			No	Yes	
Riding speeds	Less than 80 km/h	Count	109	59	168
		% within riding speeds	64.9%	35.1%	100.0%
		% within near-miss	70.3%	72.8%	71.2%

	80 km/h and above	Count	46	22	68
		% within riding speeds	67.6%	32.4%	100.0%
		% within near-miss	29.7%	27.2%	28.8%
Total		Count	155	81	236
		% within riding speeds	65.7%	34.3%	100.0%
		% within near-miss	100.0%	100.0%	100.0%

A3: The descriptive statistics of near-misses based on conflict partner

			Near-miss		**Total**
			No	**Yes**	
Conflict partner	Motorcycle	Count	4	17	21
		% within conflict partner	19.0%	81.0%	100.0%
		% within near-miss	2.4%	20.2%	8.4%
	Car	Count	111	48	159
		% within conflict partner	69.8%	30.2%	100.0%
		% within near-miss	66.9%	57.1%	63.6%
	Heavy vehicle	Count	50	19	69
		% within conflict partner	72.5%	27.5%	100.0%
		% within near-miss	30.1%	22.6%	27.6%
Total		Count	166	84	250
		% within conflict partner	66.4%	33.6%	100.0%
		% within near-miss	100.0%	100.0%	100.0%

A4: The descriptive statistics of near-misses based on engine displacement

			Near-miss		Total
			No	Yes	
Engine displacement	150 cc and above	Count	69	31	100
		% within engine displacement	69.0%	31.0%	100.0%
		% within near-miss	40.1%	36.0%	38.8%
	Less than 150 cc	Count	103	55	158
		% within engine displacement	65.2%	34.8%	100.0%
		% within near-miss	59.9%	64.0%	61.2%
Total		Count	172	86	258
		% within engine displacement	66.7%	33.3%	100.0%
		% within near-miss	100.0%	100.0%	100.0%

A5: The descriptive statistics of near-misses based on travel distance

			Near-miss		Total
			No	Yes	
Travel distance	Less than 15 km	Count	48	31	79
		% travel distance	60.8%	39.2%	100.0%
		% within near-miss	28.6%	38.3%	31.7%
	15 – 30 km	Count	91	38	129
		% travel distance	70.5%	29.5%	100.0%
		% within near-miss	54.2%	46.9%	51.8%
	More than 30 km	Count	29	12	41
		% travel distance	70.7%	29.3%	100.0%
		% within near-miss	17.3%	14.8%	16.5%

Total	Count	168	81	249
	% travel distance	67.5%	32.5%	100.0%
	% within near-miss	100.0%	100.0%	100.0%

A6: The descriptive statistics of near-misses based on weather

			Near-miss		Total
			No	Yes	
Weather	Fine	Count	142	73	215
		% within weather	66.0%	34.0%	100.0%
		% within near-miss	82.6%	84.9%	83.3%
	Rainy	Count	30	13	43
		% within weather	69.8%	30.2%	100.0%
		% within near-miss	17.4%	15.1%	16.7%
Total		Count	172	86	258
		% within weather	66.7%	33.3%	100.0%
		% within near-miss	100.0%	100.0%	100.0%

A7: The descriptive statistics of near-misses based on types of roads

			Near-miss		Total
			No	Yes	
Types of road	Non-highway	Count	76	49	125
		% within types of road	60.8%	39.2%	100.0%
		% within near-miss	44.2%	57.0%	48.4%
	Highway	Count	96	37	133
		% within types of road	72.2%	27.8%	100.0%
		% within near-miss	55.8%	43.0%	51.6%
Total		Count	172	86	258

	% within types of road	66.7%	33.3%	100.0%
	% within near-miss	100.0%	100.0%	100.0%

A8: The descriptive statistics of near-misses based on trip categories

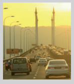
			Near-miss		Total
			No	Yes	
Trip category	Trip to work	Count	56	18	74
		% within trip category	75.7%	24.3%	100.0%
		% within near-miss	32.6%	20.9%	28.7%
	Trip to home	Count	59	33	92
		% within trip category	64.1%	35.9%	100.0%
		% within near-miss	34.3%	38.4%	35.7%
	Other trips	Count	57	35	92
		% within trip category	62.0%	38.0%	100.0%
		% within near-miss	33.1%	40.7%	35.7%
Total		Count	172	86	258
		% within trip category	66.7%	33.3%	100.0%
		% within near-miss	100.0%	100.0%	100.0%

A9: The descriptive statistics of near-misses based on the number of lanes

			Near-miss		Total
			No	Yes	
No. of lanes	1.00	Count	34	13	47
		% within no. of lane	72.3%	27.7%	100.0%
		% within near-miss	19.8%	15.1%	18.2%
	2.00	Count	30	25	55
		% within no. of lane	54.5%	45.5%	100.0%

		% within near-miss	17.4%	29.1%	21.3%
	3.00	Count	100	41	141
		% within no. of lane	70.9%	29.1%	100.0%
		% within near-miss	58.1%	47.7%	54.7%
	4.00	Count	8	7	15
		% within no. of lane	53.3%	46.7%	100.0%
		% within near-miss	4.7%	8.1%	5.8%
Total		Count	172	86	258
		% within no. of lane	66.7%	33.3%	100.0%
		% within near-miss	100.0%	100.0%	100.0%





Research Report

Motorcyclists' Crash Causation Factors Associated with Lane Filtering and Splitting

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ISBN 978-967-2078-73-9