RELATIONSHIP BETWEEN MERGING LANE LENGTH AND MOTORCYCLIST'S HEAD CHECK BEHAVIOR DURING MERGING IN EXPRESSWAY

Adnan A.[1,*], Ismail H.[1], Radin Umar R. Z.[2], Samuel S.[3], Shaffiar, N.M.[1], Ani M.H.[1], Hamid M.[1,]**

[1]*Department of Manufacturing and Materials Engineering, International Islamic University Malaysia, 50728, Kuala Lumpur, Malaysia*

[2]*Faculty of Manufacturing Engineering, Universiti Teknikal Malaysia Melaka, 76100, Melaka, Malaysia*

[3]*Department of System Design Engineering, University of Waterloo, Ontario, N2L 3G1, Canada*

[*]For correspondence; Tel. + (60) 189794123, E-mail:ammarcloud@gmail.com

[**]For correspondence; Tel. + (60) 132665576, E-mail: abdmalek@iium.edu.my

ABSTRACT: *In Malaysia, risky driving/riding is accounted for two-thirds of the total road crashes. It includes speeding, ignoring signal or sign, improper overtaking and merging. In this study, the focus is on motorcyclist's behavior during merging in traffic. The objectives are: (i) to evaluate motorcyclist's head check behavior during merging in urban expressway; and (ii) to evaluate the effect of merging lane length on motorcyclist's head check behavior during merging in traffic – urban expressway. Field observational study was conducted at 16 scenario locations with different lengths of merging lane (20 – 300 meters). The recording was done for 4 weeks on 1600 motorcyclists. Each scenario was observed from 2.00 p.m. to 5.00 p.m. on a good weather condition. Dependent variable of the study is the percentage of head check. If a motorcyclist performed head check towards the target zone while in launch zone, he or she was scored 1, otherwise 0 (binary scoring). Results obtained shows that, three-quarters (76.9%) of the motorcyclists did not performed head check during merging onto urban expressway. Among regression models being analyzed, cubic regression model shows the highest correlation value, R^2 of 0.644. Merging lanes between 147 – 227 meters was found to be the optimal length that may influence the motorcyclists to perform head check during merging in traffic. Findings from this study, recommended the merging road design improvement for road safety. In addition, it contributes in improving the riding education program in general, specifically on how to merge safely during merging in traffic.*

Keywords: Road Safety, Motorcyclists Behavior, Merging Lane Length, Head Check

1. INTRODUCTION

Based on Association for Safety International Road Travel (ASIRT), approximately 1.24 million deaths occurred annually due to road crashes [1]. Nearly half of road-death in the world involved motorcyclist, cyclist, and pedestrian with 23%, 22% and 4% respectively. In South-East Asia, road traffic death is higher among motorized 2-3 wheelers compared to car occupants, while in Europe and America, this condition is vice versa [2]. The reason for the difference is because motorcycles are the main transportation in South-East Asia region. For instance, in 2013, nearly half of new vehicles being registered in Malaysia are motorcycles with the total amount of 600,332 out of 1,237,379 [3]. In addition, out of 27 million registered vehicles in Malaysia, over half a million (521,466) were involved in road crashes. Moreover, 7152 road deaths were reported in the year 2016, which is increased by 6% from the previous year [4]. In Malaysia, risky driving is the number one contributing factor for road crashes with one-third of the total crashes. It involved speeding, ignoring the signals or signage, improper lane usage, improper overtaking and improper merging [5]. Malaysia has the highest road fatality risk (per 100,000 population) among the ASEAN countries, and more than 50% of the road accident fatalities involve motorcyclists [6]. Among the risky behavior, improper merging is one of the causes that lead to road crashes. Therefore, there is a need to explore motorcyclist's behavior during merging in traffic.

Merging occurred when two separate traffic streams combine to form a single stream [7-8]. Based on Queensland Government, the rule in merging into another lane is by giving way to another vehicle that pass through the lane to be merged. As other road users, motorcyclists also have blind spots. By depending solely on the mirrors, a death-trap could happen [9]. Blind spot is the area next to the motorcyclist that are not covered by the mirrors [10]. A safe practice during merging is to turn head quickly over shoulder before merging in traffic. A standard term for this procedure is known as the head check. Performing head check is enough to cover the blind spot areas of motorcyclist. There is not a need of turning head all the way back as the areas are covered by the side mirror [10-11].

According to American Association of State Highway and Transportation Officials (ASSHTO), expressway is highway that have all the controls on road access and intended to provide movement of large volume of traffic at high speeds with high level of safety and efficiency [12]. It includes the design of the frontage road, entrance ramp, physical nose, and acceleration lane (or also known as merging lane) [13]. Longer merging lane is known to be an advantage for the road user during merging in traffic – the extra length can be utilized by the road users [13-16]. However, the length of merging lane may or may not be the factor of the behavior during merging onto expressway traffic [11, 17-18]. Study by Calvi & De Blasiis [17] stated that length of acceleration lane does not affect merging pattern except in high traffic volume. On the other hand, Chu et al. [18] stated that, shorter acceleration lane length causes less opportunity for vehicles to merge into the main traffic lane. None of these studies [11, 13-18] investigate on the effect of merging lane length on the head check behavior among the road users. However, Zabidi et al. [11] did discussed about the potential effect of the merging lane length. In his study, one of the scenarios was found did not agree with the hypothesis, and it was discussed that the particular scenario was differ from other scenario in term of the merging lane length. Thus, there is a need to investigate the effect of the merging lane length on the motorcyclist's head check behavior during merging in traffic.

The aim of this study is to investigate the effect of merging lane length on the motorcyclists' head check behavior during merging in urban expressway. To achieve this aim, the following objectives need to be achieved: (i) to evaluate motorcyclist's head check behavior during merging in urban expressway; and (ii) to evaluate the effect of merging lane length on motorcyclist's head check behavior during merging in urban expressway

2. METHODOLOGY

Scenarios: The area of study was the Klang Valley metropolitan area – Kuala Lumpur, Malaysia. In other similar observational studies, the number of scenario varies around three [19[, four [20-21], and eight scenarios [22]. Thus, in this study 16 scenarios were considered which was more than sufficient for this type of research study. The 16 scenarios were selected based on the percentile of the 48 samples merging lanes length measured. Dividing 100 by 15 (interval for 16 scenarios) given approximately 6.67 percentile. Thus, the scenarios were chosen in multiple of 6.67 percentile – or the nearest target length, in the case there is no exact length – in order to ensure that the distributions of the scenarios are evenly between the minimum length (20 meters) and maximum length (300 meters). The merging lane length of the chosen scenarios were 20, 30, 40, 50, 60, 67, 70, 90, 100, 110, 160, 180, 200, 210, 270, and 300 meters.

In order to describe the scenario in details, two terms will be defined – target zone' and 'launch zone'. Target zone is defined as the area from which the potential hazard could emerge, and launch zone is the area where it is crucial for a road user to anticipate the hazard [23]. A safe rider is expected to perform head check towards the target zone while in the launch zone – approximately two seconds before merge into the traffic [23-24]. In general, each scenario consists of either single or two lanes merging lane with 50 km/h speed limit that merge onto a three lanes expressway with 90 km/h speed limit. Figure (1) illustrates the sample of the scenario. Note that Malaysia is left-hand side traffic.

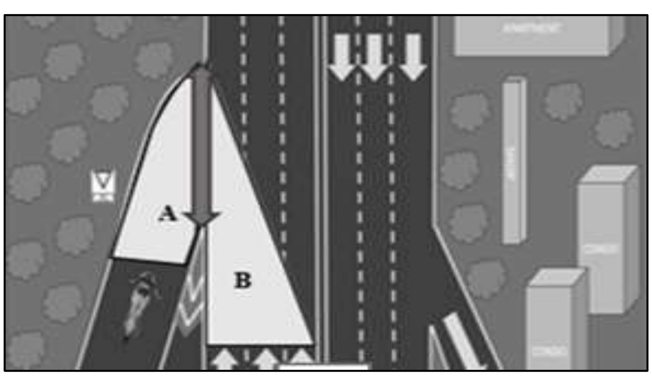

Figure (1) Plan view of a sample scenario

In Figure (1) below, launch zone is labeled as A, target zone as B, and merging lane length as grey double arrow line. The merging road (leaving road) consists of either one or two lanes and the speed limit is 60 km/h. The speed limit of the expressway (entering road) is 90 km/h with three lanes. The available cue is the 'keep way' signage that is located on the merging road.

Design of the Study: The observation (using a Panasonic HC V210) was conducted for 4 weeks on Monday, Tuesday, Wednesday, and Thursday. Friday and weekends were excluded to avoid any potential factoring effect (e.g. traffic congestion). Moreover, if public holiday falls on the weekdays, it will be excluded for the same explanation. The recording was divided into two 90-minutes-slots per day: (i) slot 1 – from 2:00 p.m. to 3:30 p.m.; and (ii) slot 2 – from 3:30 p.m. to 5:00 p.m. Another important design aspect was to avoid rush hour – during lunch hour (12 p.m. – 2 p.m.) and during workers' commuting period (after 5 p.m.). The observation was done only in a good weather condition (e.g. no rain), and normal traffic congestion (e.g. no road crashes at surrounding area). In addition, Latin square was applied for scenario counterbalancing. Each scenario was observed twice – one in slot 1 and the other in slot 2 – on the different day.

Dependent Variable: Dependent variable for the study is the percentage of head checks. If a motorcyclist perform a head check towards the target zone (the area in which the potential hazard may merge – at the entering road) while in launch zone (the area where a motorcyclist should turn head to the target zone – on the leaving road), he or she will be scored 1, otherwise he or she will be scored 0 (binary scoring).

3. RESULTS

In this study, 1600 motorcyclists were observed at the 16 selected scenarios around the Klang Valley area. Figure (2) shows the percentages of head check performance by motorcyclists during merging in expressway for each scenario. It can be seen in Figure (2) that the percentages of motorcyclists who did not performed head check are always higher than who did performed head check, except for Klang Gate scenario, where the contrary result was shown.

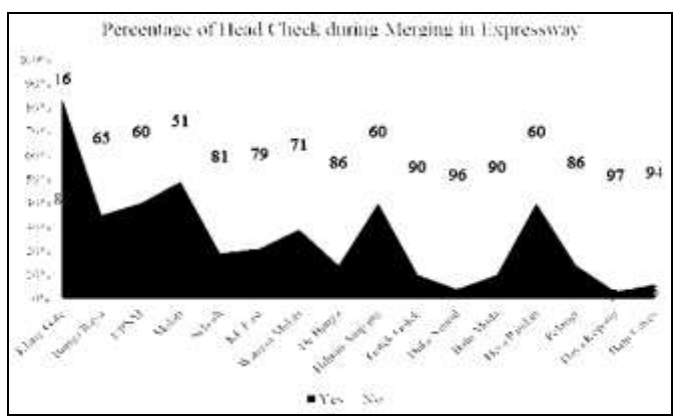

Figure (2) Percentage of head check during merging in expressway

The average percentages were calculated and it shows that the percentage of motorcyclists who did not performed head check (73.9%) is higher compared to motorcyclists who did performed head check (26.1%). The different of the percentages is 47.8%. The result was then analyzed by using

Significant Difference Test [25]. In this test, four data were required to be filled: (i) total count of the head check performed (n=418); (ii) total count of head check did not perform (n=1182); (iii) percentage of head check performed (26.125%); and (iv) percentage of head check did not perform (73.875%). The output given at 95% confidence level was 4.9%. Thus, the results were significant as the percentage difference (47.8%) was higher than the required percentage (4.9%).

Using SPSS software (version 23), the 16 data were analyzed by looking at the regression line for the best interpretation of the relationship between the lengths of the merging lane with the motorcyclists' head check behavior during merging in the expressway. There are three types of regression scatter plot lines model were analyzed to get the best-fitted line of the data. They are (i) Linear Regression Line Model; (ii) Quadratic Regression Line Model; and (iii) Cubic Regression Line Model. The analysis shows that the correlation value (R^2) for each model is 0.373, 0.474, and 0.644 for Linear, Quadratic, and Cubic model respectively. Since the correlation value for the Cubic Model is closer to 1, i.e. the best-fitted model, the Cubic Model equation $y = 93.1 – 1.54 x + 9.38E\text{-}3 x^2 – 1.76E\text{-}5 x^3$ is the most profound results. Figure (3) illustrates the cubic regression line model output from the SPSS.

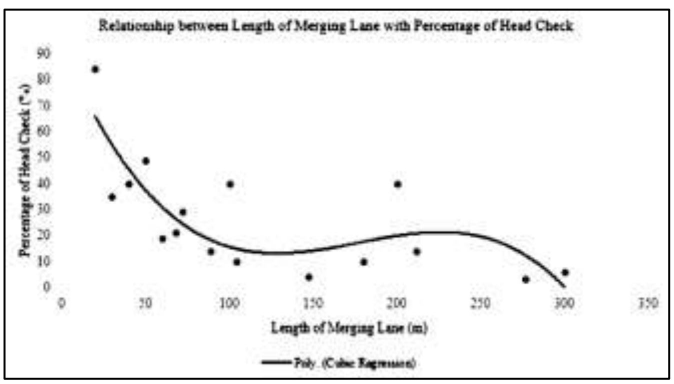

Figure (3) Cubic regression line model

Figure (3) above was redrawn as Figure (4) below in which illustrates the relationship between the length of merging lane and motorcyclists' head check behavior – utilizing the Cubic Regression Line Model.

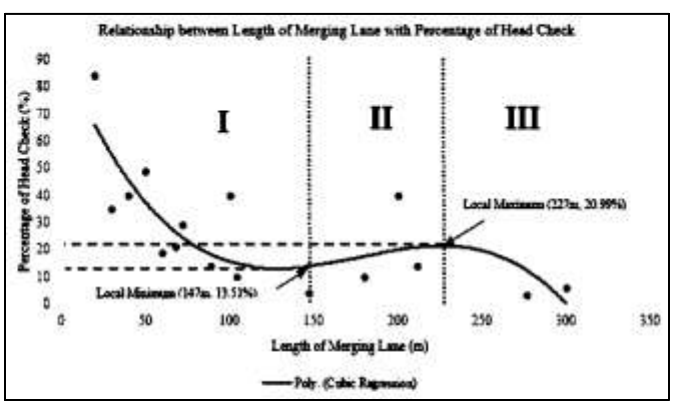

Figure (4) Relationship between the percentage of head check and length of merging lane

There are two local extrema points in Figure (4) – one local minimum and one local maximum. Vertical dotted lines were drawn at each local extremum point which resulting the local minimum and maximum to be at 147 meters and 227 meters respectively. Then horizontal dotted lines were drawn at each local extremum point which resulting the local minimum and maximum to be at 13.51% and 20.99% respectively. The horizontal dotted lines in Figure (4) also resulting in the length of the merging lanes (X-axis) to be categorized into three ranges named range I, II, and III. The range I is less than 147 meters (named as shorter merging lane length), Range II is between 147 – 227 meters (named as average merging lane length), and Range III is more than 227 meters (named as longer merging lane length). As can be seen in Figure (4), Range I and III shows are showing a decreasing trend in the percentage of the head check performed. In contrast, Range II is showing an increasing trend in the percentage of the head check performed.

The range I (in Figure (4) above) on average has a higher percentage of head check in comparison to other ranges. This is parallel with the discussion by Zabidi et al., [11] where motorcyclists tend to perform a higher percentage of head check at the shorter merging lane. The reason for this is motorcyclists at shorter merging lane do not have an ample time to look in the side mirror. As stated by Chu et al., shorter acceleration lane results in fewer opportunities for vehicles to merge into the main lane [18]. However, a decreasing trend in the percentage of head check indicates less awareness among motorcyclists in performing a head check before merging into traffic and the length is considered not safe.

In Range II (in Figure (4) above), there is an increasing trend in the percentage of the head check. Even though the behavior of motorcyclists was contradicted from the expected behavior (the longer the length of the merging lane, the lower the percentage of the head check) it demonstrates that the awareness of motorcyclists to perform head check was gradually increasing. At this range, perhaps, motorcyclists have an adequate amount of time to stable the manoeuvre of his or her motorcycle and positioning himself in relative to the traffic's speed for a safe entering gap before merging into traffic [14]. The local maximum (in Figure (4) above) indicates the optimal length of the merging lane is at 227 meters. However, the whole length of Range II can be considered as safe considering the increasing trend in head check behavior.

Range III on average has a similar percentage of head check in comparison to Range II. Although some of the points in Range III has a higher percentage of a head check than some points in Range II there is no point to consider a longer length (more than 227 meters) as the optimal length of merging lane is 227 meters (the local maximum). Moreover, Chu et al. stated that longer merging lane may not provide any benefit to the vehicles during merging, rather than, adding cost for the construction and maintenance of the lane [18].

4. DISCUSSION

Based on the research question, which is to evaluate motorcyclists' head check behavior during merging in urban expressway, the study found that almost three-quarters (73.88%) of the motorcyclists did not perform head check during merging in the expressway. This result is congruent with the study by Zabidi et al., [11] where motorcyclists tend to performed less head check towards potential hazard (at the target zones) during merging in traffic in both highway and town without U-turn environments. It is a risky riding behavior made by the motorcyclists as the head check is crucial to eliminate motorcyclist's blind spot and at the same time to detect any incoming vehicles (hazard) from the road to be merged [10-11]. The cause of this risky riding behavior may be due to aggressive riding, lack of experience, or lack of knowledge by the motorcyclist and lack of training in driving/riding system in Malaysia. As of now, to obtain motorcycle driving license, three phases need to be followed. The first phase is KPP01 (theory test), then KPP02 (skill test) and lastly, KPP03 (road test-controlled track for B2 license). In KPP01, a blind spot is mentioned in general as awareness procedure for changing lane, overriding traffic and entering an intersection. However, the importance of it during merging is not mentioned. During the KPP02, the skills that are being measured are 8 turns, bridge crossing, serpentine ride and emergency brake. Head check is performed only at the start of KPP03 before participant start to ride motorcycles. Besides that, failing to perform head check is not considered as a mandatory fail for the test [26]. In order to encounter risky driving/riding problem, a new driving curriculum has been developed by the Malaysian government which focuses on the hazard perception skills and response time. A study by Ibrahim shows those who received the new curriculum perceived hazard faster than the old curriculum [27]. However, the content is not emphasized on the merging situation. Thus, it could be improved considering the finding of this study.

Two outlier data were observed in the results (triangle shape, in Figure (5) below). These outlier data are differing from its adjacent data (box shape, in Figure (5) below). They occurred probably because of other contributing factors that may or may not affect the motorcyclists' head check behavior.

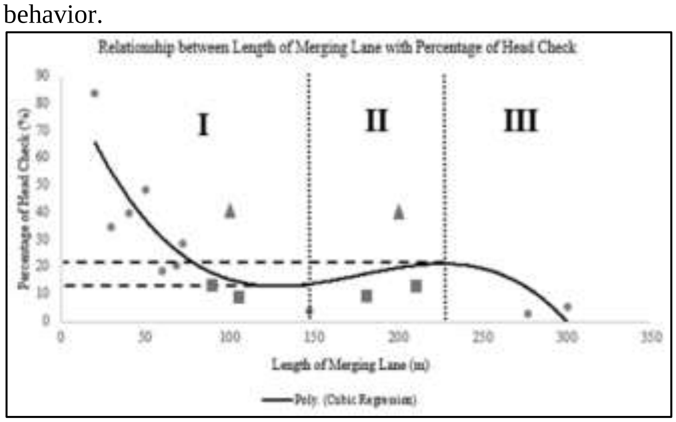

Figure (5) Outlier data (represent by the triangle shape)

The possible factors are: (i) the length of the physical nose; (ii) the shape of the entrance ramp – either curve or straight line, and (iii) surrounding vegetation. An analysis, in term of these three possible factors, was performed to investigate if there were any differences between the outlier scenarios with its adjacent scenarios. It was found that the shape of the entrance ramp of the outlier data differs from both its adjacent data. Both outlier scenarios have a curve entrance ramp while their adjacent scenarios have a straight entrance ramp. This difference probably affects the head check behavior among the motorcyclists during merging into the expressway, and only future research can answer it. There were no differences between those scenarios in term of length of the nose and surrounding vegetation.

5. CONCLUSIONS

In general, the number of motorcyclist who performed a proper head check during merging in traffic is very low. It was also found that the shorter merging lane may force motorcyclists to performed more head check. In contrast, the longer merging lanes show a decreasing trend of the head check made by motorcyclists. The optimal length of merging lane found in this study is between 147m to 227m. Findings from this study provide a useful insight into the behavior of motorcyclist in general, particularly motorcyclists head check behavior during merging in expressway, in which, would assist in improving the current riding education curriculum. The finding also would provide a guideline in designing a safer merging area i.e. the optimal merging lane length.

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*For correspondence; Tel. + (60) 189794123, E-mail:ammarcloud@gmail.com
**For correspondence; Tel. + (60) 132665576, E-mail: abdmalek@iium.edu.my