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Riding Hazards and Crash Risks Facing Malaysian Courier Riders in the Last Mile Delivery

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Abstract – *This study aims to determine the types of hazards and crash risks facing courier riders during delivery trips by recording the riding scenarios on their actual delivery route. A digital camera and a hands-free camera harness were used to hold the camera at the chest level to record the riding scenarios. Fifteen courier riders in the Klang Valley, Malaysia participated in the study. The final analysis reveals that a courier rider encounters 30 hazardous riding events and 5 near misses on average for each hour of delivery trips. Two-thirds of all hazardous riding events were instigated by road users, including the participants themselves. Interestingly, the participants' own riding behaviours contributed to almost a third (29%) of the total near misses. Obstruction of view was found to increase the odds of causing a near miss by 4.61 times compared to hazards related to driving behaviours of other motorists. Further, incidents related to lane changing or overtaking manoeuvres were found to have 7.81 times higher odds of causing a near miss compared to incidents related to braking or sudden stopping. The classification of hazards and risk assessment presented in this study should be seriously considered for better operation management and defensive driving training.*

Keywords: Motorcyclists, riding hazards, courier riders, last mile delivery, transportation planning

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1.0 INTRODUCTION

Every year, around 2.2 million work-related fatalities occur around the globe, with 1.7 million fatalities linked to occupational diseases, while another 350,000 are related to accidents at work, and 158,000 are due to commuting crashes (International Labour Organization, 2016). In Malaysia, recent data suggest that the number of commuting or road crashes involving employees is on the rise from 24,809 crashes in 2011 to 28,579 crashes in 2015; hence indicating a 15.2% increase (Social Security Organisation (SOCSO), 2018). Due to their higher on-road exposure, courier and postal delivery workers are more likely to be involved in a road crash. In the first half of 2017, 16,495,042 domestic parcel deliveries have been recorded throughout the country; marking a 41.2% increase compared to the first half of 2016 (Malaysian Communications and Multimedia Commission (MCMC), 2018). These delivery trips could amount to an average of 45,819 trips per day. For courier riders who use a motorcycle for delivery, the risk of road crashes is even higher. MCMC data reveal that 59.8% out of 19,638 courier vehicles used by the postal and courier companies in Malaysia are motorcycles, indicating that courier riders are heavily employed for parcel and document delivery. In addition, courier riders are exposed to higher crash risk on Malaysian roads due to the mixture of high-speed motorised traffic and other vulnerable road users (e.g., pedestrians and cyclists) especially in busy urban areas. This traffic pattern has been identified as one of the factors influencing exposure to risk of road traffic injuries (World Health Organisation (WHO), 2004).

1.1 Hazards Perception and Avoidance Skills as Predictors of Crash

Previous studies have identified the skill to perceive and avoid hazards as one of the predictors of a road crash. The view that a driver's ability to perceive hazards influences his or her crash involvement has been supported in many studies. For instance, a significant association between hazard perception test score with police reported crashes was reported by Congdon (1999) and Wells et al. (2008). Hazard perception has also been found to be highly correlated with self-reported road crashes involvement (Darby et al., 2009; Horswill et al., 2010). Another study by Cheng et al. (2011) reported a link between history of road crashes and difficulties to identify hazardous situations among motorcyclists. These findings ultimately point to the influence of hazards along the road on the risk of road crashes facing courier riders every time they are out delivering parcels and documents.

The lack of skill to avoid hazards is another crash risk factor, which should be treated independently from hazard perception skill. Hazard perception by itself is insufficient for safe driving without the skill to respond to such hazard (Haworth et al., 2000). A previous literature review has reported that hazard perception and avoidance skills should be the main target skills for an impactful driver training (Beanland et al., 2013). On the other hand, desensitization of potential crash risks from any riding scenarios can happen to courier riders with fixed delivery routes. Overexposure to these scenarios during their daily delivery runs may cause the courier riders to become less alert to certain hazardous riding scenarios. Ibrahim and Ab Rashid (2016) reported the link between desensitization and late response to on-the-road hazards among motorcycle riders in Malaysia. Thus, the main goal of this study was to use a naturalistic riding data to profile the types of hazards facing courier riders along their delivery routes. The data was supplemented with an analysis of the recorded participants' pre-event manoeuvres to determine the degree of hazards and the likelihood of a crash.

2.0 METHODOLOGY

Methodology of the study comprises selection of participants, recording apparatus and procedures.

2.1 Selection of the Participants

A convenience sampling method was used to recruit participants of this study. Courier companies were randomly approached to seek their participation. Courier riders from the participating companies were then randomly selected based on the unique delivery routes assigned to them by the companies. Fifteen courier riders were recruited as participants of the study. All the participants signed an informed consent form and were aware of the procedures involved. All the delivery trips in this study were within the Klang Valley, Malaysia. The Klang Valley includes the city of Kuala Lumpur and its adjoining towns in the state of Selangor.

2.2 Recording Apparatus and Procedures

The recording apparatus consisted of an SJCAM SJ500 digital camera and a hands-free camera harness to keep the camera at the chest level of the participant (Figure 1).

Figure 1: The recording apparatus used in the study

Researchers conducted a briefing and training session for each participant on the actual data collection day. Due to limited power supply and capacity of data storage, participants were asked to turn the camera on only when they commence their delivery trips and to turn the camera off upon arrival at each delivery point. An additional memory card, battery, and a battery charger were prepared for participants to prevent interruption of the video recording.

3.0 RESULTS AND DISCUSSION

The final data set consisted of 12 hours of recorded riding trips. The recorded videos were analysed manually to identify crash-relevant events including near miss and actual crash. Relevant riding hazards and the pre-event manoeuvres related to such hazardous scenarios were coded into a datasheet. Observations were coded numerically by counting the number of times each category of hazards or events of near miss were encountered by the participants. An event was coded as a near miss when either one of the following situations was observed:

- Participants braked abruptly to slow down the motorcycle,
- Participants performed an evasive manoeuvring to avoid a collision, and
- Any unexpected and unsafe riding scenario that was deemed susceptible to crash.

3.1 Classification of Hazardous Riding Events and Near Misses

The analysis had resulted in a classification of 361 hazardous riding events throughout the 12 hours of recorded delivery trips. Classification of the hazardous events was based on the primary source of riding hazards. Eight different sources of riding hazards were identified, which can be further categorized into road user related hazards and non-road user related hazards. Three emergent commonalities of hazards were identified for the road user related hazards namely driving behaviours of other motorists, participants' riding behaviours and behaviours of pedestrians. Table 1 lists the description and prevalence of road user related hazards. Non-road user related hazards were categorized into hazards related to obstruction of view, road surface issues, construction and maintenance works, objects on road and others. Table 2 lists the descriptions and prevalence of non-road user related hazards.

Out of 361 hazardous riding events, 66 events were classified as near misses. On average, participants encountered 30 hazardous riding scenarios and 5 near misses for each hour of delivery trips. Half of all near-miss incidents were related to driving or riding behaviours of other motorists. Interestingly, incidents caused by participants' own riding behaviours contributed to almost a third (29%) of the total near misses, making them the second most dangerous category of riding hazards. Another 14% of all recorded near misses involved pedestrians and cyclists. Obstruction of view was also a notable source of hazards that led to near misses, contributing 6% of all recorded incidents. No cases of near misses were recorded for incidents involving hazards related to construction/maintenance, cyclists, objects on road and others. Figure 2 shows the distribution of all events and near misses across all categories of hazards.

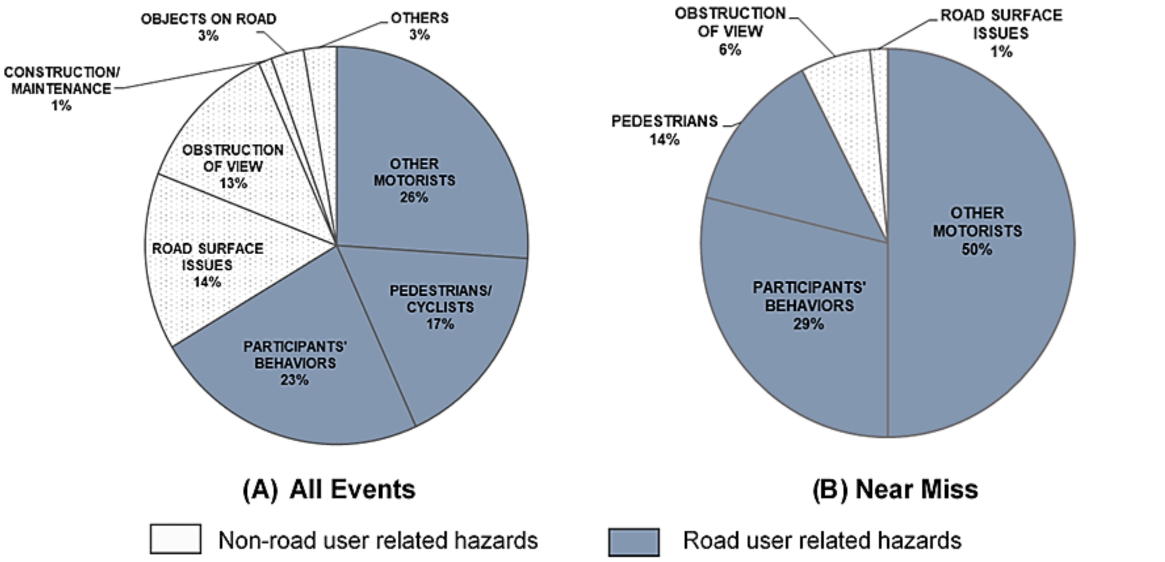

Figure 2: Distribution of hazardous riding events and near miss

Table 1: Prevalence of hazardous riding events associated with road user related hazards

Description of Hazards	Number of Events	Prevalence in Road User Related Hazards (%)	Prevalence in All Hazards (%)
Driving/riding behaviours of other motorists			
Braking	29	12.0	8.0
Having trajectory crossing participants' trajectory	23	9.6	6.4
Encroachment of participants' riding path	19	7.9	5.3
Unsafe lane changing or merging	14	5.8	3.9
Reversing towards participants	4	1.7	1.1
Motorcycle riding wrong way	3	1.3	0.8
Running red light	2	0.8	0.6
Participants' riding behaviours			
Unsafe lane filtering	30	12.5	8.3
Not stopping at unsignalised junction	20	8.3	5.5
Riding on pedestrian facilities	7	2.9	1.9
Riding wrong way	5	2.1	1.4
Late overtaking	5	2.1	1.4
Close following	4	1.7	1.1
Illegal U-turn	4	1.7	1.1
Unsafe turning at unsignalised junction	3	1.3	0.8
Distracted riding	2	0.8	0.6
Riding on unpaved shoulder	2	0.8	0.6
Unsafe lane changing or merging	2	0.8	0.6
Pedestrians and cyclists			
Crossing at undesignated places (jaywalking)	24	10.0	6.6
Obscured by traffic	15	6.3	4.2
Waiting to cross on the roadside	7	2.9	1.9
On pedestrian crossing when participants' have the right of way	6	2.5	1.7
Utility worker working on the roadside	4	1.7	1.1
Walking on the roadside next to riders	3	1.3	0.8
Children on the roadside	2	0.8	0.6
Bicyclist encroached participant's riding path	1	0.4	0.3
Total	240	100	66.5

Table 2: Prevalence of hazardous riding events associated with non-road user related hazards

Description of Hazards	Number of Incidents	Prevalence in Non-road User Related Hazards (%)	Prevalence in All Hazards (%)
Obstruction of view			
Parked vehicles on the roadside	29	24.0	8.0
Obscured unsignalised junction	15	12.4	4.2
Hedges and landscaping greenery	1	0.8	0.3
Road surface issues			
Potholes	14	11.6	3.9
Uneven surface due to poor resurfacing works	11	9.1	3.0
Depression in asphalt surface	10	8.3	2.8
Uneven surface due to manhole	7	5.8	1.9
Leftover concrete mix	5	4.1	1.4
A sudden change in surface types	5	4.1	1.4
Construction and maintenance works			
Closure of riding lane and shoulder	3	2.5	0.8
Dug out adjacent lane	1	0.8	0.3
Objects on road			
Construction waste bin	3	2.5	0.8
Construction materials	3	2.5	0.8
Portable traffic barrier	2	1.7	0.6
Sizable debris	2	1.7	0.6
Others			
Unmarked road humps	10	8.3	2.8
Total	121	100	33.5

3.2 Factors Affecting the Likelihood of a Near Miss

A logistic regression analysis was performed to predict the likelihood of a near miss encountered by the courier riders, using the category of hazards and types of pre-event manoeuvre as the predictor variables. The pre-event manoeuvre was categorized based on the driving or riding manoeuvres committed by or associated with the primary source of hazards. The two predictor variables were entered into the models as dummy variables, coding four category of hazards and eight pre-event manoeuvres respectively. Logit models were selected because the coefficients in logit models are interpretable as an odds ratio, which is more appropriate to explain the impact of predictor variables on the likelihood of a near miss. In addition, multinomial logit models are associated with simpler computational implementation compared to multinomial probit models (Cheng & Long, 2007; Hausman & McFadden, 1984). We tested a certain number of model configurations using the Nagelkerke R^2 values to obtain the best logistic model. The best model was obtained with an exclusion of some data entry, involving hazard categories with small sample size. In addition, a substantial improvement of Nagelkerke R^2 value (from 0.230 to 0.438) was observed when the constant was excluded from the model. The final model (versus a model with intercept only) was found to be statistically significant, $\chi^2(10, N = 276) = 109.83$, $p < 0.001$. The model correctly classified 96.6% of no near miss incidents and 17.6% of near miss incidents, for an overall success rate of 77.2%.

Table 3 shows the logistic regression coefficient and summarizes the test results. The Wald criterion indicated that one dummy variable for the categories of hazards and four types of dummy variables for pre-event manoeuvres had significant partial effects in predicting near miss incidents. The category of hazards was dummy coded using hazards related to obstruction of view as the reference. Hazards related to driving behaviours of other motorists had a less significant effect on the odds of a near miss, compared to hazards related to obstruction of view. Inverted odd ratios indicate that the odds of a near miss for hazards related to obstruction of view were 4.61 times higher than hazards related to driving behaviours of other motorists. No other category of hazards had a significantly different effect on a near miss than hazards related to obstruction of view.

The variables for the types of pre-event manoeuvres were dummy coded using braking or sudden stopping as the reference. Two types of pre-event manoeuvre had significantly higher odds of causing a near miss than braking or sudden stopping. Events related to lane changing or overtaking manoeuvres had 7.81 times higher odds of causing a near miss than braking or sudden stopping. Further, events categorized as lane encroachment or trajectory crossing had 4.42 times higher odds of causing a near miss than braking or sudden stopping. Two other pre-event manoeuvres were found to have significantly lesser odds of causing a near miss compared to braking or sudden stopping. Inverted odd ratios indicate that the odds of a near miss for braking or sudden stopping were 3.79 and 2.73 times higher than manoeuvres related to riding forward within a lane without lane filtering and turning or crossing at a junction, respectively. No other types of pre-event manoeuvre had a significantly different effect on near miss than braking or sudden stopping.

This study discovered that two-thirds of all hazardous riding events were instigated by road users, including the participants themselves. Interestingly, drivers of passenger cars and motorcyclists were reported to be responsible for approximately the same fractions of fatal motorcycle crashes in Malaysia (Abdul Manan & Várhelyi, 2012). The five most frequent causes of a hazardous event included participants' lane filtering manoeuvres, followed by other motorists' braking behaviours, pedestrian crossing roads at undesignated places and obstruction of view related to parked vehicles on the roadside and obscured unsignalised junction. Even though our analysis did not yield any significant relation between lane filtering and the odds of a near miss, crashes involving improper weaving through traffic and crossing the center line was found to be among the most serious for delivery-purpose motorcyclists (Chung et al., 2014). Hazards related to obstruction of view and pre-event manoeuvres related to lane changing and overtaking were found to be the riskiest for courier riders. Among the limitations discovered in this study were the lack of riding speed and time-to-collision data. On the other hand, classification of a near miss incident can be made more accurate with the measurement of the force related to braking and acceleration. For motorcycle riding, an average lateral acceleration of 0.47 g was found by a local study to be the critical value of an uncomfortable overtaking (Ibrahim et al., 2018).

Table 3: Binary logistic regression analysis results

Predictor Variable	***B***	***SE***	**z ratio**	**Wald χ^2**	***p***	**Odds Ratio (95% CI)**
Category of hazards						
Participants' riding behaviours	-0.996	0.586	-1.701	2.893	0.089	0.369 (0.116, 0.601)
Other motorists' driving/riding behaviours	-1.528**	0.447	-3.416	11.668	0.001	0.217 (0.253, 3.362)
Pedestrian (not obscured)	-1.118	0.639	-1.750	3.064	0.080	0.327 (0.094, 1.143)
Obstruction of view	Reference case					
Types of pre-event manoeuvre						
Riding forward within a lane (no lane filtering)	-1.331**	0.419	-3.176	10.090	0.001	0.264 (0.116, 0.601)
Lane filtering or lane splitting	-0.081	0.660	-0.123	0.015	0.902	0.922 (0.253, 3.362)
Close following	0.996	1.159	0.860	0.739	0.390	2.708 (0.279, 26.254)
Lane changing or overtaking	2.055**	0.680	3.021	9.125	0.003	7.805 (2.058, 29.606)
Turning or crossing at all types of junction	-1.006*	0.457	-2.202	4.848	0.028	0.366 (0.149, 0.895)
Riding at undesignated places or against the traffic	-0.837	0.812	-1.031	1.063	0.303	0.433 (0.088, 2.127)
Lane encroachment or trajectory crossing	1.487**	0.531	2.802	7.848	0.005	4.423 (1.563, 12.517)
Braking or sudden stopping	Reference case					

Summary statistics
Model χ^2 = 109.83, $p < 0.001$
Pseudo $R^2 = 0.438$
Hosmer and Lemeshow test χ^2 = 6.27 (DF = 7; p = 0.509)
The number of correctly predicted near miss: 56 (17.6%)
The number of correctly predicted no near miss: 201 (96.6%)
N = 276

*$p < 0.05$. **$p < 0.01$.

4.0 CONCLUSION

Findings of this study have a number of important implications for policies and initiatives related to safety of motorcyclists in general and courier riders in particular. For instance, an average 30 hazardous riding scenarios and 5 near misses encountered by participants for each hour of delivery trips should not be taken lightly. This study recommends route safety assessment to be conducted to minimize risk. In addition, relevant training modules and risk mitigation initiatives should be seriously considered by the relevant industry players to ensure safety of courier riders. Further, inclusion of hazard perception training and test modules in the pre-license motorcycle riding curriculum is highly recommended due to the lack of skills as discovered in this study.

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