

Data Mining on Motorcyclists' Behaviour among Commuting Workers in Malaysia

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ABSTRACT

Commuting is a process to travel from one place to another. In the context of workers, they need to commute from their residences to their workplace or otherwise, usually every day. However, the risk to involve in road crashes during commuting is high for such a group in Malaysia. According to statistics from the Social Security Organisation (SOCSO), the trend of commuting accidents in Malaysia has consistently increased year after year. Compared to 17,609 cases in 2003, the number of cases rose almost double to 33,319 cases in 2017, and most of the travellers involved commuted by motorcycle. This study aims to explore the risky riding behaviours at signalised intersections among commuting workers on motorcycles. A total of 33,122 workers commuting by motorcycles were observed at six intersections during six days in Terengganu. Two risk behaviours (helmet non-use and turn signal neglect) were observed together with demographic and contextual factors. Data mining approach – decision tree models for helmet non-use and turn signal neglect were performed based on a 10-fold cross-validation technique, with the demographic and contextual explanatory factors. The results showed that non-use helmet among commuting workers significantly related to carrying passenger, gender, day of the week, and time of the day. Predicted factors related to turn signal neglect behaviour included carrying passenger, gender, type of junction, number of lanes, and day of the week. Findings from this research can help safety department in workplaces to include awareness regarding these behaviours in their training program.

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1. Introduction

Malaysia is among the developing countries that are showing a rapid growth in industrialisation, economy and population. Before the COVID-19 (Coronavirus) pandemic spread around the world, Malaysia was projected to shift from an upper-middle-income economy country to a high-income economic country in 2024 (The World Bank, 2020). In terms of population, compared to the first quartile of 2017 growth of about 0.8 million, Malaysia's population increased by 32.73 million in the fourth quartile of 2020 (Department of Statistics Malaysia, 2021). Consistent with this growth, the motorisation demand also increases each year. Based on statistics from the Road Transport Department Malaysia, the number of active vehicles registered in 2008 was 13,587,457 and rose to 18,619,514 in 2015 (Road Transport Department, 2016). Due to the high demand of travelling, some cities in Malaysia such as Kuala Lumpur, Johor Bahru, and Penang are confronting traffic congestion. A study by Hasmita et al. (2018) revealed that the maximum duration road users are trapped in traffic congestion is up to 45 minutes in Kuala Lumpur. As an alternative, the motorcycle has been chosen by workers for daily commute. The other reasons for selecting motorcycle over passenger car or public transport as the commuting vehicle include low price,

insurance rates, running cost, availability of licence offer for people ages 16 years old, and ease of use during congested roads (Oxley et al., 2013).

In Malaysia, road traffic crashes have become a noteworthy issue to tackle by the government. The number of traffic crashes increases each year and rose to 548,598 cases in 2018 (Ministry of Transport Malaysia, 2019). In Southeast Asia, Malaysia has become the country with the second-highest recorded fatalities in road crashes after Thailand with 24 deaths per 100,000 populations (WHO, 2018). The effect of road traffic crashes is not only on the victim or victim's family but also on the country. For example, Malaysia lost about RM1.9 billion in traffic crashes in 2016 (Ling, 2017). Based on crash statistics, passenger car is the most common type of vehicle involved in a traffic crash (Ministry of Transport Malaysia, 2019). However, in terms of fatality, motorcycle recorded higher fatalities compared to the other types of vehicles (Manan et al., 2012). There is room for more research to understand the trend and factors associated with crash occurrence and fatalities involving motorcycles in Malaysia.

According to the International Labour Organisation (ILO), commuting accidents refer to accidents that occur between the workplace and workers' either principal or secondary residence. This includes the accidents that occur between the place workers take meal

or place where workers get paid by employers (International Labour Organization, 2017). In Malaysia, the Social Security Organisation (SOCISO) define commuting accident as the accidents that happen on the route from residence or place of stay to workplace, including any journey related to the workers' job or having meal during allocated times (Bakar, 2018). McNoe et al. (2005) found that work-related crash fatalities during commuting significantly contributed to the number of work-related fatalities in New Zealand. They revealed that the rate of deaths among workers between 1985 and 1998 during commuting was higher at 0.89 per 100,000 workers per year compared with the total number of worker's deaths, which was 1.1 per 100,000 workers per year. A study in France (Charbotel et al., 2010) identified that work-related accidents varied slightly over the decade, where 10% of such accidents occurred while at work and 18% occurred while commuting. In Malaysia, the number of traffic crashes involving commuting workers has also shown a growth rate. For example, in 2017, the number of cases rose up to 33,319 cases compared to 17,609 cases in 2003 (Bakar, 2018). The total compensation paid to crash victims or family in 2017 was RM1.3 billion (Bakar, 2018). It is crucial to reduce crashes involving commuting workers for the nation's development.

There are many factors that influence traffic crashes involving commuting workers. Salminen (2000) found that females and married people had a significantly lower degree of contribution to the crash, while adults of ages 50 to 65 years old were found mostly involved in traffic crash related to work. A continuous study by Salminen et al. (2002) identified that time pressure, tiredness, thinking about work during driving, and usage of mobile phone were the risk factors in driving working hours. Souto et al. (2016) profiled victims of work-related road traffic accidents in Brazil from 2012 to 2014. They found that majority of crash involved people who were males (87.8%), aged 20 to 39 years old (69.0%), drivers (82.0%), used motorcycle (82.0%), worked in sectors of transport (24.4%) and trade (21.3%). A study conducted on professional drivers in Spanish identified that commuting crashes were associated with demographic and job-related variables of professional drivers (Llamazares et al., 2019). Additionally, they also revealed that gender and temporal factors (such as peak hours) explained different trends in crashes involving commuting workers. In Malaysia, Jamaluddin et al. (2013) analysed 377 commuting crashes in Klang Valley using claims data from 2009 to 2010. They found that 83% of the traffic crashes involved males and 92.2% of them rode motorcycles. Selamat et al. (2015) conducted an analysis using five years of crash data about commuting workers in Malaysia and found that individual and family factors, work burden, workplace support, bad weather, and road conditions contributed to commuting crash, and motorcycle was the most common vehicle used by commuting workers who were involved in traffic crashes. A study focusing on healthcare workers in Malaysia identified that adults of ages 50 years and above, were environmental health assistant, male and travelled from residence to workplace was the highest group involved in traffic crashes (Zuwairy et al., 2020). Sukor et al. (2018) reviewed the guidelines in Malaysia related to commuting workers in the construction sector. They concluded that safe commuting factors can be divided into four categories, which are drivers, vehicles, environments, and others. These findings revealed that risky behaviours among commuting workers are associated with many factors. However, limited research has observed risk-taking behaviours of commuting workers along roadside, especially at signalised intersection.

Helmet was designed to protect motorcyclists from head injury when crash happens. There are many studies that have identified that helmet could reduce the impact of crash on motorcyclists. For example, a systematic review conducted by Kim et al. (2015) wearing helmet could reduce the severity of crashes and hospitalisation cost. However, some motorcyclists were not fully aware of the importance of helmet wearing. A study in Hai Dung Province, Vietnam observed that only 23% of motorcyclists wore helmet (Hung et al., 2008). A cross-sectional study in Wa, Ghana revealed that out of 14,467 motorcyclists observed, only 36.9% used helmet when riding

motorcycle (Akaateba et al., 2014). The same findings were also discovered by the study conducted in Thailand, whereby it was found that only 30% of adolescent motorcyclists wore helmet (Tongklao et al., 2016). Bolbol et al. (2018) conducted a cross-sectional study about 319 motorcyclists involved in traffic crashes and admitted to hospitals in Egypt. It was revealed that only 1.9% of them wore helmet when crash happened. A study in Myanmar observed 124,784 motorcyclists using pre-recorded videos and discovered that 51.5% of motorcyclists wore helmets (Siebert et al., 2019). In Malaysia, an observation of 100 motorcyclists by Kulanthayan et al. (2000) found that 24.2% did not wear helmet and another 21.4% did not wear the helmet properly. However, contradictory results were found for worker motorcyclists. Oxley et al. (2013) conducted a survey on commuter motorcycles in Klang Valley and observed that majority of motorcyclists and pillioners wore helmets. The same findings were also found in study about industrial workers commuting to work in Bangi, Selangor (Alias et al., 2020).

The way of communication between road users is another issue that needs to be considered in road safety. The drivers need to know manoeuvre of other vehicles along the highway. For this reason, the vehicles are equipped with turn signal at the front, side, and rear. However, previous studies identified most of the drivers do not give much attention to the usage of signal when making a turning. Outcome from this behaviour yield more crashes than distracted driving in the U.S. (Ponziani, 2012). In terms of motorcycles, there are findings that showed that motorcyclists avoided using a signal when made a turning. A study in Taiwan applied a self-report survey to the motorcyclists and identified that the majority of motorcyclists were involved in risky behaviours such as neglect in giving turn signals at intersections (Chang et al., 2007). Nguyen-Phuoc et al. (2019) found that travelling with passengers on weekdays, outside of the city centre, on roads without separate car lanes, with pedestrian crossing and traffic lights were associated with turn signal neglect behaviours in Vietnam. A study in Malaysia found that imperfect turn signal was significantly associated with motorcycle road crashes (Sapuan et al., 2016). Rusli et al. (2020) identified that turn signal neglect commonly occurred during weekend and peak hours. Furthermore, males, solo motorcyclists, and riding on clear weather had higher chances of showing behaviours of turn signal neglect.

The main objective of this study is to explore the risky riding behaviours at signalised intersections among workers who commute on motorcycles in Malaysia. Two main risky behaviours were focused on this study: helmet non-use and turn signal neglect. The selection of these two risk behaviours were based on the analysis conducted by Rusli et al. (2020). This study found out of 72,377 observations, 4,315 (6.0%) were observed helmet non-use and 21,484 (29.7%) neglect to active their signal. It was mentioned here that turning signal neglect behaviours were only observed from the approaches without exclusive or dedicated right or left turn. In addition, rider demographics and contextual factors were also observed to identify the association between the risky behaviours mentioned above. Findings from this investigation can give some input to companies in designing safety program targeted towards workers who commute by motorcycle.

2. Method

2.1. Data Description

The dataset of this study was collected in two districts in Terengganu, Malaysia: Kemaman and Dungun. These districts have been known as one of the biggest oil gas industry parks in Malaysia with 386,600 population covering 527.1 km² area (UPE, 2017). There are many oil industry workers who commute every day from their residents to different companies located in this area. Six intersections were selected for data collection along the main road from Kemaman to Dungun. Traffic census in 2015 identified 25% of traffic composition was motorcycle (Ministry of Works Malaysia, 2016).

Data of risky behaviours (helmet non-use and turn signal neglect) was collected manually by two trained research assistants (RAs) at

each selected intersection together with data of traffic counts, demographic of the motorcyclists, and contextual characteristics. During this process, the RAs stood at safe places with visibility of the intersection and out of visibility of the motorcyclists.

In this study, the main criteria to identify commuting workers was based on the industrial uniforms that they wore during riding. Demographic and contextual characteristics included: gender (male or female), carrying passenger (yes or no), day of the week (weekdays or weekends), time of the day (peak or off-peak hours), weather condition (clear or rain), type of junction (T/Y-junction or cross-junction), number of lanes (single or multiple), and approach of the motorcyclist to the intersections (from a major or minor road). Observations were conducted for six days from 7.00 am to 11.00 am, and a total of 33,122 commuting workers using motorcycle were observed. The selection of variables in this study was based on findings from previous studies. For example, it was observed that there were different behaviours of male and female motorcyclists (Akaateba et al., 2014; Hung et al., 2006; Setty et al., 2020; Siebert et al., 2019). In addition, solo motorcyclists behaved differently when riding with pillion (Nguyen-Phuoc et al., 2019).

In this present study, day of the week represented an observation between weekdays and weekend, time of the day represented peak and off-peak hours, where peak and off-peak hours were identified based on the report from traffic census from the Ministry of Works Malaysia that was along the selected road (Ministry of Works Malaysia, 2016). Peak hours were identified from 7.00 am to 9.00 am, and off-peak hours from 9.00 am to 11.00 am. In addition, weather data was collected to compare the effect of clear and rainy conditions on commuting workers' behaviours. For geometric information, three variables considered in this study were the type of junction, number of lanes, and approach of motorcyclists to intersection (either major or minor).

2.2. Data Analysis

This study applied one of the non-parametric analyses known as decision tree. This method has been widely used in road safety research. For example, Ospina-Mateus et al. (2021) used a decision tree as one of the analysis methods for the analysis of accidents of motorcyclists on Bogota roads in Columbia. Chang et al. (2019) employed a classification and regression tree to determine the relative contribution of illegal behaviours to motorcycle killed and severely injured crashes in Hunan, China. The Decision Tree Classification Model was developed by Dong and Zhou (2020) to identify factors associated to drivers' stop/go decisions at signalized intersections. In Malaysia, Rusli et al. (2018) combined decision tree and logistics regression techniques to model crash severity along mountainous highways. The advantages of this method are that it can easily interpret the complicated association in risk behaviour modelling, and the relationship between independent variables does not need to be identified. In addition, this method has the capability to capture interaction between independent variables through the structure of the tree (Rashidi et al., 2014).

The decision tree analysis classified the risky behaviours by segmenting the dataset into mutually exclusive and exhaustive subgroups. In this analysis procedure, the selection of independent and dependent variables was made initially. The Chi-square test using Automatic Interaction (CHAID) data mining algorithm, developed by Kass (1980), was used to identify the number of categories of independent variables based on significance level. The dependent variables (helmet non-use and turn signal neglect) and independent variables (gender, carrying passenger, day of the week, time of the day, weather, type of junction, number of lanes, and approach) were used as input for the decision tree. In this study, decision tree analysis was performed in the Statistical Package for the Social Sciences (SPSS) 20.0 to identify the best decision tree model. The first node in this tree was the most significant independent variable towards dependent variable and this tree continued to split until no significant independent variable was found. The significance level used in the

CHAID analysis was 5% with a maximum tree depth of 3 and minimum cases for a given node was 25.

3. Results

3.1. Descriptive Analysis

A total of 33,122 workers commuting by motorcycle were observed during six days at six intersections in Terengganu, Malaysia. Table 1 shows the summary of statistics of explanatory variables. It was shown that 94.7% of the workers who commuted by motorcycle were males, whereas, 96.6% of the commute workers rode motorcycle without carrying passenger. As expected, weekdays and peak hours had the highest proportion of workers who commuted, 85.2% and 86.4%, respectively. The highest number of workers were observed to ride during clear weather (98.6%). Additionally, a larger proportion of workers rode motorcycles for commute at T/Y-junction (60.0%), roads with multi-lane (94.8%), and approaching from major roads (84.8%).

Out of the total number of workers observed commuting by motorcycle, 2,188 (6.6%) were found with helmet non-use. The observation also made to motorcyclists who made a turn either to the left or right at the signalised intersections. It was observed that 12,444 workers made a turn during the observation period and 11,232 (90.3%) were observed to do turn signal neglect.

Table 1: Summary statistics of explanatory variables.

Variable	Category	Helmet Use		Turn Signal Neglect	
		Yes (%)	No (%)	Yes (%)	No (%)
Gender	Males	29,674 (94.6)	1,680 (5.4)	889 (7.8)	10,482 (92.2)
	Females	1,260 (71.3)	508 (28.7)	323 (30.1)	750 (69.9)
Carrying passenger	No	30,211 (94.4)	1,795 (5.6)	939 (8.1)	10,655 (91.9)
	Yes	723 (64.8)	393 (35.2)	273 (32.1)	577 (67.9)
Day of week	Weekdays	26,779 (94.9)	1,432 (5.1)	1,031 (9.8)	9,500 (90.2)
	Weekend	4,155 (84.6)	756 (15.4)	181 (9.5)	1,732 (90.5)
Time of day	Peak hours	26,936 (94.2)	1,667 (5.8)	1,000 (9.7)	9,280 (90.3)
	Off-peak hours	3,998 (88.5)	521 (11.5)	212 (9.8)	1,952 (90.2)
Weather	Clear	30,461 (93.3)	2,188 (6.7)	1,199 (9.8)	11,084 (90.2)
	Rain	473 (100.0)	0 (0.0)	13 (8.1)	148 (91.9)
Type of junction	T/Y-junction	18,441 (92.8)	1,431 (7.2)	742 (9.4)	7,183 (90.6)
	Cross junction	12,493 (94.3)	757 (5.7)	470 (10.4)	4,049 (89.6)
Number of lanes	Single	1,691 (98.0)	34 (2.0)	1,201 (10.5)	10,245 (89.5)
	Multiple	29,243 (93.1)	2,154 (6.9)	11 (1.1)	987 (98.9)
Approach	Major	26,514 (94.4)	1,571 (5.6)	1,029 (11.6)	7,857 (88.4)
	Minor	4,420 (87.8)	617 (12.2)	183 (5.1)	3,375 (94.9)

3.2. Decision Tree

Figure 1 shows the results of CHAID procedure on helmet non-use behaviour. Seven descriptors split the nodes into carrying passenger, gender, day of the week, and time of the day. Among the observation ($n = 33,122$), 6.6% were observed with helmet non-use, whereas 93.4% were found to use helmet. The first splitting variable was carrying passenger ($\chi^2 = 1532$, d.f. = 1, p -value = 0.000). In Node 1, 5.6% of the commuting workers without passenger were found with helmet non-use, and 35.2% of commuting workers with passenger were found with helmet non-use.

The second and third pruning trees were based on the variable gender. Node 1 was diverged into Node 3 and Node 4 ($\chi^2 = 791$, d.f. = 1, p -value = 0.000), and Node 2 was diverged into Node 5 and Node 6 ($\chi^2 = 250$, d.f. = 1, p -value = 0.000). About 4.8% of male motorcyclists who were not carrying passenger were found with helmet non-use. On the other hand, 21.6% of females who were not carrying passenger were found not to use helmet. For commuting workers with passenger, about 24.4% of male motorcyclists were not wearing helmet (Node 5), while 82.6% of female motorcyclists were observed not wearing a helmet (Node 6).

The next split was day of the week ($\chi^2 = 305$, d.f. = 1, p -value = 0.000). Node 3 ($n = 30,445$) was pruned into Node 7 ($n = 4,247$) and Node 8 ($n = 26,198$). About 10.1% of solo male motorcyclists were found not wearing helmet during weekend riding (Node 7). Additionally, about 3.9% of solo male motorcyclists were found not wearing helmet when riding during weekdays (Node 8). Time of the day split solo female motorcyclists (Node 4) into Node 9 and Node 10 ($\chi^2 = 95.508$, d.f. = 1, p -value = 0.000). It was found that about 16.8% of solo female motorcyclists did not wear helmet during peak hours period (Node 9), while 43.3% in non-peak hours period (Node 10).

Day of the week also split male ($\chi^2 = 44.054$, d.f. = 1, p -value = 0.000) and female ($\chi^2 = 21.420$, d.f. = 1, p -value = 0.000) motorcyclists with passenger. It was found that 43.9% of male motorcyclists with passenger were not wearing helmet during weekend (Node 11) and 19.8% during weekdays (Node 12). Lastly, about 92.2% of female motorcyclists with passenger were found not wearing helmet during weekend (Node 13) and 67.1% during weekdays (Node 14).

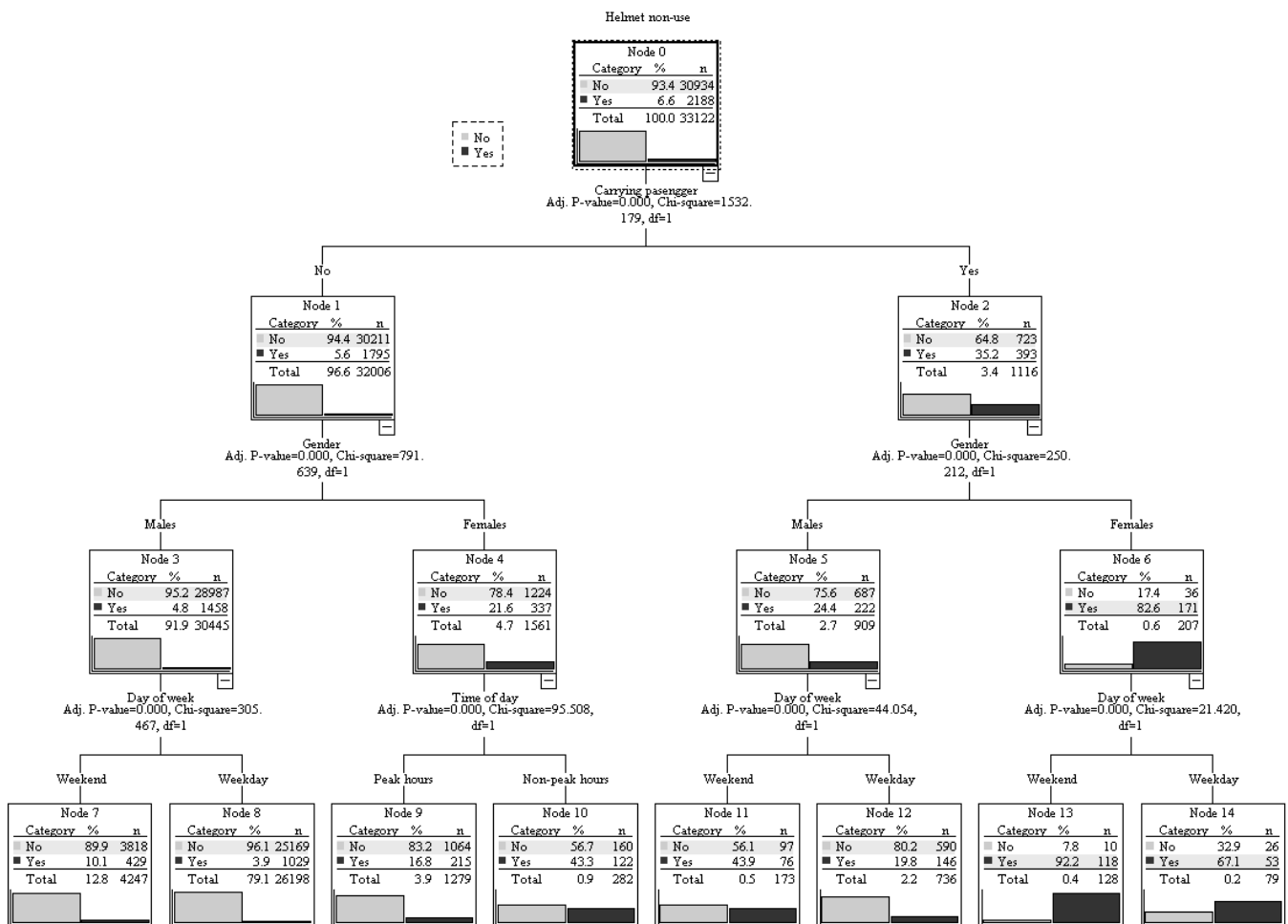


Figure 1: Decision tree model for helmet non-use.

Figure 2 shows the results of CHAID procedure to identify factors associated with turn signal neglect. The dependent variable was turn signal neglect, and five independent variables found associated were gender, carrying passenger, approach, number of lanes, type of junction, and day of the week. Out of 12,444 observations, 11,232 (90.3%) commute motorcyclists predicted turn signal neglect when making turning.

The first pruning descriptor was gender ($\chi^2 = 553$, d.f. = 1, p -value = 0.000). About 92.2% of male motorcyclists were predicted to not make turn signal when turning (Node 1), compared to 69.9% of female motorcyclists (Node 2). The second split was based on the variable carrying passenger ($\chi^2 = 490.469$, d.f. = 1, p -value = 0.000). Node 1 was pruned into Node 3 and Node 4. About 93.6% of male solo motorcyclists (Node 3) and 69.5% male motorcyclists with passenger

(Node 4) were found not making turn signal when turning at signalised intersection. For female motorcyclists, it was split with approach variable into Node 5 and Node 6 ($\chi^2 = 88.188$, d.f. = 1, p -value = 0.000). About 60.5% of female motorcyclists along major road were found to turn signal neglect (Node 5) and about 88.4% on minor road (Node 6).

Number of lanes split male solo motorcyclists into Node 7 and Node 8 ($\chi^2 = 48.718$, d.f. = 1, p -value = 0.000). About 93.0% of male solo motorcyclists turn signal neglect along multi-lane (Node 7) and about 98.8% on single lane (Node 8). Variable type of junction found splitting male motorcyclists with passenger into Node 9 and Node 10 ($\chi^2 = 47.140$, d.f. = 1, p -value = 0.000). About 83.4% of male motorcyclists with passenger were found not to turn a signal when

making a turning at the cross junction (Node 9). About 58.4% of male motorcyclists with passenger were found to neglect turn signal at T/Y-junction (Node 10).

The next splitting was also contributed from the type of junction. This time it was splitting Node 5 into Node 11 and Node 12 ($\chi^2 = 48.372$, d.f. = 1, p -value = 0.000). About 73.6% of female motorcyclists on major road did not turn a signal at cross junction (Node 11). For T/Y junction, about 48.1% were observed to neglect turn signal (Node 12). Lastly, female motorcyclists on minor road were split by day of the week ($\chi^2 = 6.049$, d.f. = 1, p -value = 0.014). About 94.6% of female motorcyclists along minor road were found to neglect turn signal during weekend (Node 13) and about 85.6% during weekdays (Node 14).

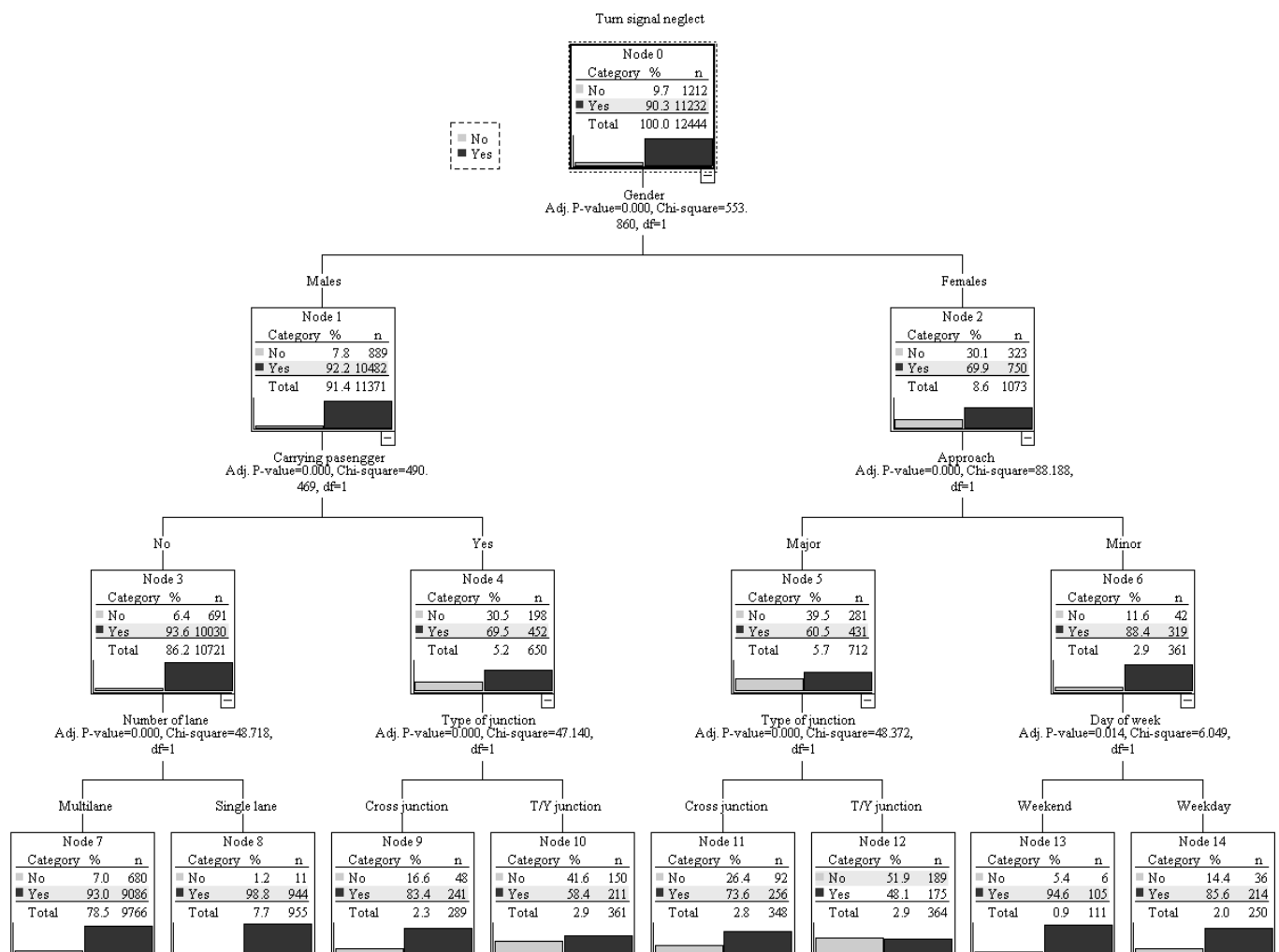


Figure 2: Decision tree for turn signal neglect.

4. Discussion

This study applied decision tree to investigate the behaviours of commuter motorcyclists at signalised intersection. Generally, the results showed that commuting workers were more likely to commit turn signal neglect compared to helmet non-use. Similar findings were also reported in the previous research conducted in Klang Valley and Bangi, Selangor, Malaysia (Alias et al., 2020; Oxley et al., 2013). They found that the level of compliance in helmet wearing was higher among the commute motorcyclists. The differences in compliance level between these behaviours might be because of the difference in exposure time period. Compared to helmet non-use, turn signal neglect behaviour only occurred in short time periods at the

intersection as the enforcement authorities could only spot this behaviour at the intersection. Figure 1 shows that there are four contextual factors associated with helmet non-use behaviours among commuting workers, which include carrying a passenger, gender, day of the week, and time of the day. For turn signal neglect behaviour, six contextual factors were found influencing it, which include gender, carrying passenger, approach, number of lanes, type of junctions, and time of the day (Figure 2).

This study showed that helmet non-use and turn signal neglect linked to contextual factors in Malaysia. Carrying a passenger was found to influence both behaviours. For helmet non-use, this factor represented the highest information in gain and was therefore at the top of the tree. Commuter motorcyclists who travelled with passenger

were found more likely to get involved in helmet non-use behaviour. This finding shows that peers play an important role in shaping the riding behaviours of commute workers. Research conducted in Klang Valley on 540 motorcyclists also found a positive association between peers and riders without helmet (Ibrahim et al., 2012).

Gardner et al. (2005) also found the role of peers to be more motivating to adolescents and youths than adults in committing risky behaviours. Rusli et al. (2019) conducted an online survey of higher education students in the East Coast Region of Peninsular Malaysia to identify the effect of personal and social factors on risk-taking behaviours. They found peers were positively associated with risky behaviours including riding over the speed limit, helmet non-use and turn signal neglect. In China, limited availability of helmets for multiple passengers was found to be one of the reasons for lower helmet compliance among the motorcyclists carrying more passengers (Xuequn et al., 2011). However, the likelihood of turn signal neglect among male motorcyclists was higher when they were travelling without a passenger. The same finding was also found in Vietnam (Nguyen-Phuoc et al., 2019). They determined that carrying a passenger increases the safety considerations among motorcyclists.

Gender also found influenced both risk behaviours among commuting workers. Female motorcyclists were found more likely to engage in helmet non-use, with or without passenger. Although previous research found that females tended to comply with road traffic regulations (Xuequn et al., 2011); hair and hijab style might be one of the reasons to explain this finding. A study in Vietnam also found that females were less likely to use helmet than male motorcyclists (Hung et al., 2006). However, contradictory findings were found in other studies (Akaateba et al., 2014; Siebert et al., 2019; Setty et al., 2020). For the turn signal neglect, gender represented the highest information in gain and was therefore at the top of the tree. Males were found to be more likely to neglect turn signal compared to females. Nguyen-Phuoc et al. (2019) also reported that the odds of female motorcyclists to turn signal was higher than males.

Another factor that influencing both behaviours was day of the week. Riding during weekend increased the helmet non-use behaviour in male and female motorcyclists with passenger. However, for solo motorcyclists, only male motorcyclists were found to be more likely to contribute to the helmet non-use behaviour. A study conducted in Argentina also reported the same finding (Ledesma et al., 2015). Among the fact behind this conclusion was the presence of less police enforcement during weekend. It was also found that female motorcycles along minor roads were most likely to turn signal neglect behaviour during weekend. In terms of time, it was observed that solo female motorcyclists were more likely to not use helmet when riding during non-peak hours period. Less traffic volume and proportion of larger vehicles during weekend and off-peak hours might be the explanation behind this observation. Truong et al. (2016) revealed that during weekdays and peak-hour periods, motorcyclists gave more attention to navigation and control of their motorcycles.

Female motorcyclists were shown to be more likely to turn signal neglect on minor roads compared to major roads. For male motorcyclists, the number of lanes seemed to influence turn signal neglect behaviour. Solo male motorcyclists were prone to get involved in turn signal neglect on single-lane roads compared to multi-lane roads. Male motorcyclists with passenger showed to be more active in neglecting to turn signal at cross junction compared to T/Y-junction. The same observation was also found for female motorcyclists. Higher traffic volume and higher proportion of large vehicles increased cautiousness among motorcyclists when riding on such roads (Truong et al., 2016). However, Nguyen-Phuoc et al. (2019) reported that turn signal neglect behaviours were negatively associated with the number of traffic lanes. Chang et al. (2007) stated that motorcyclists increased their attention and awareness of the complex intersections. Furthermore, the current research has identified that intersection geometry plays a vital role in influencing turn signal neglect behaviours of commuting motorcyclists, and more research needs to done to confirm these findings.

5. Conclusion and Recommendations

This study applied decision tree analyses to explore the risky riding behaviours at signalised intersections among commute works in Kemaman and Dungun, Terengganu, Malaysia. The results showed that four variables had significant relationships with helmet non-use behaviour, including carrying a passenger, gender, day of the week, and time of the day. Carrying a passenger, gender, type of junction, number of lanes, and day of the week were the variables identified to be significantly influencing turn signal neglect. The decision tree also classified the significant variables affecting helmet non-use and turn signal neglect behaviours into eight small and homogeneous groups, respectively.

The limitation of this study is the use of uniform as an indicator for commuter workers. This might create some bias because it referred to oil industry's workers only and there were some commuters who did not use uniform when riding a motorcycle. The future study needs to include all types of commute workers to gain more information regarding the behaviours of workers during commute. However, there are a few key points that can be obtained from this study, which include the effect of passengers on motorcyclists' behaviours, differences between male and female commuters' risk-behaviours, temporal effects (such as day and time), and effect of intersection geometries on commuter workers need to have a deep understanding. The findings of this recent research can help companies to design additional knowledge to their workers about risk-behaviours during commuting, especially for motorcyclists.

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