FATIGUE FACTOR ON MOTORCYCLISTS' ACCIDENT; ANALYSIS USING BAYESIAN NETWORK

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Abstract

This study aims to determine the possibility of accident for motorcyclists who take a break and those who do not take a break along their way due to fatigue. Data statistically from July to December 2015, around 70.93% of the crashes that occurred in Indonesia had involved motorcycles. The study area is located in Indonesia. The number of samples consist of 220 motorcyclists who had suffered accident. From 220 respondent, around 120 respondents were used to analyze data and 100 respondents were used to validate of model. Criteria of respondent are motorcyclists who had suffered accident. Data was collected by distributing questionnaire links on social media by asking something that are related to accidents experienced by respondents. Because the data that is obtained from survey in form probabilistic, thus the data is analyzed by the Bayesian Network Method. The results showed that the accident probability for motorcyclists who did not take a break on the way due to fatigue was 74%, while motorcyclists who took a break on the way due to fatigue had an accident probability of 26%. To obtain an accurate model, the model is validated by calculating the value of Mean Absolute Deviation (MAD). The results indicated that MAD value was 15.43%. This shows that the model has high accuracy, after that several scenarios are performed to determine the dominant variables that influence the risk of accidents in motorcyclists who take a break and those who do not take a break along their way.

Keywords: **Bayesian, motorcycle, network, probability**

Introduction

The Accidents are caused by 3 factors including human factor, road and environment and vehicle. The cause of accidents are due to human factors such as the characteristics of the driver, the behavior of the driver and fatigue. There were several previous studies related to driver characteristics such as gender of drivers. According to Ultra *et al.* (2020) in their research in Thailand showed that gender of driver significantly influenced driving behavior. According to Jiwattanakulpaisarn *et al.* (2013) the compliance of using helmet were influenced by gender, age, and riding frequency. Beside that male drivers will more likely to have an accidents compared to female drivers (Karacasu and Er, 2011) and male drivers also will more likely to have fatal accidents (Vorko-Jovic *et al*., 2006) especially driver drive between 12.00-06.00 and drive at high speed (Vorko-Jovic *et al*., 2006). This is because male drivers are more likely to be aggressive and tend to underestimate the risks that

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will be occured, especially for young drivers. Young drivers are even more likely to perform violation traffic rule than female drivers (Putranto and Rostiana, 2015). Meanwhile, interm of age, young male drivers also will be more likely to have an accidents compared to the middle aged and older male drivers (Karacasu and Er, 2011) and even also tend to violate traffic regulations and neglect risk (Chang and Yeh, 2007). Other studies, especially the occurrence of accidents in elderly was also conducted by (Baker *et al*., 2003) that show indicated elder women are more often in crashes under the ''safest'' conditions. In addition, according to Dobson *et al*. (1999) young women drivers tend to do risky driving behavior.

Another characteristic of the driver that affects the risk of an accident is the age factor. Young drivers tend to use social media while driving compared to the middle-age driver (Lyon *et al*., 2020) and also tend to suffered accident (McKnight and McKnight, 2002) and in addition, even tend to risky to suffered fatal accident (Zambon and Hasselberg, 2006; Clarke *et al*., 2010). Young riders are generally novice riders who tend to have a slow response (Scialfa *et al*., 2011). In addition, the riders of all ages are more vulnerable to disturbance inside the vehicle compared to disturbance that come from the outside of vehicle (Lam, 2002).

Accidents are also influenced by the driver's behavior while driving. Other study also show that personality traits can decrease ability of driver (Biernacki and Lewkowicz, 2020). Generally, driving behavior of driver is not constant and this behavior of driver even always change significantly over time (Hyodo *et al*., 2017). Furthermore, the differences in risk perception of drivers will influence driving behavior, and certainly it will influence safety and ability of drivers in the trip (Ulak *et al*., 2019). Other behavior of driver that influence risky of accident such as reckless. According to Lumba *et al*. (2017a) show that reckless motorcyclists are 30% more likely to have severely injuries in road traffic accidents. Other study related behavior was conducted by Mon *et al*. (2018) good driving behavior factor was found to have the highest influence on the willingness to pay (WTP). In addition, Lack of sleep can cause driver to commit traffic violations (Philip *et al*., 2005), and even have the potential to suffer accidents (Stutts *et al*., 2003).

The fatigue can decrease ability of driver while driving (Dingus *et al*., 2006). There are many factors that cause fatigue to the driver. One cause of fatigue of driver is lack of rest, such as: less sleep (Ma *et al*., 2003). According to Philip *et al*. (2005) time awake of driver and previous sleep duration of driver will impact to driving impairment in the trip. In addition, driver drive for 60 min are more likely to suffer fatigue by 73.9% (Lumba *et al*., 2017c). Other studies show that 80 min (Ting *et al*., 2008) and 90 min (Lumba *et al*., 2017b) long duration of driving was the safe limit to drive motorcycle on monotonous road condition.

Beside accident is caused human factor, other factor such as road condition can cause of accident. The accidents that is caused by road factors are very rare, because in general, traffic signs have been installed in dangerous locations that can lead to accidents. The drivers are more likely obey to roadside safety signs when auditory warning sound is used (Kang and Momtaz, 2018). Road familiarity also influence road traffic accident (Bucsuházy *et al*., 2020). According to Larue *et al*. (2011) roadside variability greatly impacts on driver of low sensation seeker.

In general, accidents are caused by vehicle factors include: brake conditions of vehicle, tire conditions of vehicle, and light systems of vehicle. According to Saladié *et al*. (2020) the fewer of mobility of vehicle, the fewer of accidents and injuries will be. Other study show that the fewer trips to work by motorcycle and more trips to work by public transport, bicycle and foot, the fewer transport fatalities are more likely to happen (Moeinaddini *et al*., 2015). In addition, motorcycles with engine capacity above 125 cm^3 were more likely to have severely injuries compared to motorcycles with engine capacity 125 cm^3 (Lumba *et al*., 2018). Differences of motorcycle performance will affect the risk of driving behavior and will also lead to fatal accidents (Yannis *et al*., 2004; Teoh and Campbell, 2010; Bjørnskau *et al*., 2012). According to Jomnonkwao *et al*. (2020) that at urban area drivers tend to use helmets due to health motivation, while at suburban areas drivers tend to use helmets due to accident severity, cue to action and benefit.

Based on statistic data in Indonesia from 2015 shows that the number of motorcycle has increased quite high, with a growth of 6.2% annually. In 2019 the number of motorcycle in Indonesia reached 112,771,136 or 84.40% compared to other vehicles (Land Transportation Statistics, 2019). The high use of motorcycle is caused by the high mobility of these vehicles. In addition, to obtain a motorcycle is quite easy, with or without down payment. The high the use of motorcycle in Indonesia has increased the number of accidents.

Based on (Land Transportation Statistics, 2019), the number of accident cases increased from 96,233 case in 2015 to 106,644 case in 2016. Then in 2017 the accident cases decrease to 104,327 cases, in the next period, accident cases increased every year, namely 109,215 case in 2018, and 116,411 cases in 2019. The fatalities victim increased from 24,275 in 2015 to 31,262 in 2016. In the next period, there were decrease fatalities victim, namely 30,694 in 2017, and 29,472 in 2018, and 25,671 in 2019.

This study aims to determine the possibility of accident for motorcyclists who take a break and those who do not take a break along their way due to fatigue. The study related above mention is very few, especially for the model that is analyzed in terms of 3 factors including: human, road and environment factors and vehicle factors, such as: characteristics of driver, fatigue, driving behavior, road and environment and vehicle. All of these factors are analyzed simultaneously to obtain an accurate model. After obtaining the basic model of Structure Bayesian Network, then the basic model is validated. After obtaining an accurate model, several scenarios are carried out in order to determine all factors influence the possibility of accident. After that the best alternative can be taken to minimize the risk of accidents on motorcyclists.

Materials and Methods

The research located in Indonesia with a sample that consists of 220 respondents, where 120 respondents were used to analyze data and 100 respondents were used to validate the basic model. The respondent's criteria are motorcyclists who had suffered accident. The collection of data was carried out by spreading of questionnaires on social media by proposing questions related to accidents that is experienced by motorcycle riders. The justifications of the variables in this study are shown in Table 1. Explanation of Table 1 that several previous studies related to the variable age that affect accidents had been carried out by: (Lam, 2002; Karacasu and Er, 2011; Jiwattanakulpaisarn, 2013; Lyon *et al*., 2020).

Analyzing data use the Bayesian Network with GeNIe 2 software. The Bayesian network originated from Bayes theory. The theory explain about the correlation between the occurrence of event A and provided that event B has occurred, which is formulated in the Equation 1.

$$P(A|B)=\frac{P(B|BA)P(A)}{P(B|A)P(A)+P(B|-A)P(-A)} \quad (1)$$

where: P(B|A) = posterior distribution of conditional parameter B on A, P(B) = prior distribution of parameter B, P(A|B) = posterior distribution of data A conditional parameter B, P(A) = prior distribution of data A.

Example calculation of Bayesian Network in Figure 1 is:

$$\begin{aligned} P(Y) = \; & P(P|M,O,N)\ P(M|N) \text{ x } P(O|N) + \\ & P(P|M,-O,N) \text{ x } P(-M|N) \text{ x } P(-O|N) + \\ & P(P|-M,-O,N) \text{ x } P(-M|N) \text{ x } P(O|N) + \\ & P(P|-M,-O,N) \text{ x } P(-M|N) \text{ x } P(-O|N) \end{aligned}$$

Furthermore, the model is validated as a requirement to make several scenarios on model that is obtained. The calculation of validation is performed by calculating the Mean Absolute Deviation (MAD) value, which is the average difference between the reality in the field and the model results, with the formula:

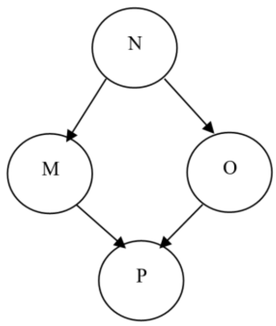

Figure 1. Example of analysis of bayessian network

Table 1. Justification of variables

Independent variables	Dependent variables	Previous study by
Age	Risky driving behavior	Lam (2002); McKnight and McKnight (2002); Zambon and Hasselberg (2006); Clarke *et al.* (2010); Scialfa *et al.* (2010); Karacasu and Er (2011); Jiwattanakulpaisam (2013); Lyon *et al.* (2020)
Gender		Dobson *et al.* (1999); Baker *et al.* (2003); Vorko-Jovic *et al.* (2005); Chang and Yeh (2007); Karacasu and Er (2011); Jiwattanakulpaisarn (2013); Putranto and Rostiana (2015)
Engine capacity		Yannis *et al.* (2004); Teoh and Campbell, (2010); Bjørnskau *et al.* (2011); Lumba *et al.* (2018)
Long duration of driving	Fatigue	Lumba *et al.* (2017c)
Driving time		Vorko-Jovic (2006)
Condition of road		Lumba *et al.* (2017b)
Road side variability	Condition of road	Larue *et al.* (2011)
Weather	Road surface	Baker *et al.* (2003)

MAD = ½ ∑ |Actual – Forecast|

Results and Discussion

The variables and statistics as shown in Table 2. The variable of Roadside variability has 2 values or indicators namely variability with a percentage of 51% and unvariability with a percentage of 49%. It means that 51% of motorcyclists experience accident on the roads that have roadside variability along its way and 49% motorcyclist experience accident on the roads that have no roadside variability along its way. In addition, 35% of motorcyclists who had accidents on monotonous roads, meanwhile 65% of motorcyclists who experience accidents on unmonotonous roads. The high number of accidents on monotonous roads is caused by monotonous roads that can cause of fatigue and it even can lead to decrease level of vigilance of the driver. Around 47% of accidents on motorcycles occured between 12.00 and 18.00. This condition is reasonable because at that time in general the people have felt fatigue due to the workload that was performed before. Furthermore, the survey results also show that the most accidents that occured within 30 min duration of driving, which is 83%. This shows that fatigue is not only caused by the long duration of driving, but it is also caused by the workload before driving, monotonous road conditions and low traffic volume. The data also shows that 30% of motorcyclists experience fatigue before they had the accident. In addition, 9% of motorcyclists had accidents in the rain and 19% had accidents on wet road surfaces. Furthermore, 58% of drivers who had accidents aged 20 years and below and 32% of motorcyclists conducted traffic violations before they had accident. Lastly, 69% of the drivers involved in accidents are male drivers.

Model of Structure Bayesian Network in this study shows that the variables that affected the probability of accident include: fatigue, road surface, and risky driving behavior. Meanwhile fatigue is affected by road conditions, long duration of driving and driving time. Risky driving behavior is influenced by engine capacity, gender, age. Besides, the road surface is affected by weather and the road condition is affected by the road side variability, as shown in Figure 2.

The results of the Bayesian Network Structural analysis show that motorcyclists who do not take a break along their way more likely to experience accident amounted 74%, while those who take a break more likely to experienced accident amounted 26%, as shown in Figure 2. The drivers are advised to take a break when they are fatigue on the way, it goal to recover the driver's stamina.

Based on Bayes Theory, from the Structure of Bayesian Network in Figure 2 are obtained the equation as shown in Table 3. The probability of accidents in Table 3 was directly influenced by 3 variables including road surface, fatigue and risky driving behavior. Therefore, the probability of accident was 16 possibilities that consisted of 8 probability of accident for motorcyclists who take a break and 8 probability of accident for motorcyclists who do not take a break. This was obtained from 2 options of response to road surface × 2 options of response to fatigue × 2 options of response to risky driving behavior × 2 options of

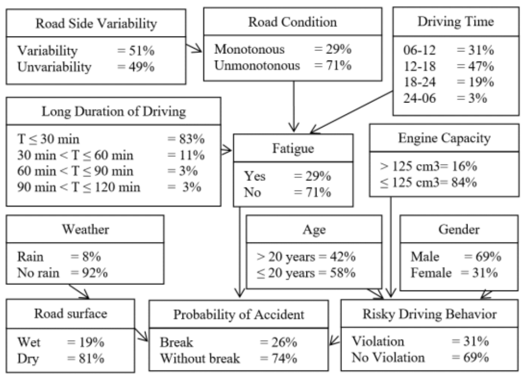

Figure 2. Model Structure bayesian network of probability of accident severity

Table 2. Variables and statistics

Number	Variables	Value	Percentage
1	Roadside variability	Variability	51%
		Unvariability	49%
2	Condition of road	Monotonous	35%
		Unmonotonous	65%
3	Driving time	06.00-12.00	31%
		12.00-18.00	47%
		18.00-24.00	19%
		24.00-06.00	3%
4	Long duration of driving	30 min	83%
		60 min	11%
		90 min	3%
		120 min	4%
5	Fatigue	Yes	30%
		No	70%
6	Weather	Rain	9%
		No Rain	92%
7	Road surface	Wet	19%
		Dry	81%
8	Age	Above 20 years	42%
		20 years and below	58%
9	Violation	Yes	32%
		No	68%
10	Gender	Male	69%
		Female	31%

response to probability of accident. As an example of the calculations in Table 3, the equation for the probability of an accident occurs in probability 2.

The probability of accident for motorcyclists who take a break

P(AC)2 = P(AC|A1,B1,C2,D,E,F,G,H,I,J,K) × P(A1) x P(B1) x P(C2)
P(AC| A1,B1,C2,D,E,F,G,H,I,J,K) = 40%; P(A1) = 28.5%; P(B1) = 30.6%; P(C2) = 81%
P(AC)2 = 0.4 x 0.285 x 0.306 x 0.81

P(AC)2 = 0,028 (meaning that the motorcyclists who experienced fatigue before the accident, and conducted traffic violations, and had an accident on a dry road surface, besides that this the motorcyclists had stopped to rest because of fatigue before the accident, the number of the motorcyclists as mentioned above in the sample was 2,8%).

The probability of accident for motorcyclists who do not take a break

P(AC)2 = P(AC|A1,B1,C2,D,E,F,G,H,I,J,K) × P(A1) x P(B1) x P(C2)
P(AC| A1,B1,C2,D,E,F,G,H,I,J,K) = 60%; P(A1) = 28.5%; P(B1) = 30.6%; P(C2) = 81%
P(AC)2 = 0.6 x 0.285 x 0.306 x 0.81

P(AC)2 = 0.042 (meaning that the motorcyclists who experienced fatigue before the accident, and conducted traffic violations, and had an accident on a dry road surface, besides that this the motorcyclists had not stopped to rest because of fatigue before the accident, the number of the motorcyclists as mentioned above in the sample was 4.2%).

After that, the basic model was validated by calculating the MAD value by using new data. Based on the model validation analysis, it shows that the probability 1 does not have in actual conditions. The explanation of Table 4 is: the probability 2 shows that the drivers had fatigue before the accident, besides that the drivers also conducted traffic violation and location of accident was on dry road surface, the probability the driver above mention around 25% of the samples that is taken in the field for validation stage and based on model analysys, the probability the driver above mention around 40%, thus the absolute difference

Table 3. Equations of accident probability

P	P(A)	P(B)	P(C)	Equation of Accident Probability (AC)	Accident Probability (AC1)	Accident Probability (AC2)
1	A1	B1	C1	P(AC)1 = P(AC|A1,B1,C1,D,E,F,G,H,I,J,K) × P(A1|I,J,K) × P(B1|E,F,H) × P(C1|D)	0.0	1.7
2	A1	B1	C2	P(AC)2 = P(AC| A1,B1,C2,D,E,F,G,H,I,J,K) × P(A1|I,J,K) × P(B1|E,F,H) × P(C2|D)	2.8	4.2
3	A1	B2	C1	P(AC)3 = P(AC| A1,B2,C1,D,E,F,G,H,I,J,K) × P(A1|I,J,K) × P(B2|E,F,H) × P(C1|D)	0.0	3.8
4	A1	B2	C2	P(AC)4 = P(AC| A1,B2,C2,D,E,F,G,H,I,J,K) × P(A1|I,J,K) × P(B2|E,F,H) × P(C2|D)	4.6	11.4
5	A2	B1	C1	P(AC)5 = P(AC| A2,B1,C1,D,E,F,G,H,I,J,K) × P(A2|I,J,K) × P(B1|E,F,H) × P(C1|D)	1.0	3.1
6	A2	B1	C2	P(AC)6 = P(AC| A2,B1,C2,D,E,F,G,H,I,J,K) × P(A2|I,J,K) × P(B1|E,F,H) × P(C2|D)	6.2	11.5
7	A2	B2	C1	P(AC)7 = P(AC| A2,B2,C1,D,E,F,G,H,I,J,K) × P(A2|I,J,K) × P(B2|E,F,H) × P(C1|D)	2.9	6.5
8	A2	B2	C2	P(AC)8 = P(AC| A2,B2,C2,D,E,F,G,H,I,J,K) × P(A2|I,J,K) × P(B2|E,F,H) × P(C2|D)	7.9	32.3
				Accident Probability (∑ AC)	25.5	74.5

Table 4. The Calculation of the mean absolute deviation (MAD) value

Probability	Fatigue	Violation	Road surface	Number Respondent		Probability of Accident %		Deviation %
				Break	Not Break	Actual	Model	
2	Yes	Yes	Dry	4	12	25	40	15.00
3	Yes	No	Wet	0	1	0	0	0.00
4	Yes	No	Dry	2	16	11	29	18.00
5	No	Yes	Wet	1	1	50	25	25.00
6	No	Yes	Dry	3	32	9	35	26.00
7	No	No	Wet	1	1	50	31	19.00
8	No	No	Dry	4	22	15	20	5.00
Number of Respondent				15	85			
Mean Absolute Deviation (MAD)								15.43

between actual condition and model by 15%. The result of the calculation shows the MAD value of 15.43% as shown in Table 4. Meaning that the deviations between the actual condition and the model by 15.43%.

Several scenarios were carried out, where scenario 1: the roads which have roadside variability. The results of show that roads which have roadside variability can reduce motorcyclist's monotony by 6% from 29% to 23%, and there is also a decrease in driver fatigue levels by 3% from 29% to 26%, as shown in Figure 3. The roads that have a variety of sides of the road tend to make drivers more focused, and avoid feeling drowsy and monotonous situations. For example, a driver who crosses a plantation area without any other variations, this conditions can cause the drivers drowsiness, thus it is risk of accidents. In addition, the straight roads and long can cause motorists to feel drowsy. This study is consistent with the study conducted by Larue *et al*. (2011). Likewise, roads that tend to be flat without any inclines and descents, this condition will also affect the level of monotony of motorcyclists.

Scenario 2: the effect of weather conditions on the probability of accident. Weather conditions affect the wet or dry of road surface. Wet road conditions cause the road to tend to be slippery, thus it is risk of accidents. The results show that the rain cause road surface becomes wet and the probability of accident decreases by 5% from 26% to 21%, especially for drivers who take a break along their way due to fatigue, as shown in Figure 4. This phenomenon shows that in general people will travel during sunny weather than during rainy conditions. This condition is one of the factors cause the high accident when the weather on sunny days. This study is consistent with the study conducted by: Lumba *et al*. (2017c). When it is rains, motorcyclists are expected to take shelter for a while or take a rest because it will decrease the risk of accident such as slipping, or falling due to a hole covered by water.

Scenarios 3 and 4: effect of driver aged to risky driving behavior and probability of accident. The driver age affects behavior in driving. Young drivers are usually more likely to be aggressive and even tend to conduct traffic violations. On the other hand, older drivers also have problems with their visual abilities and also with their ability to concentrate. The results of the analysis showed that motorcyclists aged >20 years conducted traffic violations by 21% while drivers aged ≤20 years conducted traffic violations by 37%. The probability of accidents for motorists aged >20 years is 25%. Meanwhile, the probability of an accident for drivers aged ≤20 years is 26%. The result of analysis show that the drivers aged above 20 years were less likely to perform traffic violations than drivers aged 20 years and below and motorcyclists aged above 20 years are less likely to experience accident compared to motorcyclists aged 20 years and below, especially for drivers who take a break along their way due to

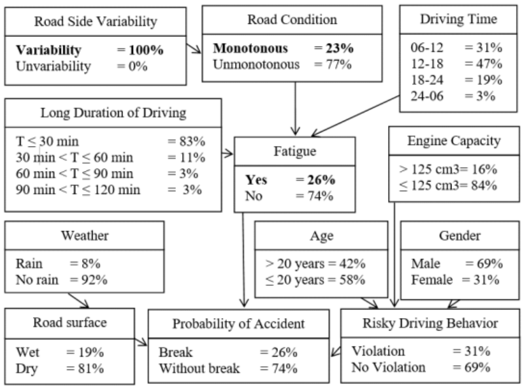

Figure 3. Scenario 1: Effect roadside variability to road condition and fatigue

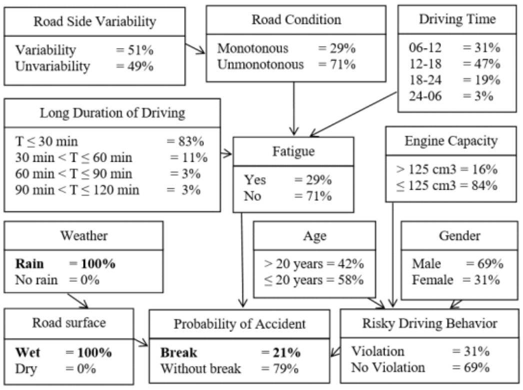

Figure 4. Scenario 2: Effect weather to probability of accident

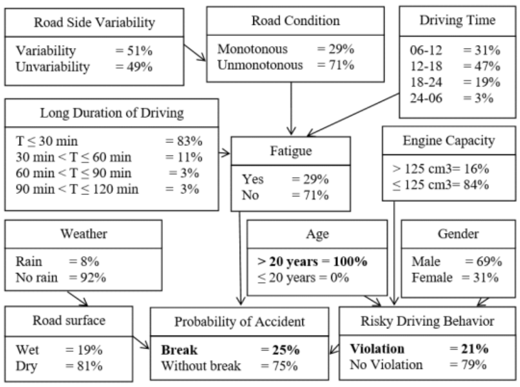

Figure 5. Scenario 3: Effect of driver aged above 20 years to risky driving behavior and probability of accident

fatigue, as shown in Figures 5 and 6. The differences of age factor of drivers is one of cause that affect the risk of accidents for motorists (Nordfjærn *et al*., 2012). This shows that young, middle aged and older drivers have the different ability to drive vehicles. The Increasing age of drivers will lead to decrease in the ability to drive, especially related to concentration during the trip. The driver's age affects the driver's behavior while driving. Young drivers tend to have less driving experience than adult drivers. In addition, young drivers are usually more aggressive than adult drivers. This has resulted in a higher percentage of accidents for young drivers than adult drivers. This study is consistent with the study conducted by: (Clarke *et al*., 2010).

In scenarios 5 and 6: Effect of male driver to risky driving behavior and probability of accident. Male drivers are 33% likely to coduct traffic violations, while female drivers are 24% likely to conduct traffic violations. Meanwhile, the probability of an accident for male drivers is 26% and the probability for an accident for female drivers is 25%, especially for drivers who take a break along their way due to fatigue. Meaning that the probability of male drivers were more likely perform traffic violations than female drivers. Male driver are also more likely to experience accident compared to female, especially for drivers who take a break along their way due to fatigue, as shown in Figures 7 and 8. The factors of gender can affect safety behavior when driving. According to Chang and Yeh (2007) male drivers are more better driving skills than female drivers, but male drivers tend to have a lower perception of risk than female drivers of risk of accident. This shows that accidents for male drivers are more caused by a low perception of the risk of accidents, while accidents for female drivers are more due to a lack of skill in driving. While female drivers are more panic than male drivers. Female drivers are also less likely to have driving experience than male drivers. This can be seen from our daily phenomenon, where women tend to be more passengers than drivers. This study is consistent with the study conducted by Vorko-Jovic *et al*. (2006); Chang and Yeh (2007); Karacasu and Er (2011).

Scenarios 7 and 8: effect of motorcyclists with engine capacity above 125 cm^3 to risky driving behavior and probability of accident. Motorcyclists with an engine capacity >125 cm^3 has 20% probability to conduct traffic violation, while motorcyclists with an engine capacity of 125 cm^3 has 33% probability to conduct traffic violation. The probability of accidents for drivers with engine capacity >125 cm^3 is 25%, while for drivers with engine capacity 125 cm^3 is 26%. It means that the drivers with engine capacity 125 cm^3 and below are

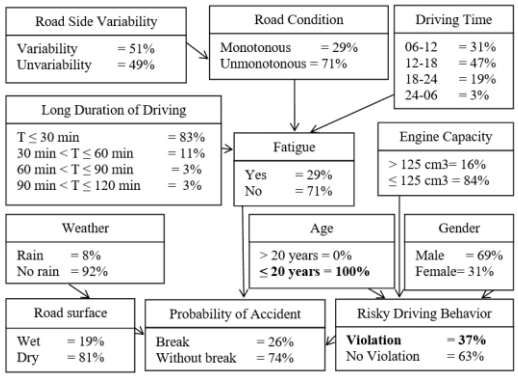

Figure 6. Scenario 4: Effect of driver aged 20 years and below to risky driving behavior and probability of accident

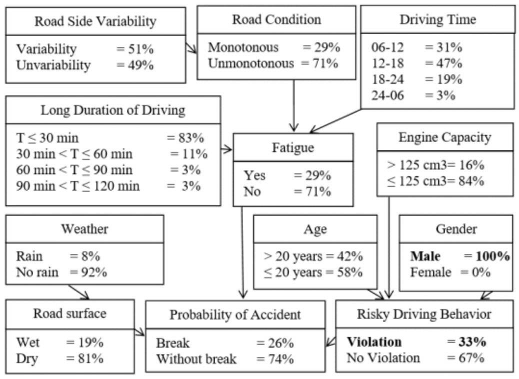

Figure 7. Scenario 5: Effect of male driver to risky driving behavior and probability of accident

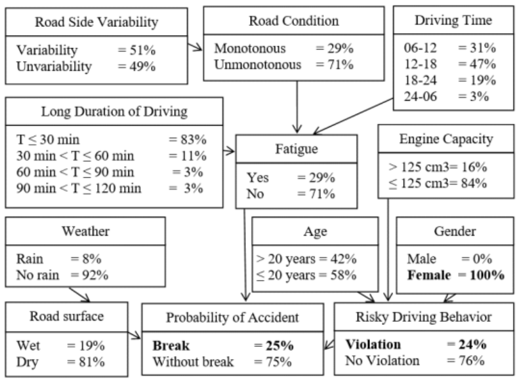

Figure 8. Scenario 6: Effect of female driver to risky driving behavior and probability of accident

more likely perform traffic violations than drivers with an engine capacity above 125 cm^3. Motorcylists with engine capacity above 125 cm^3 are less likely to experience accident than motorcylists with engine capacity 125 cm^3 and below, especially for drivers who take a break along their way due to fatigue, as shown in Figures 9 and 10. This study is not consistent with the study conducted by Teoh and Campbell (2010).

To prevent accidents to motorcyclists, it is necessary to issue a policy related to:

1. The motorcyclists should take a rest if they feel fatigue while driving;

2. The sosialitation to motorcycle users related to the effect of rider characteristics (age and gender) on risky driving behavior;

3. There is curriculum at school related to safety in driving with material on the causes and effects of fatigue when driving.

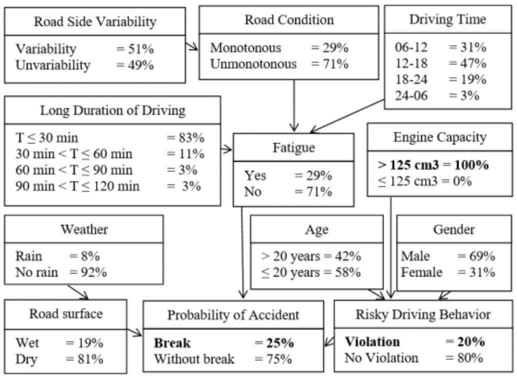

Figure 9. Scenario 7: Effect of motorcyclists with engine capacity above 125 cm^3 to risky driving behavior and probability of accident

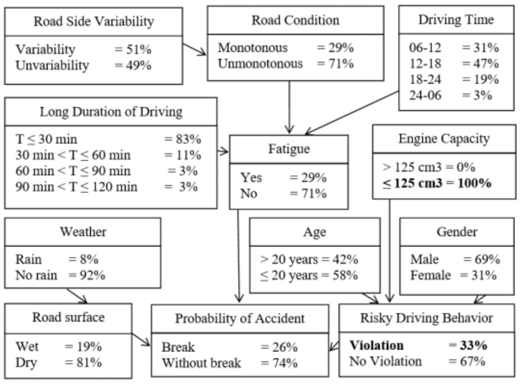

Figure 10. Scenario 8: Effect of motorcyclists with engine capacity 125 cm^3 and below to risky driving behavior and probability of accident

Conclusions

The probability of accidents for motorcyclists who do not take a rest in journey due to fatigue is greater than that of motorcyclists who take a rest in journey. Scenario 1 show that the roads which have roadside variability can reduce motorcyclist's monotony and reduce fatigue level. Scenario 2 shows that when it rains, it will cause the road surface become wet and it also reduce the probability of accidents for motorcyclists who take a break along their way. Scenarios 3 and 4 show that the drivers aged above 20 years are less likely to perform traffic violations than drivers aged 20 years and below. Motorcyclists aged above 20 years are less likely to experience accident compared to motorcyclists aged 20 years and below, especially for drivers who take a break along their way due to fatigue. In scenarios 5 and 6 where the probability of male drivers are more likely to perform traffic violations than female drivers. Male driver are also more likely to experience accident compared to female, especially for drivers who take a break along their way due to fatigue. Scenarios 7 and 8 show that the drivers with engine capacitiy 125 cm^3 and below are more likely to perform traffic violations than drivers with engine capacitiy of 125 cm^3 and below. Motorcylists with engine capacity 125 cm^3 and below, especially for drivers who take a break along their way due to fatigue. Motorcylists with engine capacity above 125 cm^3 are less likely to experience accident than Motorcylists with engine capacity 125 cm^3 and below, especially for drivers who take a break along their way due to fatigue.

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