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Coffee Consumption Factor on Increasing of Alertness and Decreassing of the Risk of Accidents; Analysis Using Bayessian Network

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ABSTRAK

Sebagian besar pengendara sepeda motor merasakan lelah sebelum mengalami kecelakaan. Salah satu penyebabnya adalah bentuk desain kendaraan yang terbuka tanpa perlindungan dan dapat mempercepat terjadinya proses kelelahan dan disamping itu, 50,5% pengendara yang mengalami kecelakaan juga memiliki waktu tidur pada malam sebelum kecelakaan selama 6 jam dan kebawahnya. Untuk itu perlu dicari solusi dalam upaya memberikan gambaran kepada pengendara sepeda motor terkait penyebab timbulnya kelelahan selama berkendara. Analisis data menggunakan software GeNie 2.0 dengan menggunakan sampel sebanyak 381 responden yang pernah mengalami kecelakaan sepeda motor. Hasil analisis menunjukan bahwa pengendara sepeda motor yang mengkonsumsi kopi berkemungkinan mengalami kecelakaan sebesar 11% dan 89% pengendara yang tidak mengkonsumsi kopi. Hasil validasi model menunjukkan nilai Mean Absolute Deviation (MAD) sebesar 21,07%. Skenario 1 menunjukkan pengendara yang mengkonsumsi kopi dan tidurnya kurang dari waktu jam tidur normal berpotensi mengalami kecelakaan. Disamping itu pengendara yang mengkonsumsi kopi dan mengendara di jalan lurus berkemungkinan mengalami kecelakaan lebih besar dibandingkan berkendara di perbukitan atau tikungan. Sementara itu pada scenario 3 kondisi geometry jalan tidak berpengaruh pada tingkat kelelahan dan probabilitas terjadinya kecelakaan pada pengendara yang mengkonsumsi kopi. Pada scenario 4 menunjukkan semakin lama berkendara tingkat kelelahan pengendara meningkat namun demikian tingkat kelelahan pengendara menurun pada saat diatas 60 menit hal ini disebabkan karena pengendara telah beristirahat karena kelelahan. Sementara itu scenario 5 menunjukkan pengendara yang mengkonsumsi kopi dan memiliki kerja sampingan berkemungkinan mengalami kelelahan dan probabilitas kecelakaan lebih besar dari pengendara pengendara yang tidak mengkonsumsi kopi dan tidak memiliki kerja sampingan.

Kata kunci: *Bayessian; Kecelakaan; Network; Probabilitas; Sepeda Motor*

ABSTRACT

Most of the motorcyclists feel exhausted before they had accident. 50.5% of motorcyclists who have accident sleep at night before the accident for 6 hours and below. The sample consist of 381 respondents who had experienced accident. Data analysis used GeNie 2.0 software. The results show that the motorcyclists who consume coffee are more likely to have accident by 11% and 89% for the motorcyclists who do not consume coffee . The results of the model validation show the Mean Absolute Deviation (MAD) value was 21.07%. Scenario 1 shows that motorcyclists who consume coffee and sleep less than normal sleeping hours have the potential to have accidents. The drivers who drink coffee and drive on a straight road are more likely to have accident than driving on hills or bends. In scenario 3, the road geometry has no effect on the level of fatigue and the probability of accidents that occurred for drivers who consume coffee. In scenario 4 shows that the longer the driving time, thus the driver's fatigue level increases. However, the driver's fatigue level decreases when long duration of driving is over 60 minutes and it is caused by the driver has rested due to the driver is fatigue. Scenario 5 shows that drivers who consume coffee and have side job are more likely to experience fatigue

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and tend to have accident than drivers who do not consume coffee and the drivers do not have side job.

***Key words**: Accident; Bayessian; Motorcycle; Network; Probability*

1. INTRODUCTION

Nearly 50% of accidents that occurred in motorcyclists were caused by fatigue. Fatigue can reduce the level of alertness and performance of drivers to drive safely ([1]; [2]). Several factors that affect fatigue including: the workload of the rider before driving [3], and long duration of driving ([3]; [4]; [5]), as well as lack of rest [4]. The workload that is high for every week will affect a driver's level of fatigue, especially if this has became a daily routine. Likewise with the long duration of driving, the longer the driver travels, the more likely the driver will experience fatigue. In addition, lack of rest can also affect driver fatigue, such as working continuously without any rest, or driving for too long without rest, and lack of sleep or poor sleep quality. Lack of sleep can result in motorcyclists committing traffic violations [6], even in this condition it is possible for drivers to have traffic accidents ([7]; [8]).

In addition, driving time also affects rider fatigue. In generally, accidents due to fatigue that were occurred between 12.00 and 18.00 [9]. Another study also showed that accidents due to fatigue often occurred from 14.00 to 16.00 [10]. Drivers who drive too long during the day and drive in monotonous conditions can also result in decreasing level of driver alertness [11].

However, this fatigue factor can also be caused by road geometry conditions. The condition of the road geometry affects the behavior of the driver when driving, where the driver tend to feel monotonous when the driver is on a straight road, but the driver will tend to be alert when the driver is in the curve [12] and this condition can reduce the level of monotone on the rider [13]. Another study states that 80 minutes is a safe time to drive on a monotonous road [14].

To overcome this fatigue, there are several things that can be done by drivers, including: stop for a while to rest for a certain period of time, and rest by sleeping for a while. Fatigue that occurs can cause drowsiness, thus it is very risky for accidents. To reduce sleepiness can be done by consuming caffeine ([15]; [16]) or drinking caffeine plus a nap can also reduce sleepiness ([17]; [18]). In addition, energy drinks containing carbohydrates and caffeine can also help the driver's level of alertness and can also reduce the impact of fatigue ([19]; [20]).

Several study have shown that coffee consumption can increase driver alertness for a certain period of time. However, not too many study that had been done related to the probability of accident among drivers who consume coffee and drivers who do not consume coffee. The purpose of this study is to determine several variables that affect the probability of accidents that occured in drivers who consume coffee and drivers who do not consume coffee. In addition, the results of this study are also an initial description for motorcyclists to find out how to increase the vigilance of motorcyclists when they experience fatigue.

2. METHODS

The respondents in this study are motorcycle riders who had experienced traffic accidents. Data was collected by interviewing respondents. The number of samples in this study were 381 respondents, where 300 respondents were used to analyze the data and 81 respondents were used to validate the model.

The questions that were posed to respondents including:

1. The condition of the road at the time of the accident? (Monotonous, Not monotonous)
2. You have a side job? (Yes No)
3. Long duration of driving before the accident? (30 min, 30 min < Long duration of driving ≤ 60 min, > 60 min)
4. Feel tired before suffer accident? (Yes No)
5. Duration of sleep at the night before the accident? (6 hours, 6 hours < sleep duration ≤ 7 hours, > 7 hours)
6. Commit a traffic violation before the accident? (Yes No)
7. Condition of the road geometry at the accident site? (Straight, Hill or bend)
8. Drinking coffee before the accident? (Yes No)

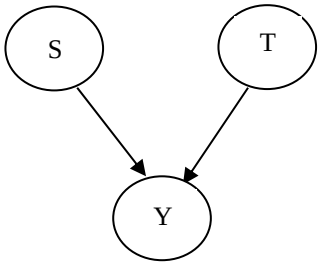

Figure 1. Example of analysis of bayesian network with 3 variables

Note: (-A) = A complement

The data that were obtained, and then it was analyzed by using a Bayesian Network which shows the relationship between event A and event B, or the occurrence of event A provided that event B has occurred or P(A|B) with the formula:

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

Stucture of Bayesian Network in Fig. 1 can be calculated with the formula:

P(Y) = P(Y|S, T) x P(S) P(T) +
P(Y|S,-T) x P(S) P(-T) +
P(Y|-S,T) x P(-S) P(T) +
P(Y|-S,-T) x P(-S) P(-T)

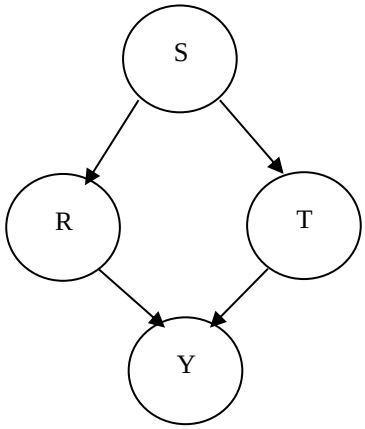

Figure 2. Example of analysis of bayessian network with 4 variables

Stucture of Bayesian Network in Fig. 2 can be calculated with the formula:

$$P(Y) = P(Y|R,T,S) \times P(R|S) \times P(T|S) + P(Y|R,-T,S) \times P(-R|S) \times P(-T|S) + P(Y|-R,-T,S) \times P(-R|S) \times P(T|S) + P(Y|-R,-T,S) \times P(-R|S) \times P(-T|S)$$

Bayesian Network analysis used GeNie 2.0 software [21]. The model that was obtained from analysis with Bayesian Network and then the model was validated by calculating the MAD value, which is the average difference between the calculation results of the model with field conditions. If the average difference is not too large, the model is considered accurate enough so that several scenarios can be made to determine the effect of each variable.

3. RESULT

3.1. Description of Data

Several variables that were used in this model including: condition of road, side job, long duration of driving, fatigue, duration of sleep, violation, road geometry, coffee consumption as shown in Table I. Based on Table I, around 45.67% who drivers suffered accident feel monotonous on the highway and 20.67% of drivers who have accidents have a side job. In addition, 70.33% of accidents occurred to drivers with long duration of driving by 30 minutes or below. Furthermore, 47% of drivers experience fatigue before the accident. Related to duration of sleep show that 52.33% of accidents that were occurred in drivers who slept 6 hours or less and 58.67% of motorcyclists violated traffic rules before suffer an accident. Finally, 83.33% of accidents occurred on the straight roads and 5% of accidents happen to drivers who consume coffee.

Table 1. Statistic and Data

No	Variable	Value	Percen-tage
1	Condition of road (CR)	Monotonous	46,67
		Unmonotonous	53,33
2	Side job (SJ)	Yes	20,67
		No	79,33
3	Long duration of driving (LDD)	≤ 30 minute (LS30)	70,33
		30 < LDD ≤ 60 (A30U60)	19,67
		> 60 minute (A60)	10,00
4	Fatigue (F)	Yes (F1)	47,00
		No (F2)	53,00
5	Duration of sleep (DS)	≤ 6 hours (s_6_h_and_below/DS1)	52,333
		6 < DS≤ 7 (s_above_6_u_7_h/DS2)	24,333
		> 7 hours (s_above_7_h/DS3)	23,333
6	Violation (VI)	Yes	58,67
		No	41,33
7	Road geometry (RG)	Straight road (RG1)	83,33
		Hill or bends (RG2)	16,67
8	Coffee (CF)	Yes	5,00
		No	95,00

3.2. Analysis of Data

The results of analysis show the drivers who consume coffee were 11% more likely to have accident and 89% for drivers who did not consume coffee as shown in Fig. 3.

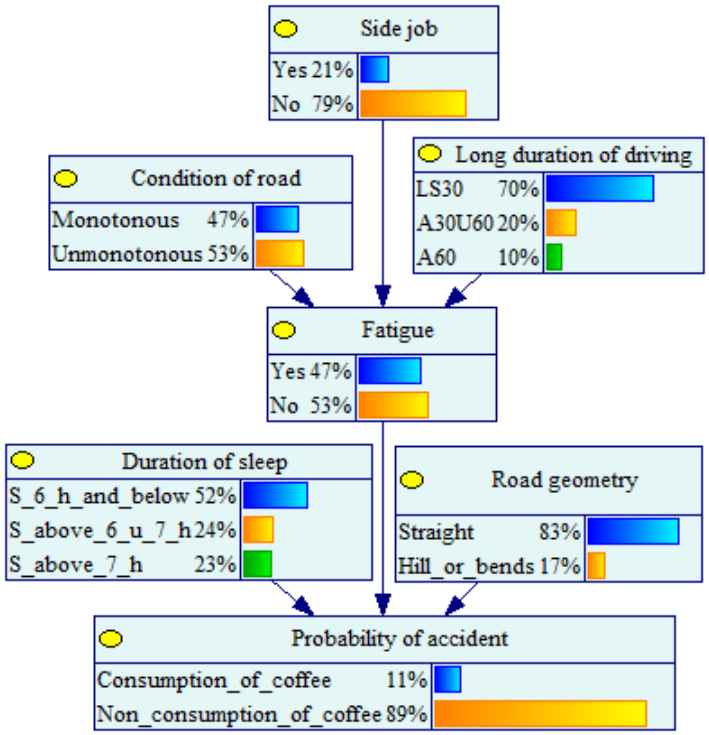

Figure 3. Structure Bayesian network of probability of accident

The probability of accidents for motorcyclists who drink coffee was lower compared driver did not consume coffee. Coffee consumption will avoid drowsiness and it will increase the level of alertness of the driver, thus it is likely that the driver will avoid accidents. The calculation of the accident probability uses the equation in Table II.

Table 2. Equation of Probability of accident

No	P(F)	P(RG)	P(DS)	P(ACC)
1	F1	RG1	DS1	P(PA)1=P(PA|F1, RG1, DS1, CR, SJ, LDD,) P(F1| CR, SJ, LDD)
2	F1	RG1	DS2	P(PA)1=P(PA|F1, RG1, DS2, CR, SJ, LDD,) P(F1| CR, SJ, LDD)
3	F1	RG1	DS3	P(PA)1=P(PA|F1, RG1, DS3, CR, SJ, LDD,) P(F1| CR, SJ, LDD)
4	F1	RG2	DS1	P(PA)1=P(PA|F1, RG2, DS1, CR, SJ, LDD,) P(F1| CR, SJ, LDD)
5	F1	RG2	DS2	P(PA)1=P(PA|F1, RG2, DS2, CR, SJ, LDD,) P(F1| CR, SJ, LDD)
6	F1	RG2	DS3	P(PA)1=P(PA|F1, RG2, DS3, CR, SJ, LDD,) P(F1| CR, SJ, LDD)
7	F2	RG1	DS1	P(PA)1=P(PA|F2, RG1, DS1, CR, SJ, LDD,) P(F2| CR, SJ, LDD)
8	F2	RG1	DS2	P(PA)1=P(PA|F2, RG1, DS2, CR, SJ, LDD,) P(F2| CR, SJ, LDD)
9	F2	RG1	DS3	P(PA)1=P(PA|F2, RG1, DS3, CR, SJ, LDD,) P(F2| CR, SJ, LDD)
10	F2	RG2	DS1	P(PA)1=P(PA|F2, RG2, DS1, CR, SJ, LDD,) P(F2| CR, SJ, LDD)
11	F2	RG2	DS2	P(PA)1=P(PA|F2, RG2, DS2, CR, SJ, LDD,) P(F2| CR, SJ, LDD)
12	F2	RG2	DS3	P(PA)1=P(PA|F2, RG2, DS3, CR, SJ, LDD,) P(F2| CR, SJ, LDD)
				∑ **P(ACC)**

To determine the accuracy of the model, validation was carried out by calculating the Mean Absolute Deviation value, which is the average difference between the model results and conditions in the field. The calculation results show the MAD value that is obtained is 21.07%, meaning that the average difference between the model results and field conditions was 21.07%. Furthermore, several scenarios were carried out to determine the effect of each variable.

TABLE 3. Validation of Model

Probability	Fatigue	Road geometry	Duration of sleep	Model	Actual	Deviation
1	Yes	Straight road	≤ 6 hours	16	11,11	4,89
2	Yes	Straight road	6 < DS ≤ 7	18	11,11	6,89
3	Yes	Straight road	> 7 hours	12	9,09	2,91
4	Yes	Hill or bends	≤ 6 hours	12	0,00	12,00
5	Yes	Hill or bends	6 < DS ≤ 7	0	25,00	25,00
6	Yes	Hill or bends	> 7 hours	14	0,00	14,00
7	No	Straight road	≤ 6 hours	11	0,00	11,00
8	No	Straight road	6 < DS ≤ 7	4	0,00	4,00
9	No	Straight road	> 7 hours	8	9,09	1,09
10	No	Hill or bends	≤ 6 hours	0	100,00	100,00
12	No	Hill or bends	> 7 hours	0	50,00	50,00
			Mean Absolute Deviation			21,07

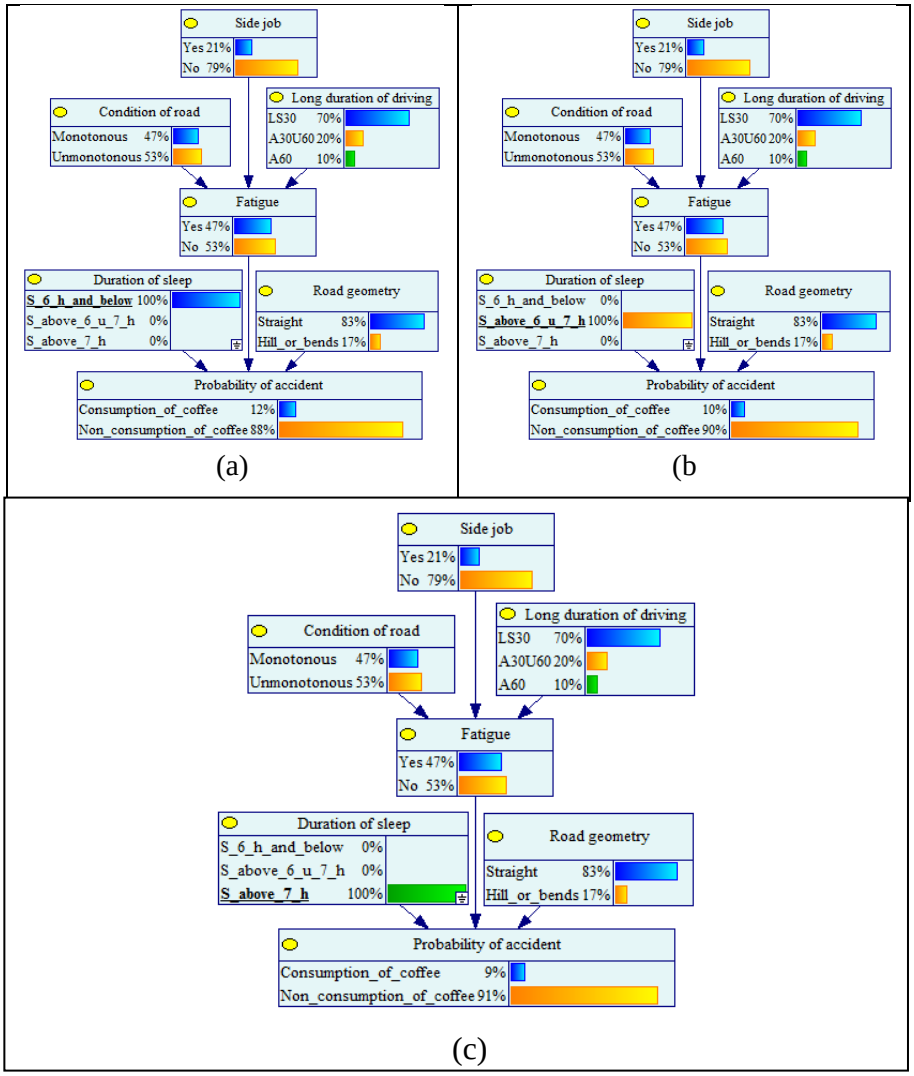

Figure 4. Scenario 1

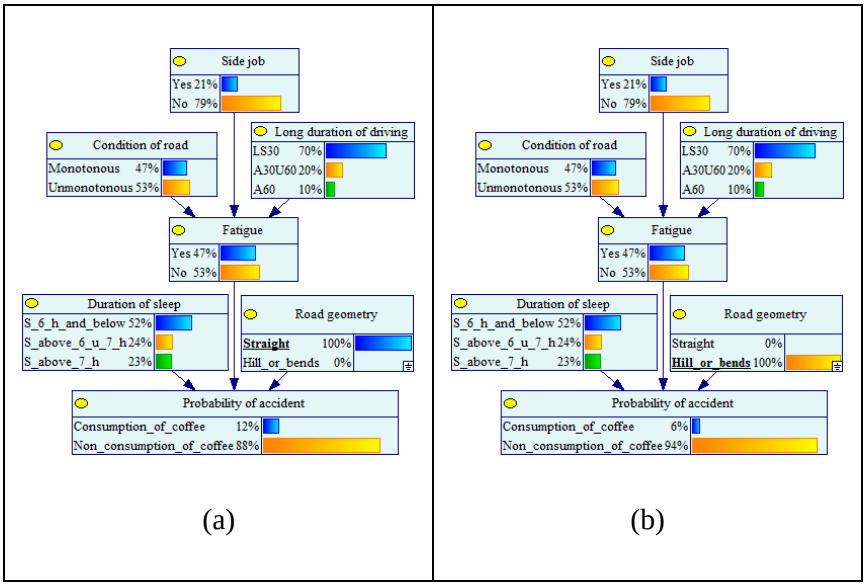

Figure 5. Scenario 2

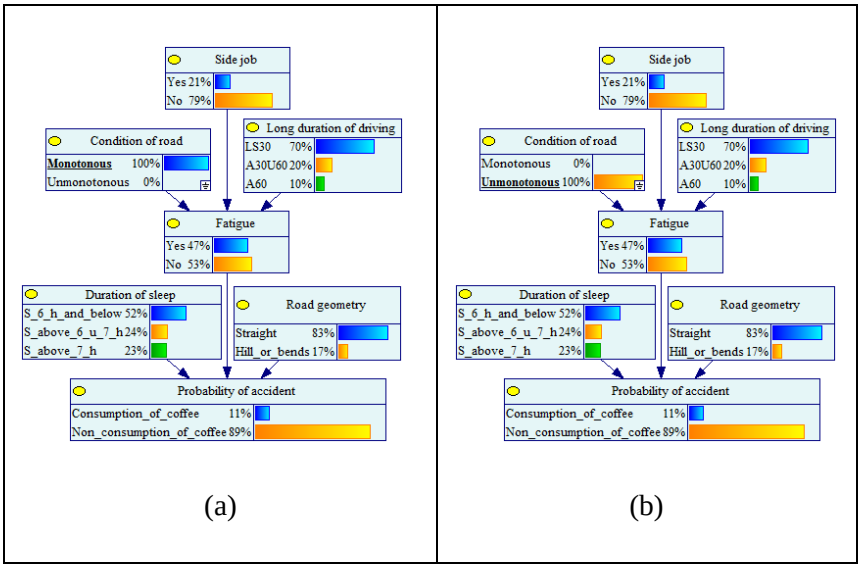

Figure 6. Scenario 3

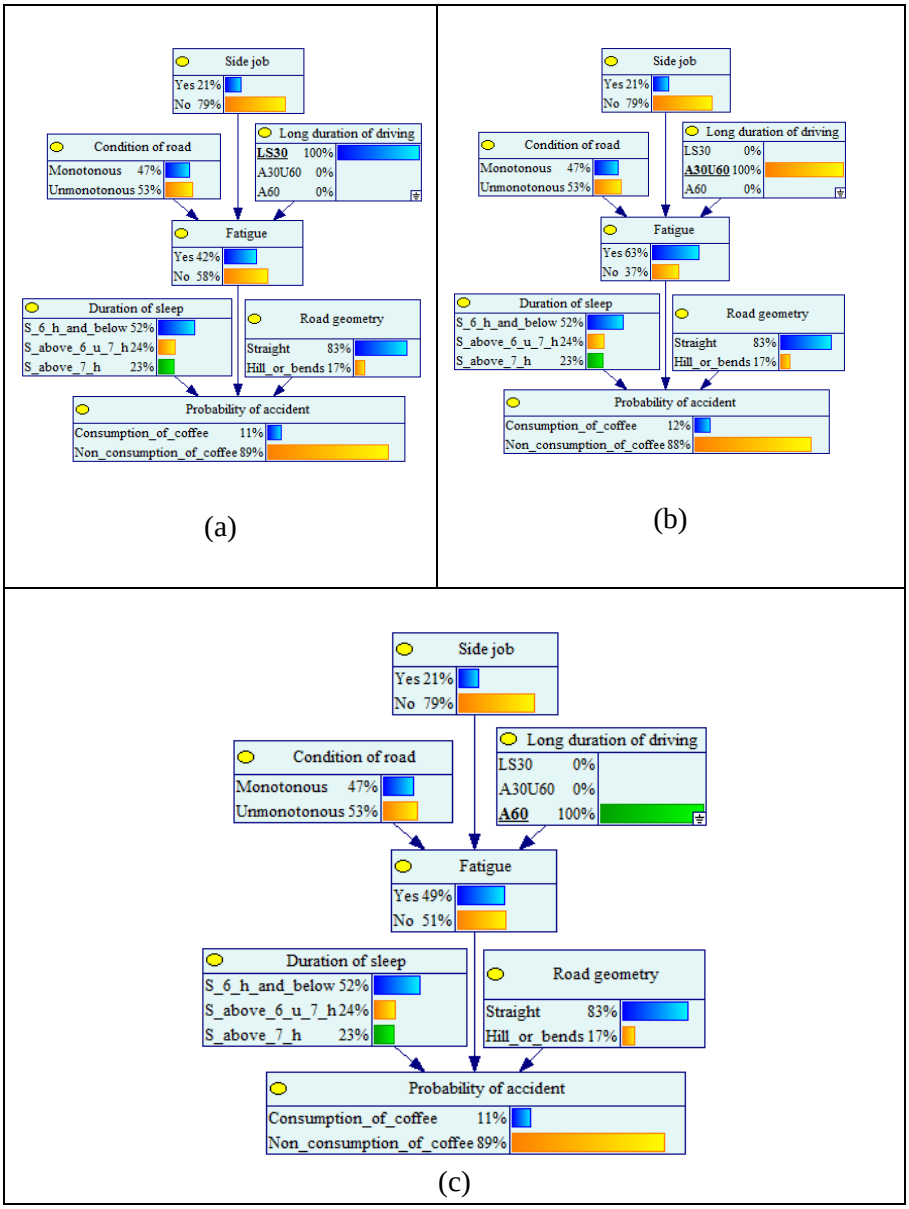

Figure 7. Scenario 4

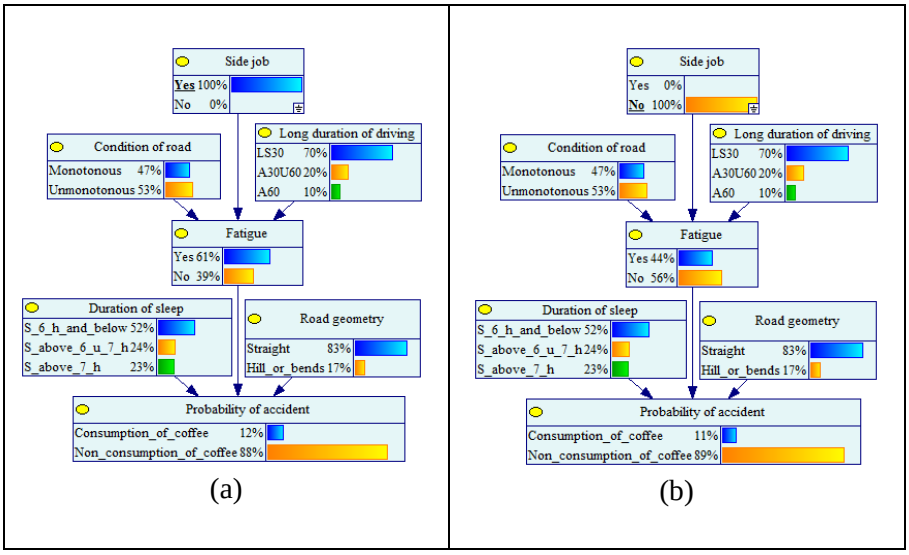

Figure 8. Scenario 5

Scenario 1 shows that the drivers who consume coffee and sleep at the night before the accident for 6 hours or less will have an accident probability by 12%, and drivers who consume coffee and sleep for more than 6 hours to 7 hours have an accident probability by 10%, and drivers who consume coffee and sleep more than 7 hours have an accident probability by 9% as shown in Fig. 4. The results of this scenario 1 show that the less duration of sleep of drivers, the greater the risky of accident. The results of this study are in line with research that are conducted by ([7]; [8]).

Scenario 2 shows that the driver who consumes coffee and drives on a straight road more likely to suffer accident by 12%, meanwhile a driver who consumes coffee and drives on a hilly road or bends has probability of an accident by 6% as shown in Fig. 5. The results of scenario 2 show that a driver who drive on a straight road tends to cause the driver feel monotonous and can also reduce the level of vigilance of the driver, thus this condition results in decreasing in the ability to drive safely. This research is in line with research that are conducted by ([12]; [13]).

Scenario 3 shows that the drivers who consume coffee and feel monotonous when driving have probability of fatigue by 47% and have probability of an accident by 11%. Meanwhile, the drivers who consume coffee and drive did not feel monotonous have a probability of fatigue by 47% and have accident probability by 11% as shown in Fig. 6. The results of scenario 3 show that road geometry conditions do not affect motorcyclists who consume coffee to the possibility of fatigue and the possibility of accidents.
Scenario 4 shows that the drivers who drink coffee and drive for 30 minutes or less have fatigue probability by 42% and have accident probability by 11%, and the drivers who drinks coffee and drives for more than 30 minutes to 60 minutes has fatigue probability by 63% and the probability of accident by 12%, drivers who drink coffee and drive for more than 60 minutes have fatigue probability by 49% and have accident probability by 11% as shown in Fig. 7. The results of this study indicated that on a trip over 60 minutes the probability of fatigue and the probability of an accident tend to decrease. This is probably caused by motorcycle riders feeling their stamina has decreased at this time, so they decide to take a rest for a while so that the level of fatigue and the probability of accident decreases.

Scenario 5 shows that the drivers who drink coffee and have side job more likely to suffer fatigue by 61% and more likely to suffer accident by 12%. In addition, the driver who consumes coffee and they did not have side job more likely to suffer fatigue level by 44% and more likely to suffer accident by 11% as shown in Fig. 8. The results of scenario 5 show that the drivers who have side jobs are more likely to experience fatigue and are more likely to have accidents.

4. CONCLUSION

The number of samples in this study were 381 respondents that consist of 300 respondents were used for analysis of data and 81 respondents were used to validate the model. The results of analysis show that the drivers who consume coffee are 11% more likely to have accident and 89% for drivers who do not consume coffee. The results of scenario 1 show that the less duration sleep of driver, the greater the driver experience fatigue and have accident. Scenario 2 shows that the driver drive on a straight road tend to have

accident than driving on a curve. Meanwhile, scenario 3 shows that there is no effect of coffee consumption to condition of road geometry. Scenario 4 shows that long duration of driving around 60 minutes show the driver tends to experience fatigue and the probability of accident increases, but long duration of driving above 60 minutes, the probability of fatigue and the probability of an accident decreases. Scenario 5 shows that drivers who have a side job are more likely to have accident than drivers who do not have side job.

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