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Probability of the Alertness Level of Elderly Drivers before an Accident Occurs

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ABSTRACT

This research aims to develop a model to predict the alertness level of elderly motorcycle riders, focusing on those aged 45–65 in Riau Province, Indonesia. Accident statistics in Indonesia show that riders aged 50 and above are more prone to accidents. Data was collected by interviewing elderly motorcycle riders who had experienced accidents at the ages of 45-65 years. The total of respondents used in this study was 564. The analysis results indicated that elderly motorcycle riders are 43% likely to have a high level of alertness and 57% likely to have a low level of alertness. Four scenarios were conducted to determine the influence of each variable. The results showed that the highest level of alertness among elderly motorcycle riders was 46%. Thus, elderly motorcycle riders are likely to be prone to accidents. The findings of this research indicate that the highest alertness level among elderly drivers is below 50%, thus several things are required to improve the safety of elderly drivers including: 1) not to ride for too long on straight road segments; 2) to ride in good physical condition; 3) sleep more than 7 hours at night; 4) not to use cell phones while riding; 5) necessary to review the eligibility of a driver's license when motorcyclists reach the age of 45years; and 6) elderly riders need to be accompanied by another rider.

Keywords: Accident; Bayesian; Elderly; Motorcyclists; Rider

1. Introduction

Motorcycles are less stable compared to other vehicles such as cars, buses, and trucks, thus making them more prone to experiencing accidents. Motorcycles are supported by two wheels, which makes them

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less stable and requires a good balance when riding. To maintain balance while riding a motorcycle, riders need to have a high level of alertness on the road, such as being aware of other riders' behaviors, the positions of other vehicles, pedestrians, and road conditions. Several factors affect the alertness level of motorcycle riders, including fatigue while riding, riding in not good condition, riding under stress [1, 2], riding experience [3, 4], using a phone while riding [5-7], road conditions, weather, and traffic density.

Fatigue can cause drivers to lose focus while driving, resulting in reduced driving ability. This condition increases the risk of accidents [8, 9] and can also escalate the severity of accidents [10]. Several factors contribute to driver fatigue, including heavy workloads before driving, driving for prolonged periods [11, 12], and lack of sleep the night before driving [13]. Lack of sleep at night can lead the driver to commit traffic violations, which increases the risk of accidents [14, 15], and can also cause serious injuries in the event of an accident [16]. Another factor that influences fatigue is the time of driving [17]. Drivers who are too tired while driving may become drowsy, which undoubtedly affects their driving performance [18, 19]. Such conditions can endanger driver safety [14; 9; 20] and significantly increase the severity of accidents [10, 21, 22].

Additionally, stress and emotions can cause drivers to lose focus while driving and hinder decision-making processes when facing hazards ahead. This condition can result in slower reaction times. Stress and emotions can also lead to more aggressive driving behavior compared to normal conditions. Moreover, experienced riders tend to have better skills and abilities in controlling motorcycles and are more likely to anticipate sudden dangers. Another issue that causes a lack of focus while driving is the use of mobile phones, which can result in slow driver response times, especially when encountering hazards. Besides these factors, road conditions such as potholes and slippery surfaces can also disrupt a rider's alertness, increasing the risk of accidents. Environmental factors, such as driving in the rain, can limit the rider's visibility and demand higher alertness to avoid accidents.

As the age of a rider increases, their level of alertness tends to decrease, which in turn reduces their driving ability. This decline in ability can endanger the safety of the rider and other road users. Age is one of the factors influencing the risk of accidents [23, 24]. Accident rates tend to rise in the 60-69 age group [25]. Older riders are at higher risk of accidents due to visual limitations, longer reaction times, reduced concentration, quick fatigue [26], impaired understanding of vehicle technology [27-30], and health issues while driving [31]. Unhealthy elderly drivers show poorer performance [32]. Statistical data in Indonesia shows the number of accident victims in 2020: 26,906 victims aged 10-19, 29,281 victims aged 20-29, 18,553 victims aged 30-39, 17,980 victims aged 40-49, and a significant increase to 31,740 victims for those aged 50 and above [33]. Therefore, efforts are needed to understand the dominant human and road factors that influence the alertness level of elderly riders. The results of this study will be beneficial for decision-makers at the ministerial and regional levels in formulating traffic safety programs, especially for elderly motorcycle riders.

2. Materials and Methods

This research was conducted in Riau Province, Indonesia. The respondents were elderly motorcycle riders (aged 46-65) who had experienced either single or multiple accidents. The total number of respondents in this study was 564; 425 respondents were used to develop the model predicting the alertness level of elderly motorcycle riders, and 139 respondents were used to validate the previously obtained model. The sample size was calculated by using the formula shown below.

$$n = \frac{N}{1 + Ne^2},$$

where n = number of sample, N = population, e = margin of error, the number of accidents in Riau Province = 2750 accident victims, e = 5%.

$$349.21 = \frac{2750}{1 + (2750 \times 0.05)^2}.$$

Data collection was carried out by interviewing respondents. Several variables that influence the alertness level of riders include using mobile phones while riding, fatigue, road conditions, and obstructed vision. The alertness of drivers could be based on the level of concentration that has begun to decline; it could be that their level of ability in driving has begun to decline; it could be that they have committed several violations without any intention or it could be that the driver is already tired so that he is very vulnerable to the risk of an accident. Meanwhile, the road condition variable is influenced by road geometry and roadside variability. Additionally, the fatigue variable is influenced by the long duration of driving and the duration of sleep the night before the accident. Furthermore, the obstructed view variable is influenced by weather conditions. The interview process is carried out in a way where the surveyor approaches the candidate of respondent by asking: Have you ever had a motorcycle accident as a driver? If the respondent answers no, then the interview is not continued. However, if the respondent answers yes, then the following questions will be asked, including:

1. What is your name?
2. What is your gender?
3. Were you using a cell phone just before the accident?
4. Were you fatigued just before the accident?
5. What were the road conditions just before the accident?
6. What were the road geometry conditions just before the accident?
7. What was the roadside variability of the road just before the accident?
8. Was your view obstructed just before the accident?
9. How long had you traveled before you had the accident?
10. How long did you sleep the night before the accident?
11. What time did you have the accident?
12. What were the weather conditions when you had the accident?
13. What was your level of alertness just before the accident?

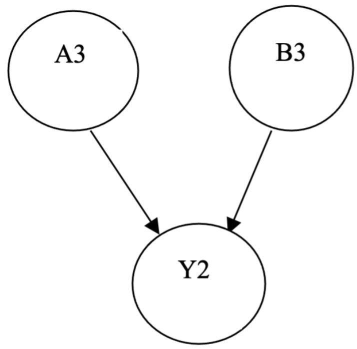

Fig. 1. Example of calculation of Bayesian Network analysis (with 3 variables).

The collected data was analyzed by using a Bayesian Network with GeNie 2.0 software [34]. A Bayesian Network represents conditional probability, indicating the probability of event B given that event A has occurred, which is formulated in the following formula:

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

For example, the calculation of Bayesian Network analysis in Fig. 1 (with 3 variables) can be calculated by using the following formula:

$$\begin{aligned} P(Y2) &= P(Y2|A3, B3) \times P(A3)P(B3) \\ &+ P(Y2|A3, -B3) \times P(A3)P(-B3) \\ &+ P(Y2|-A3, B3) \times P(-A3)P(B3) \\ &+ P(Y2|-A3, -B3) \times P(-A3)P(-B3). \end{aligned}$$

Bayesian Network Analysis has several limitations, including:

1. In creating a Bayesian Network, it is assumed that the variables are related to each other, but in several cases, this assumption may not be in accordance with reality or be less realistic.
2. It requires in-depth knowledge of the model to be created related to the difficulty of creating a Bayesian Network structure model that describes the relationship between variables
3. The more variables that are used in the Bayesian Network Structure, the more complex and difficult to analyze the network representation becomes.
4. In Bayesian Network analysis, sufficient data is needed to estimate the probability between variables accurately, if the data used for analysis is limited, the results obtained become less reliable.
5. In several cases, determining prior probabilities for several variables can be subjective, if the information obtained is very limited.

After the model is obtained, the model is validated by calculating the Mean Absolute Deviation (MAD). The MAD value indicates the closeness between the model results and field conditions. If there is no significant difference between the model results and field conditions, several scenarios are conducted to understand the dominant variables in the model. MAD calculation uses the formula:

$$MAD = \frac{1}{n} \sum |Actual - Forecast|.$$

3. Results and Discussion

Several variables directly affect the level of driver alertness, including: the use of cell phones while driving, fatigue while driving, monotonous road conditions and impaired vision by certain objects shortly before an accident occurs. The use of cell phones while driving can cause drivers to be less focused on the traffic conditions around them. In addition, the use of cell phones

Table 1. Data Description.

Variable	Value	Percentage (%)
Gender	Male	52
	Female	48
Possession of a Driver's License	Have	35
	Do Not have	65
Using a cell phone while driving	Yes	10
	No	90
Duration of sleep on the night before the accident	≤ 6 hours	29
	6-7 hours	15
	>7 hours	56
Fatigue	Yes	27
	No	73
Duration of driving	≤ 30 minute	70
	30 <Duration ≤ 60	20
	>60 minute	9
Time of the accident occurred	06:00 - 12:00	18
	12:00 - 18:00	48
	18:00 - 24:00	32
	24:00 - 06:00	2
Road Geometry	Flat and straight	59
	Curve	41
Roadside variability	Varied	63
	Not varied	37
Road condition	Monotonous	38
	Not monotonous	62
Visibility	Obstructed	40
	Not obstructed	60
Weather	Rain	28
	Not rain	72
The level of driver alertness	High	43
	Low	57

while driving can also result in slow reaction times for drivers. Lack of focus and slow reactions from drivers can result in a decreasing in the level of driver alertness, thus endangering the safety of the driver and others. In addition, fatigue felt by drivers while driving can affect the level of driver emotion, thus affecting driver behavior while driving, such as being more aggressive, less careful and having slower reaction times for drivers. Furthermore, this fatigue can also cause drivers to become drowsy or even fall asleep while driving, thus affecting the level of driver alertness while driving. Fatigue that occurs while driving can be caused by several things, including driving for too long, lack of rest time such as lack of sleep, and driving time. Driving during the day can accelerate fatigue compared to driving in the afternoon. In addition to the above problems, road factors also affect the level of driver alertness. When drivers drive on a winding road, the driver's level of alertness tends to increase compared to driving on a straight road. In addition, when the driver's view is obstructed while driving, this certainly means that the driver will not be able to identify whether there is something dangerous or not around him; in this situation the driver's level of alertness will decrease and will even affect the decisions to be taken. This obstructed view can be caused by weather conditions or other objects. The survey results showed that 71.39% of respondents experienced accidents from 2018 to 2024, while 28.61% of respondents experienced accidents before 2018. A description of each variable is shown in Table 1. The survey results show that the number of elderly male motorcyclists is greater (52%) than elderly female motorcyclists (48%). Meanwhile, 65% of elderly motorcyclists do not have a driver's license. Additionally,

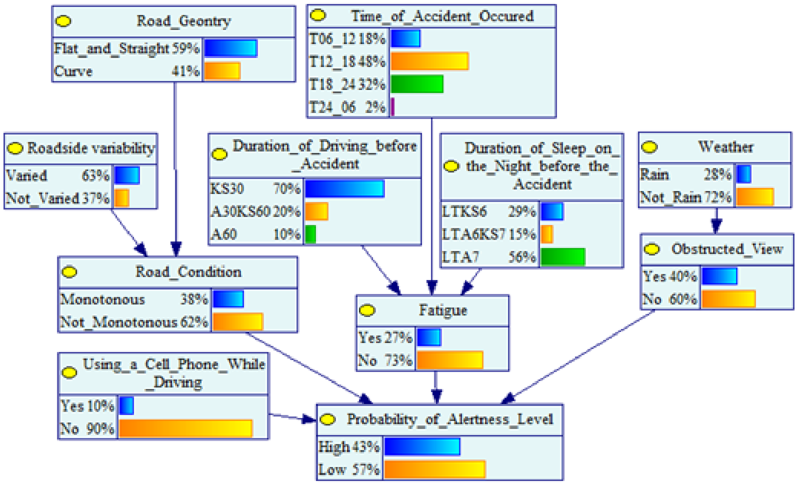

Fig. 2. Model of structure bayesian network of probability of alertness level. Information: KS30 = durarion of driving for 30 minutes or less, A30KS60 = durarion of driving for more than 30 minutes until 60 minutes, A60 = durarion of driving for more than 60 minutes, LTKS6 = sleep duration on the night before the accident of around 6 hours or less. LTA6KS7 = sleep duration on the night before the accident of more than 6 hours up to 7 hours. LTA7 = sleep duration on the night before the accident of more than 7 hours.

10% of elderly motorcyclists were using a cell phone before the accident occurred. Elderly motorcyclists who slept more than 7 hours are 56% the most likely to be involved in accidents compared to other groups. The survey also shows that 27% of elderly motorcyclists experienced fatigue before the accident occurred. Data also shows that elderly motorcyclists with long duration of driving 30 minutes or less are 70% more likely to be involved in accidents compared to elderly motorcyclists with other long duration. Additionally, 48% of accidents involving elderly motorcyclists occurred between 12:00 PM and 6:00 PM. Furthermore, 8% of elderly motorcyclists were sick at the time of the accident. Based on the accident location, 59% of elderly motorcyclists had accidents on straight roads, and 41% on curves. Elderly motorcyclists who had accidents on roads with varied roadside variability was 63%, while those on roads with no varied roadside variability was 37%. Elderly motorcyclists who had accidents on monotonous roads were 38%, while those on non-monotonous roads was 62%. Elderly motorcyclists who had their view obstructed before the accident was 40%, while those whose vision was unobstructed before accident was 60%. Lastly, 28% of elderly motorcyclists had accidents during rainy conditions, while 72% had accidents in non-rainy conditions. The analysis results using GeNie 2.0 software indicate that elderly motorcyclists have a 43% probability of having a high level of alertness and a 57% probability of having a low level of alertness, as shown in Fig. 2. This means that elderly motorcyclists tend to have a low level of alertness, it increase the risk of accidents. Several factors contribute to the low level of alertness among elderly motorcyclists, including diminished visual abilities, slow reaction times to dangerous situations, reduced concentration while riding, quick fatigue, lack of understand of vehicle

Table 2. Equality model of probability of alertness level in elderly motorcyclists.

<table>
<tr><th>P</th><th>P(PS)</th><th>P(FT)</th><th>P(RD)</th><th>P(OV)</th><th>P(AL)</th></tr>
<tr><td>P1</td><td>PS1</td><td>FT1</td><td>RD1</td><td>OV1</td><td>P(AL)1=P(AL|PS1,FT1,RD1,OV1,DDBA,TAO,DSNBA,RS,RG,W) P(FT1|DDBA,TAO,DSNBA) P(RD1|RS,RG,DDBA) P(OV1|W)</td></tr>
<tr><td>P2</td><td>PS1</td><td>FT1</td><td>RD1</td><td>OV2</td><td>P(AL)2=P(AL|PS1,FT1,RD1,OV2,DDBA,TAO,DSNBA,RS,RG,W) P(FT1|DDBA,TAO,DSNBA) P(RD1|RS, RG, DDBA) P(OV2|W)</td></tr>
<tr><td>P3</td><td>PS1</td><td>FT1</td><td>RD2</td><td>OV1</td><td>P(AL)3=P(AL|PS1,FT1,RD2,OV1,DDBA,TAO,DSNBA,RS,RG,W) P(FT1|DDBA,TAO,DSNBA) P(RD2|RS,RG,DDBA) P(OV1|W)</td></tr>
<tr><td>P4</td><td>PS1</td><td>FT1</td><td>RD2</td><td>OV2</td><td>P(AL)4=P(AL|PS1,FT1,RD2,OV2,DDBA,TAO,DSNBA,RS,RG,W) P(FT1|DDBA,TAO,DSNBA) P(RD2|RS,RG,DDBA) P(OV2|W)</td></tr>
<tr><td>P5</td><td>PS1</td><td>FT2</td><td>RD1</td><td>OV1</td><td>P(AL)5=P(AL|PS1,FT2,RD1,OV1,DDBA,TAO,DSNBA,RS,RG,W) P(FT2|DDBA,TAO,DSNBA) P(RD1|RS,RG,DDBA) P(OV1|W)</td></tr>
<tr><td>P6</td><td>PS1</td><td>FT2</td><td>RD1</td><td>OV2</td><td>P(AL)6=P(AL|PS1,FT2,RD1,OV2,DDBA,TAO,DSNBA,RS,RG,W) P(FT2|DDBA,TAO,DSNBA) P(RD1|RS,RG,DDBA) P(OV2|W)</td></tr>
<tr><td>P7</td><td>PS1</td><td>FT2</td><td>RD2</td><td>OV1</td><td>P(AL)7=P(AL|PS1,FT2,RD2,OV1,DDBA,TAO,DSNBA,RS,RG,W) P(FT2|DDBA,TAO,DSNBA) P(RD2|RS,RG,DDBA) P(OV1|W)</td></tr>
<tr><td>P8</td><td>PS1</td><td>FT2</td><td>RD2</td><td>OV2</td><td>P(AL)8=P(AL|PS1,FT2,HC2,RD2,OV2,DDBA,TAO,DSNBA,RS,RG,W) P(FT2|DDBA,TAO,DSNBA) P(RD2|RS,RG,DDBA) P(OV2|W)</td></tr>
<tr><td>P9</td><td>PS2</td><td>FT1</td><td>RD1</td><td>OV1</td><td>P(AL)9=P(AL|PS2,FT1,RD1,OV1,DDBA,TAO,DSNBA,RS,RG,W) P(FT2|DDBA,TAO,DSNBA) P(RD1|RS,RG,DDBA) P(OV1|W)</td></tr>
<tr><td>P10</td><td>PS2</td><td>FT1</td><td>RD1</td><td>OV2</td><td>P(AL)10=P(AL|PS2,FT1,RD1,OV2,DDBA,TAO,DSNBA,RS,RG,W) P(FT2|DDBA,TAO,DSNBA) P(RD1|RS,RG,DDBA) P(OV2|W)</td></tr>
<tr><td>P11</td><td>PS2</td><td>FT1</td><td>RD2</td><td>OV1</td><td>P(AL)11=P(AL|PS2,FT1,RD2,OV1,DDBA,TAO,DSNBA,RS,RG,W) P(FT2|DDBA,TAO,DSNBA) P(RD1|RS,RG,DDBA) P(OV2|W)</td></tr>
<tr><td>P12</td><td>PS2</td><td>FT1</td><td>RD2</td><td>OV2</td><td>P(AL)12=P(AL|PS2,FT1,RD2,OV2,DDBA,TAO,DSNBA,RS,RG,W) P(FT2|DDBA,TAO,DSNBA) P(RD2|RS,RG,DDBA) P(OV2|W)</td></tr>
<tr><td>P13</td><td>PS2</td><td>FT2</td><td>RD1</td><td>OV1</td><td>P(AL)13=P(AL|PS2,FT2,RD1,OV1,DDBA,TAO,DSNBA,RS,RG,W) P(FT2|DDBA,TAO,DSNBA) P(RD1|RS,RG,DDBA) P(OV1|W)</td></tr>
<tr><td>P14</td><td>PS2</td><td>FT2</td><td>RD1</td><td>OV2</td><td>P(AL)14=P(AL|PS2,FT2,RD1,OV2,DDBA,TAO,DSNBA,RS,RG,W) P(FT2|DDBA,TAO,DSNBA) P(RD1|RS,RG,DDBA) P(OV2|W)</td></tr>
<tr><td>P15</td><td>PS2</td><td>FT2</td><td>RD2</td><td>OV1</td><td>P(AL)15=P(AL|PS2,FT2,RD2,OV1,DDBA,TAO,DSNBA,RS,RG,W) P(FT2|DDBA,TAO,DSNBA) P(RD2|RS,RG,DDBA) P(OV1|W)</td></tr>
<tr><td>P16</td><td>PS2</td><td>FT2</td><td>RD2</td><td>OV2</td><td>P(AL)16=P(AL|PS2,FT2,RD2,OV2,DDBA,TAO,DSNBA,RS,RG,W) P(FT2|DDBA,TAO,DSNBA) P(RD2|RS,RG,DDBA) P(OV2|W)</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td>∑ P(AL)</td></tr>
</table>

RD=Road Condition, RD1=Monotonous, RD2=Not monotonous, OV=Obstrcted view, OV1=Yes, OV2=No, DDBA=Duration of driving before accident, TAO=Time of accident occured. DSNBA=Duration of sleep on the night before the accident, RS=Roadside variability, RG=Road geometry, W=weather.

Table 3. The calculation of probability of alertness level in elderly motorcyclists.

P	P(PS)	P(FT)	P(RD)	P(OV)	P(AL|PS,FT,RD,OV,DDBA,TAO, DSNBA,RS,RG,W)		H	L
					High	Low		
1	0,10	0,27	0,38	0,40	0,00	1,00	0,000	0,004
2	0,10	0,27	0,38	0,60	0,00	1,00	0,000	0,006
3	**0,10**	**0,27**	**0,62**	**0,40**	**0,33**	**0,67**	**0,002**	0,004
4	0,10	0,27	0,62	0,60	0,00	1,00	0,000	0,010
5	0,10	0,73	0,38	0,40	0,00	1,00	0,000	0,011
6	0,10	0,73	0,38	0,60	0,00	1,00	0,000	0,017
7	0,10	0,73	0,62	0,40	0,33	0,67	0,006	0,012
8	0,10	0,73	0,62	0,60	0,33	0,67	0,009	0,018
9	0,90	0,27	0,38	0,40	0,30	0,70	0,011	0,026
10	0,90	0,27	0,38	0,60	0,31	0,69	0,017	0,038
11	0,90	0,27	0,62	0,40	0,50	0,50	0,030	0,030
12	0,90	0,27	0,62	0,60	0,27	0,73	0,024	0,066
13	0,90	0,73	0,38	0,40	0,56	0,44	0,056	0,043
14	0,90	0,73	0,38	0,60	0,55	0,45	0,082	0,068
15	0,90	0,73	0,62	0,40	0,42	0,58	0,069	0,094
16	0,90	0,73	0,62	0,60	0,50	0,50	0,122	0,122
						∑ P(AL)	0,429	0,571

Information: P=Probability, H=High, L-Low

technology, and health issues while riding. From Model of the Structure of Bayesian Network that is obtained, as shown in Fig. 2, equations were derived as presented in Table 2. Explanation of Table 3 on P3 (Probability 3) with the equation:

P(AL)3 = P(AL|PS1, FT1, RD2, OV1, DDBA, TAO, DSNBA, RS, RG, W) × P(FT1|DDBA, TAO, DSNBA) P(RD2|RS, RG, DDBA) P(OV1| W),

P(AL)3 = PS1 × FT1 × RD2 × OV1 × P(AL|PS1, FT1, RD2, OV1, DDBA, TAO, DSNBA, RS, RG, W).

It is known (model in Fig. 2):

PS1 = 0.1 (10% of elderly drivers use cell phones shortly before an accident),

FT1 = 0.27 (27% of elderly drivers experience fatigue shortly before an accident),

RD2 = 0.62 (62% of drivers feel monotonous in driving shortly before an accident),

OV1 = 0.4 (40% of drivers who his view was obstructed before the accident).

P(AL|PS1, FT1, RD1, OV1, DDBA,

Table 4. The calculation of mean absolute deviation (MAD).

P	P(PS)	P(FT)	P(RD)	P(OV)	Probability of alertness level		Deviation
					Actual	Model	
P1	PS1	FT1	RD1	OV1	0,00	0,00	0,00
P2	PS1	FT1	RD1	OV2	0,00	0,00	0,00
P3	PS1	FT1	RD2	OV1	0,00	33,00	33,00
P4	PS1	FT1	RD2	OV2	0,00	0,00	0,00
P5	PS1	FT2	RD1	OV1			
P6	PS1	FT2	RD1	OV2	0,00	0,00	0,00
P7	PS1	FT2	RD2	OV1	0,00	33,00	33,00
P8	PS1	FT2	RD2	OV2	0,00	33,00	33,00
P9	PS2	FT1	RD1	OV1	0,00	30,00	30,00
P10	PS2	FT1	RD1	OV2	15,00	31,00	16,00
P11	PS2	FT1	RD2	OV1	5,88	50,00	44,12
P12	PS2	FT1	RD2	OV2	29,41	27,00	2,41
P13	PS2	FT2	RD1	OV1	33,33	56,00	22,67
P14	PS2	FT2	RD1	OV2	25,00	55,00	30,00
P15	PS2	FT2	RD2	OV1	21,43	42,00	20,57
P16	PS2	FT2	RD2	OV2	38,46	50,00	11,54
MAD							18,42

TAO, DSNBA, RS, RG, W) = 0.33 (drivers who use cell phones while driving, then drive in a tired state, and feel monotonous while driving, and his view is obstructed by certain objects, the percentage of drivers like that in the sample is 33%.

Solution:

P(AL)3 = PS1 × FT1 × RD2 × OV1 × P(AL|PS1, FT1,RD2 , OV1, DDBA, TAO, DSNBA, RS, RG, W),
= 0.1 × 0.27 × 0.62 × 0.4 × 0.33 = 0.002.

Next, the model was validated by calculating the Mean Absolute Deviation value, which is the average difference between the model results and field conditions, as shown in Table 4. The possibility of the fifth scenario (PS5) in the actual field conditions did not occur, so it is not considered in determining the MAD value. The validation calculation results show a Mean Absolute Deviation of 18.42%. This indicates that the model's accuracy compared to field conditions is 82.58%.

Furthermore, to understand the influence of the relationship between one variable and another and to obtain strategies to overcome the low level of alertness of elderly drivers, several scenarios were carried out. Scenario 1a shows that elderly motorcyclists riding on curved roads with varied roadside variability can reduce the level of monotony by 31% (from 38% to 7%), as shown in Fig. 3. Conversely, scenario 1b indicates that elderly motorcyclists riding on straight roads with no varied roadside variability are likely to increase their level of monotony by 33% (from 38% to 71%), beside that in this condition the probability that elderly drivers have a high level of alertness by 44% or it increase 1% from the previous condition, namely 43%, as shown in Fig. 4. This means that elderly motorcyclists are 10.14 times more likely to experience monotony when riding on straight roads with no varied roadside variability compared to riding on curved roads with varied roadside variability. This finding is supported by survey data show that 63.29% of accidents occur on straight roads, 13.65% on curves, and 23.06% on

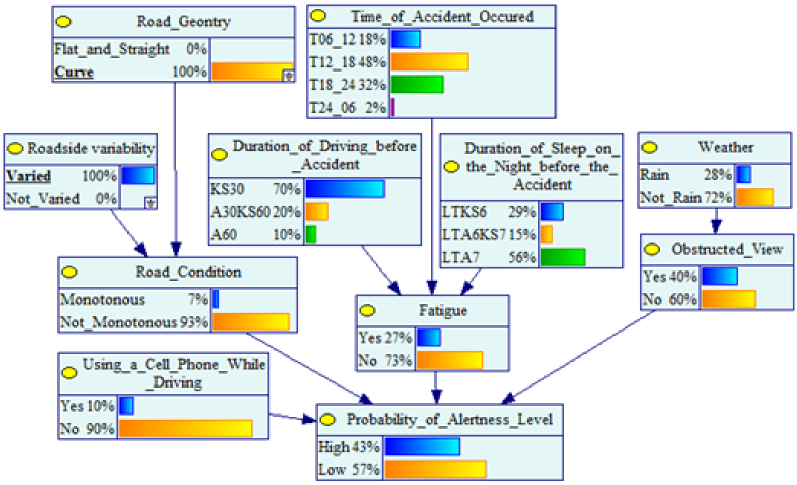

Fig. 3. Scenario 1a.

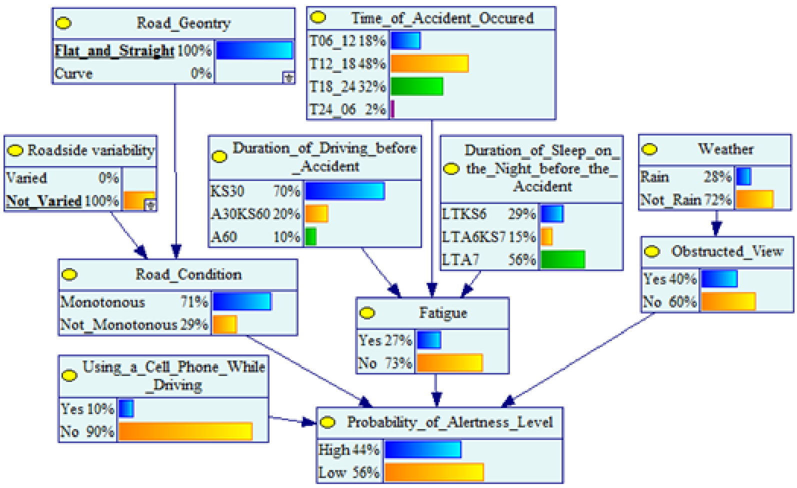

Fig. 4. Scenario 1b.

intersections. This indicates that the level of monotony experienced by riders is partly influenced by road conditions, where riding on long and straight roads tends to increase the level of monotony, leading to drowsiness while riding. Of course, in this condition it will endanger the safety of the driver himself and other drivers. The results of this study are in line with research conducted by [14, 35]. Scenarios 2a and 2b show that elderly motorcyclists riding in a fatigued condition are likely to have a high level of alertness of 32% or driver alertness levels dropped by 11% (from 43% to 32%), as shown in Fig. 5. Conversely, elderly motorcyclists riding in a non-fatigued condition are likely to have a high level of alertness of 47% or driver alertness level increased by 4% (from 43% to 47%), as shown in Fig. 6. This means that when elderly motorcyclists are not fatigued, their likelihood of high alertness is 1.5 times greater than when they are fatigued. This finding aligns with previous survey results,

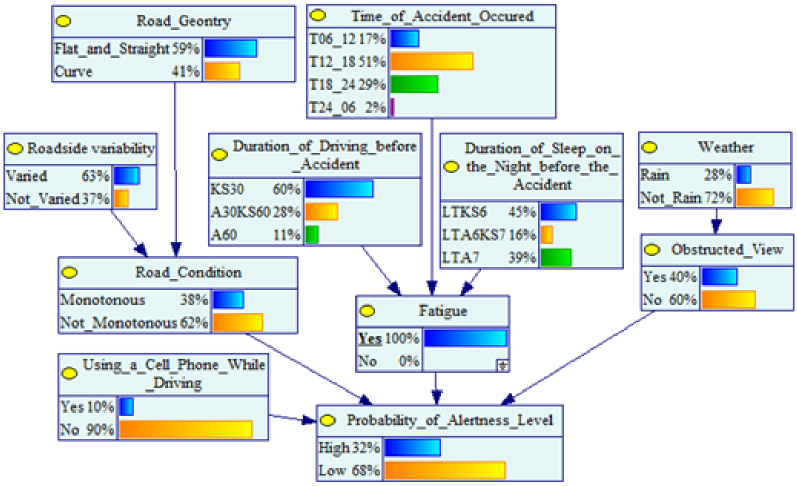

Fig. 5. Scenario 2a.

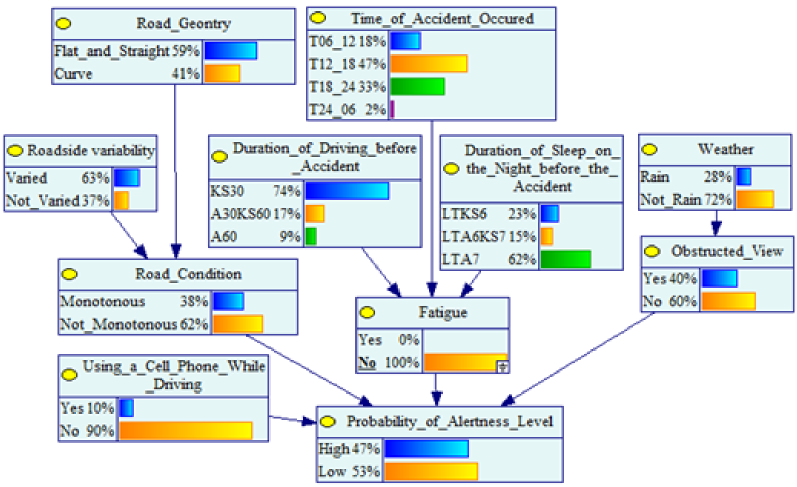

Fig. 6. Scenario 2b.

which indicated that 48% of accidents involving elderly motorcyclists occured between 12:00 PM and 6:00 PM. During this period, the weather is quite hot, and riders have often been active since the morning, thus so it is very likely that driving during this period will make the driver fatigue. Additionally, 58% of accidents involving elderly motorcyclists are single-vehicle accidents, one of the contributing factors being rider fatigue. The results of this study are in line with research conducted by [8-10, 12, 17, 26].

Scenarios 3a, 3b, and 3c show that elderly motorcyclists who sleep for 6 hours or less at night before accident are likely to experience a 15% increase in fatigue while riding (from 27% to 42%). This condition will also decrease their level of alertness by 2% (from 43% to 41%), as shown in Fig. 7. Meanwhile, elderly motorcyclists who sleep more than 6 hours up to 7 hours at night before accident are likely to experience a 1% increase in fatigue while riding

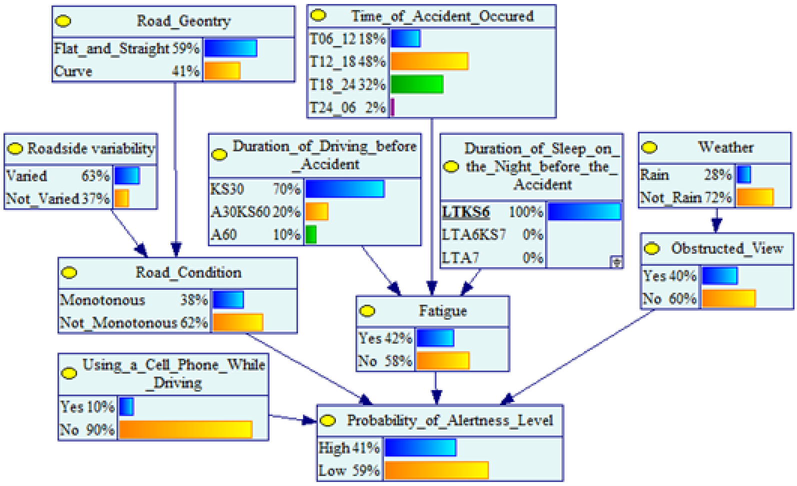

Fig. 7. Scenario 3a.

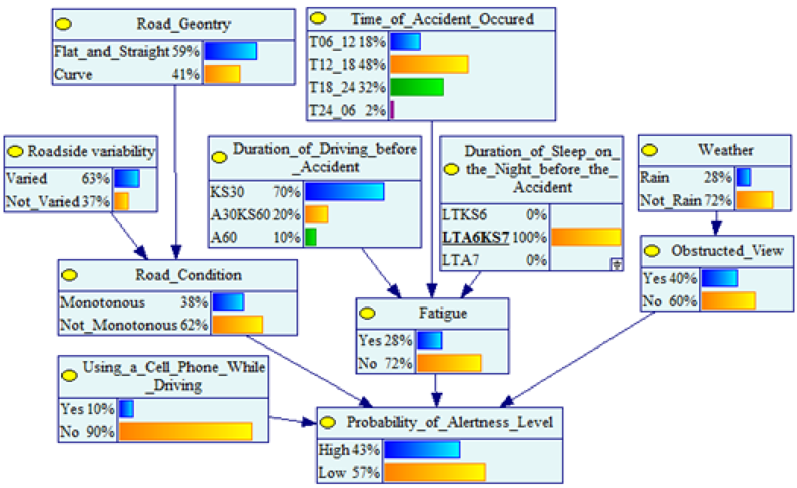

Fig. 8. Scenario 3b.

(from 27% to 28%), as shown in Fig. 8. Elderly motorcyclists who sleep more than 7 hours at night before accident are likely to experience a 7% decrease in fatigue (from 27% to 19%), and their level of alertness increases by 1% (from 43% to 44%), as shown in Fig. 9. This means that the longer the sleep or rest time, the lower the likelihood of fatigue for motorcyclists. Based on the above explanation, elderly motorcyclists who sleep for 6 hours or less before accident are 2.21 times more likely to experience fatigue compared to those who sleep for more than 7 hours at night before accident. Meanwhile, elderly motorcyclists who sleep for more than 6 hours up to 7 hours at night before accident are 1.47 times more likely to experience fatigue compared to those who sleep for more than 7 hours at night before accident. The results of this study are in line with research conducted by [13].

Scenario 4a shows that elderly motorcyclists who use cell phones while driv-

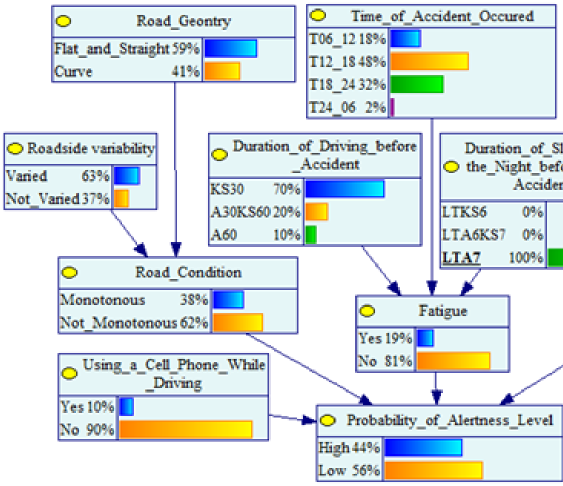

Fig. 9. Scenario 3c.

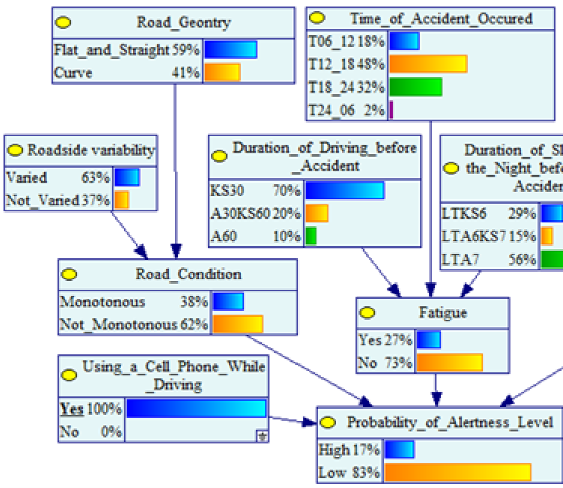

Fig. 10. Scenario 4a.

ing are likely to have a high level of alertness of 17% as shown in Fig. 10. Meaning that the level of high alertness of drivers decreased by 26% (from 43% to 17%), while scenario 4b shows that when elderly motorcyclists do not use cell phones while driving, they are likely to have a high level of alertness of 46%, as shown in Fig. 11. Meaning that the level of high alertness of drivers decreased by 3% (from 43% to 46%). This means that the level of alertness of elderly motorcyclists who do not use cell phones while driving is 2.7 times greater than that of elderly motorcyclists who use cell phones while driving. The results of this study are in line with research conducted by [5-7].

From the several scenarios above, the use of cell phones significantly affects the level of driver alertness, because it can reduce the level of driver alertness by 26%. After that, the fatigue factor also significantly affects the level of driver alertness, where drivers who drive in a tired condi-

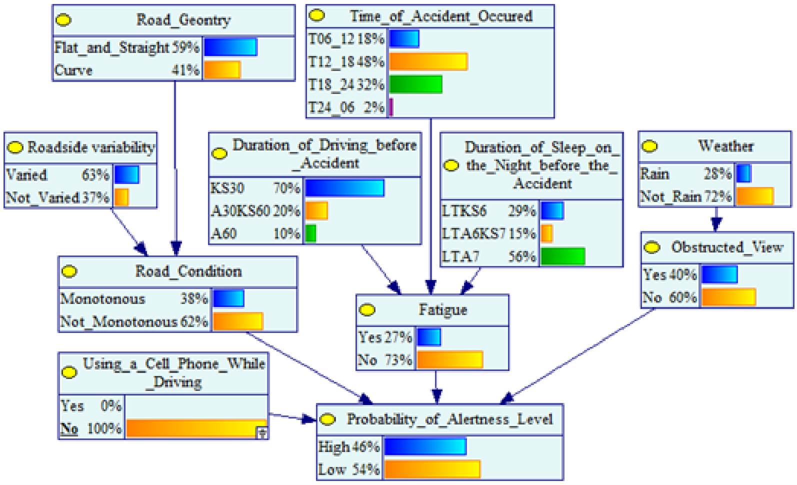

Fig. 11. Scenario 4b.

tion, the driver's alertness level decreases by 11%. Several strategies to improve the safety of elderly motorcyclists, if they still wishes to continue rideng motorcycle, including:

- Elderly motorcyclists are advised not to ride for too long on straight road segments, as this can increase the feeling of monotony while riding and decrease alertness.
- Elderly motorcyclists are encouraged to ride in good physical condition, as this can likely enhance their alertness while riding.
- Elderly motorcyclists should aim to sleep for more than 7 hours at night to reduce fatigue, which in turn can increase their alertness while riding.
- Elderly motorcyclists are advised not to use cell phones while riding, as this can likely improve their alertness while riding.
- It is necessary to review the eligibility of a driver's license when a motorcyclist reaches the age of 45 years.
- Elderly riders need to be accompanied by another experienced rider.

4. Conclusion

The total number of respondents in this study is 564, with the criteria being elderly motorcyclists (aged 45-65) who have experienced an accident. The analysis results show that elderly motorcyclists have a 43% likelihood of having a high level of alertness and a 57% likelihood of having a low level of alertness. Scenario 1a indicates that elderly motorcyclists riding on curved roads with varied roadside variability can reduce their level of monotony by 31%. Conversely, Scenario 1b indicates that riding on straight roads with no varied roadside variability can increase their level of monotony by 33% and also increase their level of alertness by 1%. Scenarios 2a and 2b show that elderly motorcyclists riding in a fatigued condition have a 32% likelihood of having a high level of alertness, while riding in a non-fatigued condition has a 47% likelihood of having a high level of alertness. Scenarios 3a, 3b, and 3c show that elderly motorcyclists who sleep for 6 hours or less at night are likely to have a 15% increase in fatigue probability and a 2% decrease in alertness. Elderly motorcyclists who sleep more than 6 hours up to 7 hours are likely to have a 1% increase in fatigue probability. Those who sleep more than 7 hours are likely to have a 7% decrease in fatigue probability, which also increases their level of alertness by 1%. Scenarios 4a and 4b show that elderly motorcyclists who use a cell phone while riding have a 17% likelihood of having a high level of alertness, while those who do not use a cell phone have a 46% likelihood of having a high level of alertness. The findings of the paper show that the highest alertness level among elderly drivers is below 50%, thus it need to be performed several strategies to improve the safety of elderly drivers including: not to drive for too long on straight road segments; 2) driving in good performance condition; sleeping for more than 7 hours at night to reduce fatigue, 4) not to use cell phones while driving; need to review the eligibility of a driver's license when a motorcyclist reaches the age of 45 years; elderly riders need to be accompanied by another experienced driver.

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