

ANALYSING ROAD ACCIDENT TRIGGERS IN MALAYSIA BY USING ANALYTICAL HIERARCHY PROCESS

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Abstract

The number of road accident fatalities in Malaysia is increasing tremendously. One of the reasons of the road accident cases is the development of motorization sector. The problems of road accidents are extremely in critical state even though various preventive measures have been taken to reduce the rate of road accidents. Thus, this study will identify the actual factors and subfactors that contribute to the road accidents to make sure the preventive measures operate successfully. This study also will rank the factors and subfactors of road accidents based on the weight obtained. Therefore, a method called Analytical Hierarchy Process (AHP) was implemented to discover the triggers of road accidents in Malaysia. Questionnaires were given to three experts who have experience in dealing with road accidents. These experts were traffic police inspector, officer from road transport department and fire brigade officer. The pair-wise comparisons were rated by the experts according to Saaty scale from 1 to 9, scale 1 refers to Equal Important and scale 9 refers to Absolutely More Important. In order to obtain the result of each factor and sub-factor of the road accident, the average of comparison scales was determined before proceeding to other steps. In this study, the three main factors of road accidents involved are human behaviour, environment and vehicle. Among the factors of road accidents analysed, human behaviour which is the most affecting factor towards road accidents cases, followed by the environment and vehicle. Then, the first ranking of subfactors for each factor is drunk driving or driving under the influence, weather condition and brake failure are the main causes of the road accidents in Malaysia.

Keyword: analytical hierarchy process, road accident, triggers

Introduction

The number of road accidents in Malaysia has increased over time. The Road Safety Department of Malaysia recorded a total of 535000 road accidents occurred in 2018 and the cases increased to 554000 in 2019. There were also fatal accidents totalling 5764 cases in 2019. Statistically, Malaysia is one of the ASEAN countries with the highest road fatalities based on overall population (Sultan et al., 2016). A national statistics by the Royal Malaysian Police shows a very significant proportion of fatal accidents which is caused by motorcyclists. The accidents also have led to an overall loss of 8.85 billion during 2019 (Khairul et al., 2018). Road traffic accidents have increased steadily over the years in Malaysia. The causation of road traffic accidents is normally related to individual and environmental factors and the traffic violation of motorcyclists (Harith & Mahmud, 2018). Road accidents are highly traumatic by all developing countries, as accidents may lead to injuries and deaths (Karem et al., 2012; Wahaballa et al., 2018). The Ministry of Transport Malaysia has put forth multiple warnings and advocated caution to Malaysian drivers in order to decrease the number of accidents occurring on the road, yet the number of road accidents

in Malaysia is still on a steady increase. Hence, this study helps to recognize the most influential factor that leads road accidents in Malaysia. The formation of this analysis method is crucial in educating road users to make safety as their main priority. Since there is an increase in injuries and fatalities due to road accidents, thus this research discovers which factors that contribute the highest weight to the road accidents problem.

Based on the study carried by Lazim and Zamri (2010) using Correlation Analysis and Fuzzy TOPSIS method, the major cause of death and injuries in Malaysia was road accidents. The increasing of road accidents nowadays is parallel with the rapid growths of population, economic development and motorization. The statistics on the road accidents issued by the Royal Malaysian Police and the experts who have been interviewed from three authorised personnels of three Malaysian Government agencies were considered as sources of data. The results from these two analyses indicated that registered vehicles yielded the highest ranking followed by the population and road length. This finding gives insight to the contribution of each factor towards road accidents.

In an article by Darma, Karim and Abdullah (2017), the study focuses on analysing road traffic deaths caused by various road environment elements recorded by the police from 2000 to 2011. The analysis was done to determine the distribution, proportion and relationship with fatal accidents. In this research, the Chi-square and Marascuilo procedure that used level significance of 5% were applied. The results show the number of road traffic deaths in rural area is 66% and in urban area is 34%. It also found that only 11.25% of the total road deaths were related to road damage. The highest percentage of deaths due to road damage was 46% related to the lack of road lighting provision, while the declining of roadside and potholed roads have contributed to 15.4% and 11.2% of road deaths respectively.

A study conducted by Islam and Kanitpong (2008) that used the In-Depth Analysis method found that about 130,000 fatal cases and 500,000 permanent disability cases were caused by the increase in motorization and socio-economic status of Thai people due to modernization. The main factors that were obtained from the analysis were human factor and road environment factor.

Ogwueleka et al. (2014) present a design of an Artificial Neural Network Model (ANN) to analyse and predict the road accident cases. The parameters used for the design are the number of population, vehicles and accidents. This study found that the main factor influencing road accidents is the human factor.

According to Muhammad et al. (2017), Decision Tree Data Mining Algorithm was used as a model to predict the causes of road traffic accidents, its prone locations and time along Kano-Wudil highway. Among 193 countries of the world, Nigeria was ranked as the second-highest rate of road accidents. The factors that cause road accident were represented by wrong overtaking then followed by the loss of control, tyre blowout, poor lights, uncertain causes and brake failure.

Research done by Najib et al. (2012) using Analytic Hierarchy Process (AHP) found that road accidents occurred more frequently because of the increasing number of road users. By identifying the main causes of road accidents, the problem could be reduced. The research showed that 'driving faster than speed limit' was ranked as the highest cause with the weightage 0.3242 and 'obstructions (i.e. animals or weather)' was ranked as the lowest cause of the road accidents.

Analytic Hierarchy Process (AHP) was applied in evaluating and ranking the factors that affect road traffic safety by obtaining the means of experts' opinions (Sordyl, 2015). This study found that the highest weight that contributed to the road traffic safety came from the driver's factors which are inappropriate speed to traffic conditions, incorrect overtaking, driving after alcohol or drugs, incorrect lane changing and not keeping a safe distance between vehicles. The second highest factor was represented by condition of the road and

then followed by the technical condition of the vehicle. Environmental factor can be included by weather conditions, objects or animals of the road, being blinded by another vehicle and poor condition of the road. The last ranking was vehicle factor which can be represented by defects in tyres, malfunction of the breaking system and malfunction of the steering system. Thus, this study was conducted to identify the factors of road accidents. Since AHP is a suitable tool of decision making, so it was used to determine and rank the factors and subfactors of the road accidents in Malaysia. This study is limited to human behaviour, environment and vehicle factor.

Materials and Methods

First, data collected from experts were used in this study. These experts include a traffic police inspector, an officer from road transport department and the fire brigade officer. In this project, a questionnaire regarding road accidents was created. Results from these experts are very important to determine the relative measurement of factors and subfactors using pair-wise comparison that was proposed by Saaty.

To propose the questionnaires, the hierarchical structure of factors and subfactors of road accidents that occurred in Malaysia need to be built as shown in **Table 1**.

Table 1 Hierarchical structure of factors and subfactors of road accidents

Factors of Road Accidents		
Human Behaviour	Environment	Vehicle
Driving faster than limited speed	Weather condition	Brake failure
Drunk driving or driving under the influence	Lighting condition	Tyre failure
Using the phone while driving	Animal crossing	Steering failure
Changing lanes without signalling	Adverse traffic and road condition	
Drowsiness		

The questionnaires of the three personnel and the average rating scales that were given by three experts for factors and subfactors converted into pair-wise comparison matrix. The process of comparison and ranking of the criteria and subcriteria can be applied to the seven steps in Analytic Hierarchy Process (AHP) which are explained as follows:

Step 1: Construct hierarchy structure for Multiple Criteria Decision Making (MCDM). Three levels of hierarchical structures are identified. The first level is the goal of the problem. The second and third levels are represented by criteria and subcriteria of Multiple Criteria Decision Making (MCDM) problem.

Step 2: Build the matrix of criteria and scale the matrix according to the relative scale measurement. The criteria are compared with respect to the goal. By using the pair wise comparison, the nxn matrix is created.

Step 3: Find the Geometric means, $\sqrt[n]{\mu_i}$ and Criteria weight, $\sum_{i=1}^n \mu_i = \sum_{i=1}^n \sum_{j=1}^n a_{ij}$.

Step 4: Find the eigenvector by normalizing the pair-wise comparisons $w_i = \sqrt[n]{\mu_i} / \sum_{i=1}^n \mu_i$.

Step 5: Find the eigenvalue $\lambda_i = \frac{\sum_j (\sum_{i=1}^n w_i) a_j}{w_i}$.

Step 6: Calculate the maximal latent root $\lambda_{max} = \frac{\sum_i A w_i}{n w_i}$, and the coincidence indicators (CI),

$CI = \frac{(\lambda_{max} - n)}{n - 1}$, as n represented by the number of factors or subfactors that are being compared. Next, the Consistency Ratio (CR) will be found by using this equation. CR is consistent when the value is less than 0.1. When the judgments matrix is reasonably consistent, the process of decision making using Analytic Hierarchy Process (AHP) can be continued. If the CR is greater than 0.1, then the subjective judgement needs to be revised to $CR = CI / RI$ where RI is the random index and depends on the number of element being compared, n .

Step 7: Factors and subfactors are ranked according to their weight values.

Table 2 shows the average of pair-wise comparison for the factors of road accident.

Table 2 Average pair-wise comparison from experts

Factors	Human Behaviour	Environment	Vehicle
Human behaviour	1.0000	8.3333	8.6667
Environment	0.1217	1.0000	2.0000
Vehicle	0.1157	0.6111	1.0000

Then, geometric mean be calculated as:

$$\begin{bmatrix} (1.0000 \times 8.3333 \times 8.6667)^{\frac{1}{3}} \\ (0.1217 \times 1.0000 \times 2.0000)^{\frac{1}{3}} \\ (0.1157 \times 0.6111 \times 1.0000)^{\frac{1}{3}} \end{bmatrix} = \begin{bmatrix} 4.1644 \\ 0.6244 \\ 0.4135 \end{bmatrix} \tag{1}$$

Sum up all the values of Geometric mean to get the Criteria weight: $4.1644 + 0.6244 + 0.4135 = 5.2023$. Eigenvector of each factor is computed as:

$$\begin{bmatrix} 4.1644 / 5.2023 \\ 0.6244 / 5.2023 \\ 0.4136 / 5.2023 \end{bmatrix} = \begin{bmatrix} 0.8005 \\ 0.1200 \\ 0.0795 \end{bmatrix} \tag{2}$$

To obtain the eigenvector of each factor, the product rule of geometric mean must be divided by the total value of geometric mean that has been sum up. Eigenvector value is the weight represented for each factor. The total sum up of the eigenvector for all factors is equal to 1.0000.

The eigenvalue of each factor is calculated in order to check the Consistency Ratio:

$$\left(\begin{bmatrix} 1.0000 & 8.3333 & 8.6667 \\ 0.1217 & 1.0000 & 2.0000 \\ 0.1157 & 0.6111 & 1.0000 \end{bmatrix} \times \begin{bmatrix} 0.8005 \\ 0.1200 \\ 0.0795 \end{bmatrix} \right) \div \begin{bmatrix} 0.8005 \\ 0.1200 \\ 0.0795 \end{bmatrix} = \begin{bmatrix} 3.1099 \\ 3.1368 \\ 3.0874 \end{bmatrix} \tag{3}$$

The average pair-wise comparison matrix is multiplied by the eigenvector of each factor first. Then, the product must be divided by the eigenvector value. The eigenvalue must be averaged in order to get maximal latent root $\lambda_{max} \therefore \frac{3.1099 + 3.1368 + 3.0874}{3} = \frac{9.3341}{3} =$

3.1113. Consistency Index (CI) can derive the value as: $\frac{(3.1113 - 3)}{3 - 1} = 0.0557$. Random indices (RI) picks based on the number of factors that are compared (n). 0.5800 is chosen

since the value of n is 3. Consistency Ratio (CR) is computed as $\frac{0.0557}{0.5800} = 0.0960$. The Consistency Ratio (CR) of the matrix factors is 0.0960. Thus, the judgement is acceptable since Consistency Ratio (CR) is less than or equal to 0.1. All steps have been applied to other subfactors of road accident.

Result and Discussion

The triggers of road accidents in Malaysia can be ranked as shown in **Table 3**. The number of the weight of each factor represents the priority value associated with the AHP hierarchy node (Saaty, 2002). Weight of human behaviour is the highest value among the factors which is 0.8005 making it the first rank. Human behaviour triggers the road accidents the most due to their carelessness and lack of alertness. Then, the factors ranking followed by environment and vehicle which the weights are 0.1200 and 0.0795 respectively. This finding is similar to what was observed by Islam & Kanitpong (2008), Ogwueleka (2014) and Sordyl (2015).

Table 3 Ranking of weights of road accident factors

Factors	Weights	Ranks
Human behaviour	0.8005	1
Environment	0.1200	2
Vehicle	0.0795	3

Subfactors of human behaviour of road accidents can be divided into five parts which are driving faster than limited speed, drunk driving or driving under the influence, using phone while driving, changing lanes without signalling and drowsiness. The subfactors of human behaviour rank as shown in **Table 4**. Drunk driving or driving under the influence becomes the first rank which the weight is 0.5771 (Xiaohua et al., 2014). This is because they were under unconscious state when they lost their control. After that, subfactors of human behaviour which are drowsiness, changing lanes without signalling, using phone while driving and driving faster than limited speed are symbolized by the weight of 0.2348, 0.0961, 0.0569 and 0.0351 respectively.

Table 4 Ranking of weights of human behaviour subfactors

Subfactors	Weights	Ranks
Driving faster than limited speed	0.0351	5
Drunk driving or Driving under the influence	0.5771	1
Using phone while driving	0.0569	4
Changing lanes without signalling	0.0961	3
Drowsiness	0.2348	2

Subfactors of environment can be divided into four parts which are weather condition, lighting condition, animal crossing and adverse road and traffic conditions. From **Table 5**, weather condition falls in the first rank due the high rate of danger because the thunderstorm, heavy rain can attack any time without giving any hint (Fanny et al., 2019). Then, animal crossing the road falls into second rank with weight 0.1929 followed by adverse road and traffic condition and lighting condition along the road with weight 0.1528 and 0.0406, respectively.

Table 5 Ranking of weights of environment subfactors

Subfactors	Weights	Ranks
Weather condition	0.6137	1
Lighting condition	0.0406	4
Animal crossing	0.1929	2
Adverse road and traffic condition	0.1528	3

Table 6 shows the ranking of weight of vehicle subfactors. Subfactors of vehicle can be divided into three parts which are brake failure, tyre failure and steering control. The rank of dangerousness of vehicle subfactors goes to brake failure which is represented as the first place with weight 0.7674 (Statista Research Department, 2020). It is followed by the tyre failure and steering control with weight 0.1453 and 0.0873 respectively.

Table 6 Ranking of weights of vehicle subfactors

Subfactors	Weights	Ranks
Brake failure	0.7674	1
Tyre failure	0.1453	2
Steering control	0.0873	3

Conclusion

This study was conducted to determine the factors and subfactors that contribute the most towards road accidents in Malaysia. The Analytic Hierarchic Process (AHP) is the suitable method to identify Multi-Attribute Decision Making. This study is limited to human behaviour, environment and vehicle factors. Human behaviour is the highest ranking with weight 0.8005 followed by environment and vehicle with weight 0.1200 and 0.0795 respectively.

Under the subfactors of human behaviour, drunk driving or driving under influence has been dominated as the first rank with eigenvector value 0.5771 since this subfactor shows the highest level of dangerousness in road accidents. Then, drowsiness falls into the second rank with weight 0.2348 since lack of rest can distract the focus of road users. Other subfactors involve are changing lanes without signalling, using phone while driving and driving faster than limited speed contributed such as 0.0961, 0.0569 and 0.0351.

The environment subfactors, weather condition have contributed 0.6137 towards the factors of road accidents since the rainy and windy situation can harm the road users. Animal crossing makes the road user condition becomes risky with weight 0.1929. This is because they could not predict when the animal will cross the road although there is a signboard of animal for the road user to be careful at certain area. Adverse road and traffic condition and lighting condition also have their own risk in environment subfactors even though their eigenvector value are 0.1528 and 0.0406.

Brake failure triggers the death of road accident which has the most weight 0.7674 for subfactors of vehicle. That is why there are many precautions and advises to check the condition of brake, tyres and steering before the beginning of any journey. The failure of tyres also has contributed to road accidents with weight 0.1453. Finally, the loss control of steering with weight 0.0873 was the reason why road accidents occurred regularly. As the factors and subfactors of road accidents in Malaysia were identified with their ranking, then the objectives of this study have been achieved.

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Conflict of Interest

Authors hereby declare that there is no conflict of interest.

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