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A Study on the Impact of Climate and Road Factors Towards Road Accidents in Malaysia with Analytic Hierarchy Process

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Abstract: The road transport industry is the pillar of strong economies and productive societies. Motorcyclists have a particularly poorer safety track record when correlate to alternative transport mode users. Based on the research done by the Malaysian Institute of Road Safety Research, road crashes and the number of road crashes in Malaysia has increased from year 2015 to 2016. This study focuses on the factors that affect the motorcycle accident rates in Malaysia. The objective of this paper is to determine the main factors among thevehicle factor, human factor, climate factor and road factorthat cause motorcycle mishaps in Malaysia with Analytic Hierarchy Process (AHP) model. AHP is an analytic tool that helps to solve multi-criteria decision making problem. The research findings of this study show that the road lighting and human distraction are prevalent factors for road accidents in Malaysia. This study is able to provide an in depth approach to analyze the environmental factor such as climate and road factors contributing to motorcycle mishaps besides human and vehicle factorsby using the AHP model. This study is significant because it will provide valuable information on causes of accidents especially among motorcyclists in Malaysia as well as the recommendations for the motorcyclists.

Keywords: Motorcycle Accident Rate, Vehicle Factor, Human Factor, Climate Factor, Road Factor

1. Introduction

Transportation represents one of our most essential human needs. Transportation is the act of moving something from one point to another point. Roads are an important element of the transport structure. A nation's road structure has to be efficient in order to optimize the social and economic benefits. The road transport industry is the pillar of strong economies and productive societies. Motorcyclists have a particularly poorer safety track record when correlate to alternative transport mode users. Road transportation is a vital mode of transport in Malaysia that secures both movement of people and distribution of goods. A motorcycle can be defined as a two-wheeled or three-wheeled vehicle which is mechanized by an engine. There are many types of motorcycles available on the industry. Motorcycle can be utilized for different purposes, which includes long-distance traveling, domestic use, racing, and also off-road riding. Motorcycles are a favoured and famous choice of transportation in the whole world. Based on the research done by the Malaysian Institute of Road Safety Research (MIROS) [1], road crashes, the number of road crashes in Malaysia has increased from year 2015 to 2016.

1.1. Statement of the Research Problem

The Attitudes of Motorcyclists

As compared to other road users, the attitudes of motorcycle riders and their understanding of the risks involved in riding motorcycles are the most vital consideration when it comes to resolving to what extent they are at risk. These are being highlighted especially in speeding, miles ridden, and reckless overtaking manoeuvres. By engaging in such dangerous riding habits, motorcyclists put their own lives and the lives of others in danger.

Road Conditions and Maintenance

A nation's transportation efficiency is as good as their road network will allow it to be. The design of a nation's roadway is one of the most significant factors that will affects road users and perceived safety. Surface discontinuities are hazardous to motorists as they may not be able to avoid it when they are travelling at speeds of 70 km/h to 100 km/h.

1.2. Research Objectives

The objective of this paper is to identify the factors that causes road accidents in Malaysia by using Analytic Hierarchy Process model (AHP) model. AHP model aims to rank the factors that causes road accidents in Malaysia. Besides that, this study also helps to recommend the preventive measures to the drivers and authorities in Malaysia.

2. Literature Review

Based on the past study by Yap [2], it was stated that most of the road fatalities which consist of more than 70% involved unprotected road users that include motorcyclists, bicyclists and pedestrians. Even a small collision is serious and fatal to motorcyclists due to their ability to travel at high speeds and lack of protection compared with other road users such as car drivers and truck drivers.

A majority of studies reported that road accident increases during rainfall [3]. It has been reported that rainfall reduces visibility - in some cases, visibility is reduced to only a few meters during heavy rain. Visibility is further reduced due to splashing water, particularly from heavy vehicles. An increase in humidity during rainfall can cloud windows and windscreens and also reduce visibility. Consequently, rainfall reduces the friction of the road surface and can lead to dynamic aquaplaning. Therefore, rainfall is concluded to display potential in increase road accidents.

Damaged pavements are among the largest contributing factors to lethal accidents. Hence, public road failures threaten drivers, who face risk of accidents due to road damage, such as surface cracking or potholes. Additionally, potholes pose a threat to motorists. This is because stumbling upon deep holes can make motorists lose control of their vehicles subsequently resulted in an accident. It becomes worse if it involves the motorcyclists. The broken surface of the roads can also create a hazard for road users as the road users cannot see the holes while driving.

Street lighting also enhances safety for drivers, riders, and pedestrians alike. Driving outside of daylight hours is more dangerous as only a quarter of all car drivers drive between hours 0700 to 2000, yet this period accounts for 40% of fatal and serious injuries to the same group [4]. 62 lighting and crash studies from 15 countries were analysed. Eighty-five percent of results showed lighting to be desirable in enhancing safety, with about one third of these having statistical significance. Depending on the type of roads and the crash classification involved, the statistically significant results show crash reductions of 13% to 75%.

A rider's riding style and an affinity for high speeds are identified as predictors of poor rider behaviour. Careless, risky and irresponsible riding styles will cause a lot of road mishaps, and riders should be encouraged to adopt safer and conservative riding styles.

According to Hurt, Ouellet and Thom [5], physiological capacity of a person also includes whether the rider has been using foreign substances. The use of substances such as marijuana, nicotine, and alcohol could cause temporary physiological impairment. These substances could cause visual or motor skills impairment because they cause chemical reactions within the human body and mind. Any type of impairment could cause the rider to lose balance and cause road mishaps. Permanent impairments can be categorized into four categories such as brain problem, vision problem, loss of limb and others.

3. Research Methodology

The main factors of motorcycle accidents in this study are climate factor, vehicle factor, human factor and road factor. The sub factors of motorcycle accidents are rider behaviour, distraction, physiological capacity, rain, road surface condition, road lighting/road signs, brake defects and tyre defects. Data is collected by conducting survey from the respondents. The Analytic Hierarchy Process (AHP) model that introduced by Professor Saaty [6] is proposed in this study to rank the factors and sub factors of motorcycle accidents. AHP is an analyic tool that helps to solve multi-criteria decision making (MCDM) problem [7-13]. MCDM evaluates multiple criteria in decision making process [14-40].

The AHP data analysis is performed in six steps.

Step 1: Identify the goal and distinguish the decision criteria as well as decision alternatives.

Step 2: Collect research data based on the relative scale of importance. Table 1 shows the ratio scale that are used for comparison in the questionnaires.

Table 1. *Ratio Scale.*

Scale	Definition
1	Equal Importance
3	Moderate Importance
5	Strong Importance
7	Very Strong Importance
9	Absolute Importance
2, 4, 6, 8	Intermediate Values

Step 3: Develop the pairwise comparison matrix by utilising the statistics taken from the questionnaires. If there are a numbers of decision criteria and b numbers of decision alternatives, then there should be one (a× a) matrix for the

comparison of decision criteria and a numbers of (b×b) matrix for the comparison of decision alternatives. The comparison matrix will be constructed.

Step 4: Calculate the weightage for each choice as well as its contingencies through Normalization Method. To perform this, the total for each column in the matrix are computed and calculated. All of the elements in the column are then divided by the column's total. The steps are done again and again for every pairwise comparison matrix. For this study, eight new normalized matrices are formed. Next, the average for each row in the newly formed matrices represents the priorities or weight for the decision criteria and decision alternative. Weight score for each decision criteria will be symbolized as w^T while the weight score for decision alternatives with respect to each criteria will be represented by Q.

Step 5: Overall weightage for each decision alternative (FDW) is computed by computing the product between $Q$and w^T. The formula is as shown:

$$FDW = Q \times w^T$$

The FDW matrix will show the weight of the decision alternatives of the research. Elements with the largest or lowest weightage will be ranked accordingly.

Step 6: Check for consistency. Saaty (1980) had proposed a consistency ratio (CR) in terms of consistency and random index, CI and RI, with the formula shown

$$CR = \frac{CI}{RI}$$

whereby CI is computed by

$$CI = \frac{\lambda_{\max} - n}{n-1}$$

where $\lambda_{\max}$ is the maximum eigenvalue and n is total number of criteria.

Saaty generated RI by calculating the average CI of randomly generated comparison matrices. Table 2 shows the random index.

Table 2. *Random Index.*

n	2	3	4	5	6	7	8	9	10
RI	0	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.51

A CR less than or equals 0.10 is targeted as it denotes that the research's consistency is satisfactory and the results are not skewed and reliable. If the CR is greater than 0.10, serious inconsistencies could happen and the model may not yield a result that is acceptable.

4. Results and Discussion

The four main factors that are being studied in this research are human factors, climate factors, vehicle factors and road factors. Table 3 shows the 4 by 4 matrix analysing the judgement for the factors.

Table 3. *Main Factors Matrix.*

Criteria	Human Factors	Vehicle Factors	Climate Factors	Road Factors
Human Factors	1.0000	0.2512	0.6619	0.7692
Vehicle Factors	3.9809	1.0000	1.3134	1.4463
Climate Factors	1.5108	0.7614	1.0000	0.8791
Road Factors	1.3001	0.6914	0.6914	1.0000

The normalized matrix to obtain the weight score of each factor is shown in Table 4.

Table 4. *Normalized Matrix.*

Criteria	Human Factors	Vehicle Factors	Climate Factors	Road Factors
Human Factors	0.1283	0.0929	0.1609	0.1879
Vehicle Factors	0.5109	0.3698	0.3194	0.3532
Climate Factors	0.1939	0.2816	0.2431	0.2147
Road Factors	0.1669	0.2557	0.2766	0.2442

After further analysis, the average weightage and ranking of the factors comes out to the result shown in Table 5.

Table 5. *Ranking on Main Factors.*

Factor	Average	Rank
Human Factors	0.1425	4
Vehicle Factors	0.3883	1
Climate Factors	0.2333	3
Road Factors	0.2359	2
Total	1	

According to the results in Table 5, it was concluded that vehicle factors are the most significant factor when studying motorcycle accident factors. With a weightage of 0.3883, vehicle factors are the most significant factor. The next most significant factor is the road factors studied, which had a weightage of 0.2359. It carries a weightage 0.1524 lower than the leading factor, which was vehicle factor. The third most significant factor are climate factors, which only lags behind road factors by a very slim margin of 0.026. Last but not least, human factors are by far the least significant factor, with a weightage of only 0.1425.

The consistency ratio is then calculated using the formula mentioned in the research methodology.

$$CI = 4.08573 - 4/(4 - 1)$$

$$= 0.02858$$

$$CR = 0.02858/0.9$$

$$= 0.03175$$

After the analysis on the main factors done, the research proceeded to the next phase. The sub-factors of each factor were paired against each other and ranked. Table 6 shows the 3 by 3 matrix analysing the judgement for the subfactors categorized under human factors.

Table 6. *Matrix on Human Subfactors.*

Criteria	Rider Behaviour	Distraction	Physiological Capacity
Rider Behaviour	1.0000	0.4979	0.7669
Distraction	2.0084	1.0000	0.8115
Physiological Capacity	1.3040	1.2323	1.0000
Total	4.3124	2.7302	2.5784

The normalized matrix to obtain the weight score of each subfactor is shown in Table 7.

Table 7. *Normalized Matrix on Human Subfactors.*

Criteria	Rider Behaviour	Distraction	Physiological Capacity
Rider Behaviour	0.2319	0.1824	0.2974
Distraction	0.4657	0.3663	0.3147
Physiological Capacity	0.3024	0.4514	0.3878
Total	0.2319	0.1824	0.2974

The ranking of the individual humansubfactors are shown in Table 8.

Table 8. *Ranking on Human Subfactors.*

Criteria	Weightage	Rank
Rider Behaviour	0.2372	3
Distraction	0.3822	1
Physiological Capacity	0.3805	2
Total	0.9999	

As shown in Table 8, the three subfactors are ranked (in order from most significant to less significant): Distraction, Physiological Capacity and Rider Behaviour. Distraction is the more significant human subfactor than physiological capacity, with a weightage of 0.3822 compared to physiological capacity, which is 0.017 less significant than distraction. Rider behaviour is the least significant, with a weightage of only 0.2372.

Table 9 shows the 2 by 2 matrix analysing the judgement for the road subfactors.

Table 9. *Matrix on Road Subfactors.*

Criteria	Road Surface Condition	Road Lighting/Road Signs
Road Surface Condition	1.0000	0.6452
Road Lighting/Road Signs	1.5500	1.0000
Total	2.5500	1.6452

The normalized matrix to obtain the weight score of each subfactor is shown in Table 10.

Table 10. *Normalized Matrix on Road Subfactors.*

Criteria	Road Surface Condition	Road Lighting/Road Signs
Road Surface Condition	0.3922	0.3922
Road Lighting/Road Signs	0.6078	0.6078

The ranking of the individual subfactors for the road factor is shown in Table 11.

Table 11. *Ranking on Road Subfactors.*

Criteria	Weightage	Rank
Road Surface Condition	0.3922	2
Road Lighting/ Road Signs	0.6078	1
Total	1	

According to Table 11, it was found that road lighting and road sign availability was the more significant of the two subfactors under the road categorization. Road lighting/road signs had a weightage of 0.6078, compared to only 0.3922 for road surface condition.

Table 12 shows the 2 by 2 matrix analysing the judgement for the vehicle subfactors.

Table 12. *Matrix on Vehicle Subfactors.*

Criteria	Brake Defects	Tyre Defects
Brake Defects	1.0000	0.7922
Tyre Defects	1.2623	1.0000
Total	2.2623	1.7922

The normalized matrix to obtain the weight score of each subfactor is shown in Table 13.

Table 13. *Normalized Matrix on Vehicle Subfactors.*

Criteria	Brake Defects	Tyre Defects
Brake Defects	0.442	0.442
Tyre Defects	0.558	0.558

The individual weightage is calculated and shown in Table 14.

Table 14. *Ranking on Vehicle Subfactors.*

Criteria	Weightage	Rank
Brake Defects	0.442	2
Tyre Defects	0.558	1
Total	1	

For the category of vehicle subfactors, it was discovered that tyre defects were a more significant factor in motorcycle accident rates. They carried a weightage of 0.5580 compared to a weightage of 0.442 for brake defects. This can be referenced from Table 14.

It is recommended that the authorities review the number of street lights and road signs on the roads in Malaysia. With limited visibility on the roads, riders are exposed to riding into potholes or obstructions that they may not be identify accurately due to the poor vision. The number of road signs on the roads are also a factor, as some direction needs to be provided to the riders for a smooth flow of traffic. Poor allocation of road signs may lead to riders breaking road laws and regulations, as well as an elevated accident rate. Riders may not be aware of some danger spots and sufficient road signs would counteract this issue. Rain and road surface conditions are significantly intertwined, as shown in the AHP results where they rank third and fourth. Poor road surface conditions include uneven sufaces, potholes, insignificant road markings. Rain would no doubt impair vision further, and the issue would be worsened. It is recommended that the authorities schedule regular road maintenance, and ensure all road markings are visible and bright.

5. Conclusions

According to the results of the AHP model, it is discovered that the vehicle factor is the most significant factor that cause motorcycle accidents in Malaysia followed by road factor, climate factor and lastly human factor. As for the subfactors, distraction, tyre defects and road lighting/road signs are the more significant criteria for the motorcycle accidents.

Recommendations

In this study, it is found that riders recommended that their fellow riders should keep learn to obey the traffic rules and regulations, and that the authorities should schedule more regular road maintenance as a measure to counteract this problem. This study has explored the main factors and subfactors that affect road accident rates for motorcycles. It is then found that vehicle factors were the biggest issue when it comes to motorcycle accidents. Therefore, it is recommended that riders take good care of their motorcycle, with regularly scheduled maintenance to prevent any mechanical error during a journey. Furthermore, the authorities should also participate in this by conducting spot checks on motorcycles. This would reduce the risk of motorcycle accidents caused by a fault in the motorcycle. In a nutshell, the main goal of this paper was to study the factors that affect motorcycle accident rates in Malaysia. After surveying and analysing the results, vehicle factors are the most significant out of the factors studied. Furthermore, distraction, tyre defects and road lighting and road signs are the most prevalent sub-factors that influence the motorcycle accident rates. Recommendations are provided and authorities should look into the ones provided to better their own policies in the nation.

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