Journal of Quality Measurement and Analysis *JQMA* 16(1) 2020, 29-36
e-ISSN: 2600-8602 *http://www.ukm.my/jqma*

ESTIMATING THE MEDICAL COST FOR MOTOR VEHICLE ACCIDENT

(Menganggar Kos Perubatan bagi Kemalangan Kenderaan Bermotor)

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ABSTRACT

The purpose of this study is to investigate the relationship between the cost of road accident treatment at Hospital Canselor Tuanku Muhriz and factors such as gender, age group, vehicle type, injury type, duration of stay in hospital and severity. The data used were population data collected at the hospital Emergency Department for a period of one year from 2007 to 2008. A total of 543 road accident patients were taken for this study but only 507 patients were used for analysis. The analyses used in this study were divided into two, namely descriptive analysis and multiple regression analysis. The results of the study show three independent variables i.e. the period of hospitalization, injury type and severity provide significant *p*-value and *t*-value to the cost of road accident patients. The methodology from this study can be used in related future research.

*Keywords***:** road accident; medical cost; regression

ABSTRAK

Kajian ini bertujuan untuk menyelidiki hubungan antara kos rawatan kemalangan jalan raya di Hospital Canselor Tuanku Muhriz dengan faktor-faktor seperti jantina, kumpulan umur, jenis kenderaan, jenis kecederaan, tempoh berada di hospital dan tahap ketenatan. Data yang digunakan adalah data yang diperoleh di Jabatan Kecemasan bagi tempoh satu tahun dari tahun 2007 hingga tahun 2008. Sejumlah 543 orang pesakit kemalangan jalan raya diambil untuk kajian ini tetapi hanya 507 orang pesakit sahaja digunakan untuk analisis. Analisis yang digunakan dalam kajian ini terbahagi kepada dua iaitu analisis perihalan dan analisis regresi berganda. Hasil kajian ini menunjukkan tiga pemboleh ubah tak bersandar iaitu tempoh berada di hospital, jenis kecederaan dan tahap ketenatan memberikan nilai-*p* dan nilai *t* yang signifikan terhadap kos rawatan pesakit kemalangan jalan raya. Tatakaedah kajian ini boleh digunakan dalam kajian masa depan yang berkaitan.

Kata kunci: kemalangan jalan raya; kos rawatan; regresi

1. Introduction

In Malaysia, the increase in road accidents is parallel to the increase in population and economic developments in the country. Based on the cumulative number of vehicles issued by the Road Transport Department until September 2018, 29,666,187 vehicles were recorded with an increase of 76.44% from 2007. Table 1 shows the total number of drivers accrued in Malaysia for 11 years. As at September 2018, 16,063,650 drivers were recorded with an increase of 49% from 2007. The increase in the total number of drivers will contribute to the increase in accident cases and accidents occurring in Malaysia.

According to the calculations from the Malaysian Road Safety Research Institute, road accidents resulted in Malaysia's economic loss of RM9.28 billion in 2017 for injuries and loss of life due to road accidents. The increase in the number of patients and economic losses will increase if there is no drastic measure taken by the responsible party to overcome the problem of Malaysian road accident cases. Road accidents can occur due to internal and external factors. External factors that contribute to accidents include road environments and road widths while

internal factor examples are due to the driver of the vehicle itself. Accidents can occur due to one of the factors or combination of these factors.

Table 1. Total number of drivers and new drivers in Malaysia

Year	Total drivers	Total new drivers	Total new male drivers	Total new female drivers
2007	10,769,801	418,199	N/A	N/A
2008	11,227,414	457,613	N/A	N/A
2009	11,697,576	470,162	225,623	201,907
2010	12,236,524	538,948	235,200	225,537
2011	12,763,722	527,198	414,899	394,966
2012	13,304,113	540,391	353,884	408,074
2013	13,803,293	499,180	517,978	504,702
2014	14,327,201	523,908	425,224	414,550
2015	14,764,527	437,326	219,223	218,282
2016	15,255,375	490,848	251,140	239,708
2017	15,708,361	452,986	230,395	222,533
2018 (Sept)	16,063,650	355,289	174,644	180,645

The logistic regression method was used by Abdul Manan *et. al* (2020) to examine the common cause and contributing factors of motorcycle crash along Malaysian expressways. The logistic regression model was used in this study because the variables depend on binary properties. Acceleration of accidents which are dependent variables in the study are variables that can be categorized into accidents involving vehicle damage only and accidents involving vehicle damage and injury or death. From the eight independent variables derived from police reports, only three were found to be statistically significant with accidents such as types of vehicles, accident time and type of error. Statistical interpretation of the model is given in the form of odds ratio.

Medical cost analysis for road accidents by taking samples from Hospital Canselor Tuanku Muhriz found that the cost for treatment on road accident patient data showed significant value with contributing factors such as age, gender, race, length of hospital stay, patient status and treatment type injuries due to road accidents (Majid *et al*. 2008). In addition, studies show increased cost of treatment proportional to the duration of hospitalization and follow-up treatment received by patients. The study aims to identify factors that contribute to the cost of patient treatment due to road accidents and to build the best model to estimate patient treatment costs. Six variables used in this study were gender, age, patient vehicle type, patient's duration stay in hospital, member of injury and patient level. This research information is expected to be a guide in planning to deal with road accident issues in Malaysia.

2. Materials and Method

A total of 517 patients involved in road accidents in 2007 to 2008 were included in the analysis of this study. Accident data obtained from the Emergency Department of the Hospital Canselor Tuanku Muhriz which contains information on patient demographic factors and information classified by different categories. Analysis that will be used in this study is multiple regression analysis. The formation of this model will analyze the relationship between the dependent variable i.e. the patient's medical costs with independent variables i.e. age, gender, vehicle, severity, duration of hospital stays and type of injuries. Multiple linear regression analysis is

used when involving two or more independent variables x_1, x_2, x_3, ..., x_p against dependent variable, y. The initial estimates of the initial double linear model for the population are as follows

$$y = f(x_{1,}x_{2,}x_3, \dots, x_p)$$

Multiple linear regression functions for general functions are as follows:

$$y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \cdots + \beta_p x_p + \varepsilon \quad (1)$$

with $\beta_1, \beta_2, \beta_3, \dots, \beta_j, j = 0, 1, 2, \dots, n$ is an unknown parameter that needs to be estimated, while ε is a random error whose value is not distorted. The existence of this error may be due to the effect of other variables not included in the model.

Usually the relationship (1) is modified by taking $x_0 = 1$ so that β_0 acts as intercept parameter. To estimate parameters $\beta_j, j = 0,1, \dots, \mathrm{p}$. The observation value is derived from each variable and (1) can be written as

$$y = \beta_0 + \beta_1 x_{i1} + \beta_2 x_{i2} + \beta_3 x_{i3} + \cdots + \beta_p x_{ip} + \varepsilon \quad (2)$$

or

$$y_i = \sum_{j=0}^{p} \beta_j x_{ij} + \varepsilon_i \text{ with } x_{i0} = 1, i = 1,2, \dots, n.$$

Data $(y_i, x_{ij}), i = 1,2, \dots, n, j = 0,1, \dots, p$ shows in Table 2.

Table 2. Data structure for multiple linear regression

i	y_i	x_{i0}	x_{i1}	x_{i2}	…	x_{ip}
1	y_i	1	x_{i1}	x_{i2}	…	x_{ip}
2	y_i	1	x_{i1}	x_{i2}	…	x_{ip}
.	.	.	.	.		.
.	.	.	.	.		.
.	.	.	.	.		.
n	y_n	1	x_{i1}	x_{i2}	…	x_{ip}

The hypothesis test performed on the gradient of the regression line is intended to determine whether there is strong evidence to support the existence of linear relationships between dependent variables with the independent variables studied. The determination coefficient (R^2) is used to find out the contribution of the independent variable to the variance in the dependent variable. Multiple linear regression models that do not conflict with assumptions such as normality, linearity and reliability can be used to estimate the value of dependent variables with a certain independent variable value.

The final results of the study were based on *t*-test dan *F* test. These tests will see the significant value of β coefficient individually and overall. The *t*-test for the regression coefficient is a statistical test used to determine whether the regression coefficients obtained based on the data from the sample are significant or vice versa. If β_1 and β_2 are significant, conclusions can be made that there is strong evidence that the values of $\beta_1$and β_2 obtained from

the samples represent the actual population rather than by coincidence or due to sampling errors. Test *F* is used to test the significance of β_i, *I = 1, 2, …, n* model as a whole.

3. Results and Discussions

Table 3 shows medical costs according to the patient's duration of hospitalization. Most accident victims are in hospital only 1 to 10 days with a percentage of 84.2 percent. Percentage of patients who stay in the hospital for the least time is 41 days and above. For the average medical cost, patients in the emergency ward for 51 days and above are subject to the highest medical cost of RM33,002.00 followed by a period of 41 to 50 days (RM31,155.00). This is supported by a number of previous studies that the patient's duration of hospitalization is a major contributor to the increase in medical costs. Patients who are in the emergency ward for 1 to 10 days are charged at the lowest cost of RM3,177.78.

Table 3. Treatment cost according to the duration of hospitalization

Duration	Frequency	Percentage (%)	Total Cost (RM)	Average Cost (RM)
1-10	427	84.2	1,356,912	3,177
11-20	60	11.8	553,742	9,229
21-30	12	2.4	174,290	14,524
31-40	4	0.8	77,384	19,346
41-50	2	0.4	62,310	31,155
51++	2	0.4	66,004	33,002

Based on the Table 4, it can be seen that patients between age 61 to 70 years old bear RM 9084 for medical expenses, followed by the patients age 70 and above which is RM8,416.23. The lowest age group was 0 to 10 years old, at RM2,895.50 and the frequency percentage of the age group 21 to 30 was the highest at 36.29 percent but the average low cost was RM4,034.04.

Table 4. Medical costs by age

Age	Frequency	Percentage(%)	Total Cost (RM)	Average Cost (RM)
0-10	8	1.58	23,164	2,895
11-20	132	26.04	541,474	4,102
21-30	184	36.29	742,264	4,034
31-40	60	11.83	282,014	4,700
41-50	60	11.83	325,575	5,426
51-60	35	6.9	130,475	3,727
61-70	15	2.96	136,265	9,084
70++	13	2.56	109,411	8,416

According to Table 5, the highest average cost of treatment received by road accident patients was moderate injury in the lower part of female patients, valued at RM10,738.55. The average cost of treatment for women injuries is higher compared to men. Male patients receiving minor injuries in upper body were charged the average treatment cost of RM3,247.14, RM2,946.39 for women patients and RM4,000.96 for lower limbs. However, for other parts of the injured limb, the average patient cost is RM6,210.80 which indirectly becomes the highest average cost for light injury cases. For moderate injuries, lower limbs recorded the highest average cost of RM6,131.71 compared to other members. Finally, for men with severe injuries,

the average patient cost of treatment is RM9,468.38 for the upper limb followed by RM9,178.64 for the lower limb.

Table 5. Average cost of patient treatment by gender, type of injury and severity

	Minor	Moderate	Critical
Men			
Upper limbs	3,247.14	4,491.56	9,468.38
Abdomen	2,946.39	5,828.43	8,522.22
Lower limbs	4,000.96	6,131.71	9,178.64
Other part	6,210.80	5,783.89	5,614.00
Women			
Upper limbs	2,690.33	4,495.00	
Abdomen	3,208.69	5,974.50	
Lower limbs	3,829.30	10,738.55	
Other part	2,769.00	2,769.00	

R^2 in Table 6 measures the amount of variation and the extent to which the independent variable describes the dependent variable such as patient treatment costs. R^2 in this model shows that the number of patient cost variation is explained by variation of independent variable which is 82% of road accident factors. The built model was also supported by ANOVA analysis in Table 7 showing a significant value of 0.000 which is less than the significant level value set at the beginning of the study of 0.05 / 2 = 0.025.

Table 6. Model summary

Model	R	R^2	R^2 adjusted	Standard Error
	0.922	0.82	0.846	1650.552

Table 7. Results from ANOVA analysis

Model	Sum of Square	*df*	Mean Square	*F*	*p*-value
Regression	7609818359.0	14	543558454.2	199.521	0.000
Residual	1340366403.0	492	27243210957.0		
Total	8950184761.0	506			

Estimating parameters in Table 8 shows every factor that contributes to the cost of road accident patient treatment giving a value of less than the level of significance of 0.10. This shows that after removal of parameter is done, each variable significantly affects the cost of treatment of victims of road accident victims.

β_0 is a regression cross line consisting of several variables ranging from 1-10 days, thorax injury and mild fatigue. Regression coefficients for each positive variable means each increase of one unit in x will results an increase in the cost of treatment by β_n, assuming the other variable is constant. Negative value of the coefficient of variables has the opposite meanings. For example, with each increase of 1 neck injury unit will reduce the medical cost of RM1154.25 assuming the other variable is constant.

Table 8 Parameter estimation

Model		Unstandardized Coefficients		Standardized Coefficients	*t*	*p*-value
		B	*Std. Error*	*Beta*		
1	(Intercept)	2545.744	220.511		11.545	.000
	Duration 11-20	5628.066	239.172	.433	23.531	.000
	Duration 21-30	10563.163	500.625	.382	21.100	.000
	Duration 31-40	15830.622	840.427	.333	18.836	.000
	Duration 41-50	26915.790	1190.639	.402	22.606	.000
	Duration 51 and above	28978.492	1192.651	.432	24.298	.000
	Head injury	464.460	170.394	.053	2.726	.007
	Neck injury	-1154.249	211.718	-.100	-5.452	.000
	Abdominal injury	417.511	227.095	.036	1.838	.067
	Elbow injury	-834.214	209.733	-.075	-3.978	.000
	Hand injury	510.581	197.472	.048	2.586	.010
	Knee injury	461.800	171.144	.054	2.698	.007
	Other injury	445.272	164.489	.053	2.707	.007
	Moderate	506.373	184.716	.052	2.741	.006
	Severe	1108.043	313.992	.067	3.529	.000

In this study, the patient's gender was not significantly contrary to the study conducted by Majid et al. (2008). This may be because the gap between male and female is too large to make this variable not significant. According to the descriptive analysis, it was found that the average cost of treatment for female patients was higher than men. A study of the cost of patient treatment on the type of vehicle found that all types of vehicles were insignificant to the patient's cost of treatment. Although the injuries and patient's level of fitness vary by vehicle type, this does not have a major impact on the patient's cost of treatment despite the descriptive analysis performed showing that other vehicles provide the highest average cost to patient's treatment costs.

Analysis towards age factor also does not give significant value to patient treatment costs. So far, few studies have been done on treatment costs using age factors as variables. The results of the descriptive analysis showed that age group 11 to 20 years recorded the highest accidents. This finding is close to some recent studies conducted by the Ministry of Transport Malaysia (2018), Selamat & Surienty (2015), Eboli *et al.* (2020), Potoglou *et al.* (2018) and Jaafar *et al.* (2003) which recorded this age group as the highest for road accidents cases. All parameters for hospital stay show a significant *p* value for treatment costs. This finding is supported by the study conducted by Lin (2000), Majid *et al*. (2008) and Ncube-Zulu and Danckwerts (2014) which prove the length of patient in the hospital for advanced treatment affects the total cost of patient treatment payable. Descriptive analysis also demonstrates that the longest stay at the hospital records the highest average cost of treatment.

Out of the 11 injuries involved for this study, seven injuries showed a significant value at the level of 0.10. This finding is supported by the study of Kual *et al*. (2005), Singh *et al*. (2014) and Ranjan *et al*. (2017) where the knee, leg and head parts are the main injuries due to accidents. Descriptive analysis shows that the highest average cost is in the abdomen due to many external injuries such as studies conducted at the Saraswathi Institute of Medical Sciences

(SIMS). Analysis performed on the tensile level also shows that all the parameters give a significant value. Parameters used are mild, moderate and severe injuries showing the effect of the relationship on patient cost of treatment. A recent study by De Leon *et al*. (2005), Gilmer *et al*. (2005), Majid *et al*. (2008) and Vlegel *et al*. (2020) each provide evidence that the level of tension has a significant relationship to the patient's cost of treatment.

4. Conclusions

The study aims to identify factors affecting the cost of treatment for patients due to road accidents, taking into accounts the factors of gender, age, vehicle type, injury, tiredness level and duration of hospitalization. All these factors have been analyzed by making each variable a statue variable before the multiple regression analysis is executed. The results of this study show that three variables become significant when multiple regression analysis is conducted that is the duration of stay in the hospital, the member of the injury and the degree of tiredness. Indirectly, gender, age and vehicle variables were insignificant in this study. The results of this study have also been further reinforced with previous studies that have taken into account the cost of treatment as a dependent variable.

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Received: 30 April 2020
Accepted: 4 June 2020

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