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Estimation of Medical Costs for Ischemic Stroke Patients - From the Perspective of a Health Care Provider

(Penganggaran Kos Perubatan Bagi Pesakit Strok Iskemia - Daripada Perspektif Pemberi Perkhidmatan Kesihatan)

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ABSTRACT

The increasing prevalence of stroke has presented challenges to all countries. Since 2007, stroke has been one of the leading causes of death in Malaysia. Furthermore, the number of strokes is expected to increase steadily. Certainly, all parties are concerned, particularly considering the socioeconomic burden that must be borne. As a result, the community and health-care providers must measure the number required to cover the medical expenses associated with a stroke. The estimated medical costs are based on the medical costs of ischemic stroke patients treated at Hospital Canselor Tuanku Mukhriz, which involved a total of 2161 stroke patients between 2016 and 2020. Demographic factors such as age and gender, as well as clinical factors such as severity, length of stay (LOS), and comorbid factors, were used to determine the medical costs of ischemic stroke patients. A logarithmic transformation was carried out on the medical cost to create a more suitable medical cost estimating model, considering the skewed nature of the medical cost data of ischemic stroke patients. As a result of the multiple linear regression analysis, age, LOS, severity level, type of comorbidity such as hypertension, ischemic heart disease (IHD), atrial fibrillation (AF), smoking and alcohol habits were found to have a significant effect on these medical costs. However, a patient's medical costs are unaffected by gender or type of comorbidity, such as diabetes or hyperlipidemia. Furthermore, it was discovered that increased LOS, severity levels, or the presence of comorbidities such as IHD, AF, and smoking habits all increased patients' medical costs. Medical costs, on the other hand, were found to be lower in patients who were older, consumed alcohol, and had hypertension.

Keywords: Ischemic stroke; medical cost; regression analysis

ABSTRAK

Peningkatan prevalens strok telah memberikan cabaran kepada semua negara. Sejak 2007, strok telah menjadi satu daripada punca utama kematian di Malaysia. Tambahan pula, bilangan strok dijangka akan terus meningkat. Pastinya ini menimbulkan kebimbangan kepada semua pihak terutama apabila memikirkan beban sosioekonomi yang perlu ditanggung. Justeru, masyarakat dan pihak pemberi perkhidmatan kesihatan perlu mengetahui amaun bagi membiayai kos perubatan bagi penyakit strok ini. Anggaran kos perubatan dibuat berdasarkan kos perubatan pesakit strok iskemia yang dirawat di Hospital Canselor Tuanku Mukhriz yang melibatkan seramai 2161 pesakit strok dari tahun 2016 sehingga 2020. Faktor demografi seperti umur dan jantina, serta faktor klinikal seperti tahap ketenatan, tempoh tinggal (LOS) dan faktor komorbid, digunakan untuk menentukan kos perubatan pesakit strok iskemia. Transformasi logaritma telah dilakukan ke atas kos perubatan untuk mendapatkan model anggaran kos perubatan yang lebih sesuai dengan mengambil kira kepencongan data kos perubatan pesakit strok iskemia. Hasil daripada analisis regresi linear berganda yang dilakukan, umur, LOS, tahap ketenatan, jenis komorbid seperti hipertensi, penyakit jantung iskemia (IHD), fibrilasi atrium (AF), tabiat merokok dan pengambilan alkohol didapati mempunyai kesan yang signifikan ke atas kos perubatan. Walau bagaimanapun, jantina dan jenis komorbiditi iaitu diabetes dan hiperlipidemia, tidak memberi kesan kepada kos perubatan pesakit. Selain itu, didapati bahawa peningkatan dalam LOS, tahap ketenatan, kehadiran komorbiditi seperti IHD, AF dan tabiat merokok didapati mengakibatkan peningkatan dalam kos perubatan pesakit. Kos perubatan, sebaliknya didapati lebih rendah bagi pesakit yang lebih tua, mengambil alkohol dan mempunyai hipertensi.

Kata kunci: Analisis regresi; kos perubatan; strok iskemia

Introduction

Stroke is a major global health issue, accounting for the leading cause of death in both developed and developing countries (Loo & Gan 2012). Stroke has also presented unique challenges for low and middle income countries (LMICs), which have seen an increase in stroke burden since 1990 (Feigin, Forouzanfar & Krishnamurthi 2014). LMICs account for approximately 87 percent of all stroke deaths worldwide (Strong, Mathers & Bonita 2007). Furthermore, prevalence data in Malaysia from 2007 to 2017 show that stroke is the third leading cause of death among Malaysians. Stroke is expected to be the second leading cause of death in Malaysia by 2040, owing to an increasing incidence trend (Foreman, Marquez & Dolgert 2018).

According to the annual report of the National Stroke Registration (NSR) Malaysia (2017), which covers data from 2009 to 2016, 60 percent of stroke patients are over the age of 60. This was followed by 26 percent of stroke patients aged 50 to 59 years old and 13.6 percent of patients aged 49 and under. Because of hypertension and cardiovascular complications that often accompany ageing, the majority of stroke patients are elderly. Furthermore, the average age of male stroke patients ranges from 60.7 to 63.6 years old, while female stroke patients range from 60.3 to 65.2 years old. Male patients outnumbered female patients in almost all age groups, with the exception of those over the age of 70. According to Reckelhoff (2001), women between the ages of 60 and 69 are at a higher risk of developing hypertension as a result of menopause. This may contribute to the slight dominance of women with stroke in the 70-year-old and older age group. Furthermore, according to NSR Malaysia, hypertension, diabetes, smoking habits, and hyperlipidemia are among the most common risk factors found in Malaysian stroke patients. Other risk factors include IHD, a family history of stroke, AF, and alcohol consumption. Table 1 shows the percentage of stroke patients who have certain risk factors.

TABLE 1. Common risk factors of stroke in Malaysia between 2009 and 2016

Risk factor	Frequency	Percentage
Hypertension	8152	69.9
Diabetes	4819	41.4
Smoking Habit	3063	26.3
Hyperlipidemia	2798	24.0
IHD	1254	10.8
Family History of Stroke	671	5.8
AF	391	3.4
Alcohol Intake	222	1.9

Stroke, in general, imposes a significant socioeconomic burden on individuals, families, and communities (Cheah et al. 2016). According to economic reports, stroke medical costs account for 1.6 percent to 6.9 percent of total health-care spending in many countries (Evers et al. 2004). As a result, various methods for calculating the medical costs of stroke have been developed, either from the perspective of the health care provider or the community. Furthermore, medical costs for each patient differ depending on the severity of the stroke, the type of treatment, and the medications required. Although the overall cost of stroke is typically determined by LOS, other factors such as gender, age, comorbid factors, and severity levels may have a significant impact on the overall medical cost of stroke in any institution (Laloux & Belgian Stroke Council 2003). According to an analysis of medical costs for stroke patients, age, gender, LOS, comorbid factors, and severity level are all

significant contributing factors (Abdo et al. 2018; Wang et al. 2014; Zhu et al. 2020). According to Mohd Nordin et al. (2012), more research on the effects of stroke on the Malaysian family economy is needed, as the trend of hospital admissions continues to rise. A comprehensive study that can analyse the relationship between stroke medical costs and demographic and clinical factors of patients is critical in order to determine the impact on the national economy and society. Shahathevan et al. (2013) also emphasised the significance of obtaining an accurate estimated cost in order to carry out better healthcare resource distribution planning and limited resource utilisation. This can only be realised if all stakeholders in the healthcare economic analysis work together. As a result, the purpose of this study was to examine the factors that influence the medical costs of ischemic stroke patients receiving treatment at HCTM from 2016 to 2020.

Materials and Methods

This study used ischemic stroke patient data obtained from the HCTM Record Unit over a five-year period beginning on January 1, 2016 and ending on December 31, 2020. The HCTM database yielded a total of 2161 samples. Patients' medical costs, demographic factors such as age and gender, and clinical factors such as severity level, LOS, and comorbid factors are all collected. Comorbidities include hypertension, diabetes, hyperlipidemia, IHD, AF, smoking, and alcohol consumption. In order to analyse the data, the multiple linear regression method is used. The goal is to examine the relationship between a patient's medical costs and factors such as age, gender, length of stay, comorbidities, and severity level. The definition of multiple linear regression is as follow:

$$Y_i = \beta_0 + \beta_1 X_{i1} + \beta_2 X_{i2} + \beta_3 D_{i3} \ldots + \beta_k D_{ik} + \varepsilon_i \quad (1)$$

where Y_i representing the i-th observation of the dependent variable and X_{ik} and D_{ik} representing the quantitative and categorical independent variables, respectively. The dependent variable in this study is the hospital's economic burden on ischemic stroke patients, while the independent variable is the patient's demographic and clinical factors. Medical costs are a continuous variable, whereas age and length of stay are quantitative independent variables. Gender, comorbidities, and severity level are also categorical independent variables.

Medical costs exhibit positive skewed data. According to Feigin, Forouzanfar and Krishnamurthi (2014), using logarithmic transformation to transform a skewed data distribution into a normal distribution with a bell-shaped shape can improve model fit. Furthermore, the logarithmic transformation method is widely used in biological and psychological research. A logarithmic transformation was applied to the medical expenses of ischemic stroke patients in order to develop a more accurate medical cost model.

To estimate the parameters, the ordinary least squares (OLS) method is used. The method determines the relationship by minimising the sum of squares in the difference between the dependent variable's observed and fitted values. The equation for OLS is as follows:

$$L(\beta_0, \beta_1, \ldots, \beta_k) = \sum_{i=1}^{n} \varepsilon_i^2 = \sum_{i=1}^{n} \left(Y_i - \hat{Y}_i\right)^2 = \sum_{i=1}^{n} \left(Y_i - \beta_0 - \sum_{j=1}^{k} \beta_j X_{ij}\right)^2 \quad (2)$$

The function L must be minimised with respect to $\beta_0, \beta_1, \ldots, \beta_k$. The estimators of $\hat{\beta}_0, \hat{\beta}_1, \ldots, \hat{\beta}_k$ must satisfy

$$\left.\frac{\partial L}{\partial \beta_0}\right|_{\hat{\beta}_0, \hat{\beta}_1, \ldots, \hat{\beta}_k} = -2\sum_{i=1}^{n} \left(Y_i - \hat{\beta}_0 - \sum_{j=1}^{k} \hat{\beta}_j X_{ij}\right) = 0 \quad (3a)$$

and

$$\left.\frac{\partial L}{\partial \beta_j}\right|_{\hat{\beta}_0, \hat{\beta}_1, \ldots, \hat{\beta}_k} = -2\sum_{i=1}^{n} \left(Y_i - \hat{\beta}_0 - \sum_{j=1}^{k} \hat{\beta}_j X_{ij}\right) X_{ij} = 0 \quad (3b)$$

By simplifying the above equation, the least squares normal equations are obtained as follows:

$$\hat{\beta}_0 \sum_{i=1}^{n} X_{ik} + \hat{\beta}_1 \sum_{i=1}^{n} X_{ik} X_{i1} + \hat{\beta}_2 \sum_{i=1}^{n} X_{ik} X_{i2} + \cdots + \hat{\beta}_k \sum_{i=1}^{n} X_{ik}^2 = \sum_{i=1}^{n} X_{ik} Y_i \quad (4)$$

The solution to the normal equations is the least squares estimators $\hat{\beta}_0, \hat{\beta}_1, \ldots, \hat{\beta}_k$.

To ascertain the statistical significance of each independent variable in a linear regression model, stepwise regression is used. The potential explanatory factors are incrementally added or subtracted after each iteration, and the statistical significance is evaluated. Forward selection begins with no model variables, tests each one as it is introduced, keeps the variables that are thought to be the most statistically significant, and repeats the procedure until the results are perfect. The importance of each model is evaluated using the adjusted R^2, which only increases when a new variable improves it by more than by chance.

Diagnostic tests must be carried out to ensure that the collected data met all of the assumptions of the

regression analysis. The first assumption is that the dependent and independent variables must be linearly related. Independent variables should be independent. There should be no correlation between the error terms. The error terms must have constant variance and normally distributed.

Results and Discussion

According to Table 2, the stroke incidence for patients aged 60 and older was higher (64.5 percent) for both genders than for patients younger than 60 (35.5 percent). This statement is supported by Reilly and McCullough (2018) who found that increasing age is a major risk factor for patients suffering from ischemic stroke. They also stated that older stroke patients have a higher mortality and morbidity rate, as well as a lower functional recovery rate than younger patients. Patients with a moderate level had a higher number of patients than the other groups for both gender and age, as shown in Table 2. Patients over the age of 60 had a twofold increase in the prevalence of moderate stroke. The highest incidence of stroke (34.38%) was found in patients with two comorbid factors out of 2161 samples.

TABLE 2. Patients frequency based on categorical variables

	Number of patients (%)											
Gender	Male						Female					
	1292 (50.79)						869 (40.21)					
Age Group	Less than 60 years old			60 years old and above			Less than 60 years old			60 years old and above		
	517 (23.92)			775 (35.86)			250 (11.57)			619 (28.64)		
	Mild	Moderate	Severe	Mild	Moderate	Severe	Mild	Moderate	Severe	Mild	Moderate	Severe
Severity Level	197 (9.12)	219 (10.13)	101 (4.67)	191 (8.84)	375 (17.35)	209 (9.67)	98 (4.53)	117 (5.41)	35 (1.62)	127 (5.88)	325 (15.04)	167 (7.73)
Number of Comorbidities												
0	34 (1.57)	34 (1.57)	16 (0.74)	27 (1.25)	43 (1.99)	19 (0.88)	17 (0.79)	18 (0.83)	4 (0.19)	11 (0.51)	38 (1.76)	15 (0.69)
1	52 (2.41)	68 (3.15)	33 (1.53)	50 (2.31)	70 (3.24)	33 (1.53)	25 (1.16)	29 (1.34)	9 (0.42)	34 (1.57)	62 (2.87)	29 (1.34)
2	67 (3.10)	62 (2.87)	25 (1.16)	60 (2.78)	148 (6.85)	65 (3.01)	40 (1.85)	45 (2.08)	13 (0.60)	41 (1.90)	123 (5.69)	54 (2.50)
3	36 (1.67)	39 (1.80)	22 (1.02)	39 (1.80)	89 (4.12)	66 (3.05)	15 (0.69)	22 (1.02)	7 (0.32)	33 (1.53)	76 (3.52)	48 (2.22)
4 and above	8 (0.37)	16 (0.74)	5 (0.23)	15 (0.69)	25 (1.16)	26 (1.20)	1 (0.05)	3 (0.14)	2 (0.09)	8 (0.37)	26 (1.20)	21 (0.97)

Table 3 shows the mean and standard deviation of medical costs for patients based on severity, age group, and number of comorbidities. According to the table, the medical costs of patients increased with the severity level of the stroke. The average cost of a severe stroke was RM 11 211.36 ± 5345.74, followed by a moderate stroke (RM 8065.18 ± 2873.39) and a mild stroke (RM 5575.33 ± 1808.17). Furthermore, medical costs were higher among patients under the age of 60 for all three severity levels. Patients under 60 years old with severe stroke cost an average of RM 12 369.03 ± 6726.58, while those 60 and older cost an average of RM 10 806.25 ± 4690.58.

TABLE 3. Patients' medical cost based on categorical variables

	Cost (RM) Mean ± Standard Deviation					
Severity Level	Mild 5575.33 ± 1808.17		Moderate 8065.18 ± 2873.39		Severe 11221.36 ± 5345.74	
Age Group	Less than 60 years old 5648.33 ± 1926.78	60 years old and above 5507.61 ± 1690.97	Less than 60 years old 8303.36 ± 3446.61	60 years old and above 7950.85 ± 2547.87	Less than 60 years old 12369.03 ± 6726.58	60 years old and above 10806.25 ± 4690.58
Number of Comorbidities						
0	6187.25 ± 3249.33	5831.13 ± 2434.72	7868.02 ± 1980.28	7835.07 ± 2000.94	10107.65 ± 3379.71	10081.32 ± 2799.83
1	5537.94 ± 1636.88	5472.04 ± 1318.43	8268.04 ± 3388.30	8152.95 ± 2896.56	13999.88 ± 7979.73	10729.21 ± 4612.18
2	5510.24 ± 1498.23	5428.04 ± 1301.26	8319.13 ± 3588.42	7922.81 ± 2584.09	12303.50 ± 6698.92	10403.94 ± 3781.55
3	5629.39 ± 1435.36	5298.32 ± 148.88	8612.70 ± 4265.02	7795.76 ± 2362.21	11925.03 ± 6566.67	11014.49 ± 5298.70
4 and above	5288.00 ± 0.00	6107.61 ± 4021.32	8593.16 ± 3362.95	8262.37 ± 2773.39	11240.14 ± 5537.94	11945.81 ± 6133.97

Table 3 also shows that patients with four or more comorbidities had higher medical costs than patients with fewer comorbidities. For all three severity levels, this statement can be observed in patients aged 60 years and older. The most significant differences were found in patients with mild strokes, as well as those aged 60 and older. Patients with four or more comorbid factors had a higher average cost (RM 6107.61 ± 4021.32) than patients with three comorbid factors (RM 5298.32 ± 148.88).

In addition, Table 4 shows the characteristics and medical costs of patients based on the type of comorbidity. According to the table, hypertension disease was the most frequently reported comorbid factor in ischemic stroke patients, accounting for 75.52 percent of the total sample. Diabetes and hyperlipidaemia are also common comorbid factors, accounting for 48.17 percent and 28.46 percent, respectively. Despite this, AF and IHD had the highest average costs, with RM 9380.05 ± 4634.41 and RM 9246.77 ± 5223.26, respectively. According to Walter et al. (2012), high medical costs for AF are caused by receiving resource-intensive care and anticoagulation treatment for an extended period of time.

TABLE 4. Characteristics and medical costs of patients based on comorbidities

Type of Comorbidities	Male Number (%)	Female Number (%)	Total Number (%)	Cost (RM) Mean ± Standard Deviation
Hypertension	931 (43.08)	701 (32.44)	1632 (75.52)	8016.21 ± 3758.23
Diabetes	598 (27.67)	443 (20.50)	1041 (48.17)	8053.96 ± 3845.43
Hyperlipidemia	338 (15.64)	277 (12.82)	615 (28.46)	8153.06 ± 4117.26
IHD	255 (11.80)	122 (5.65)	377 (17.45)	9246.77 ± 5223.26
AF	133 (6.15)	126 (5.83)	259 (11.99)	9380.05 ± 4634.41
Smoking Habit	152 (7.03)	7 (0.32)	159 (7.36)	8387.02 ± 5640.42
Alcohol Consumption	20 (0.93)	1 (0.05)	21 (0.97)	7159.19 ± 1430.58

Tables 5 and 6 summarise the regression model and ANOVA results. In Table 5, measures the amount of variation and the degree to which the independent variable describes the dependent variable. in this model indicates that the factors involved can explain up to 54.65 percent of the variation in the medical costs of ischemic stroke patients. ANOVA results in Table 6 with a *p*-value less than 0.001 also supported the built model. These findings demonstrate that the null hypothesis can be rejected, and that this regression model is appropriate for use.

TABLE 5. Model summary

		Adjusted	Residuals standard error
0.7393	0.5465	0.5446	0.2274

TABLE 6. ANOVA result

Model	Sum of squared	df	Mean of squared	*F*	*p*-value
Regression	134.784	9	14.976	288.0	<0.001
Residuals	111.236	2151	0.052	-	-
Total	246.02	2160	-	-	-

Table 7 shows the multiple linear regression model parameter estimates that are most appropriate for estimating the medical costs of ischemic stroke patients. Age, gender, LOS, severity level, and type of comorbidities such as hypertension, diabetes, hyperlipidaemia, IHD, AF, smoking habits, and alcohol intake were all factors in determining the medical costs of the patients studied. However, not all parameters are significant in the study's findings. Gender, diabetes, and hyperlipidaemia were found to be insignificant with a

p-value greater than $\alpha = 0.05$ based on the analysis. As a result, those factors have been removed and are no longer shown in the parameter estimation table below. A diagnostic test was performed, and none of the regression assumptions were violated.

TABLE 7. Estimation of parameter for multiple linear regression model

Model	Estimation of coefficient β	Standard error	t	p-value	VIF
Intercept	8.674	0.026	332.018	<0.001	-
Age	-0.002	0.000	-4.694	<0.001	1.139
LOS	0.011	0.001	12.283	<0.001	1.159
Hypertension	-0.027	0.012	-2.353	0.019	1.052
IHD	0.045	0.013	3.436	<0.001	1.049
AF	0.035	0.016	2.174	0.030	1.085
Smoking Habit	0.064	0.020	3.242	0.001	1.107
Alcohol Consumption	-0.118	0.051	-2.311	0.021	1.055
Moderate Stroke	0.357	0.012	30.057	<0.001	1.236
Severe Stroke	0.601	0.015	40.269	<0.001	1.236

The mild severity level was used as the reference group in this multiple linear regression analysis. Table 7 shows that factors such as age, LOS, hypertension, IHD, AF, smoking habits, alcohol intake, and severity levels have a significant relationship with medical costs. Because log-transformation was performed, the resulting model must be re-converted from a log-linear to a linear form to facilitate interpretation of the relationship between the patient's medical costs and the factors involved. The approximate equations in exponential form are given below. Table 8 also shows the regression coefficients for each variable in exponential form, as well as the effect of their changes on *Y*.

$$Y = e^{8.674 - 0.002X_1 + 0.011X_2 - 0.027X_3 + 0.045X_4 + 0.035X_5 + 0.064X_6 - 0.118X_7 + 0.357X_8 + 0.601X_9} \quad (5)$$

TABLE 8. Exponential regression coefficients

	β_i	exp (β_i)	Changes on Y (%)
Intercept	8.674	5849.52	-
β_1	-0.002	0.998	-0.2
β_2	0.011	1.011	1.1
β_3	-0.027	0.973	-2.7
β_4	0.045	1.046	4.6
β_5	0.034	1.035	3.5
β_6	0.064	1.066	6.6
β_7	-0.118	0.889	-11.1
β_8	0.357	1.429	42.9
β_9	0.601	1.824	82.4

A positive regression coefficient indicates that when X_i increases by one unit, the patient's medical costs will increase by exp(β_i) fold. Meanwhile, for the negative regression coefficient, the patient's medical cost will decrease at the rate of exp(β_i) for each unit increase in X_i, assuming all other variables remain constant.

The age of the patients was found to have a significant influence on the medical costs of ischemic stroke patients in this study. When a patient's age increases by one unit, his or her medical costs decrease by 0.2 percent. The findings of this study are supported by the findings of Zhu et al. (2020), who found that age is a significant determinant of the total burden of stroke medical costs in China. Furthermore, Wang et al. (2014) claimed that patient age had a significant relationship with stroke medical costs in a study of 97 374 stroke patients aged 18 to 64 years in the United States. According to the results of the analysis, younger patients have higher medical costs than older patients. The findings of this study are consistent with the findings of Chow, Aung and Meyyappan (2010), who found a 6% increase in medical costs for patients under the age of 65 compared to patients over the age of 65. When compared to older stroke patients, the influence of younger age on increased medical costs can be explained by higher side costs as well as a higher number of investigative procedures performed (Mamoli et al. 1999; Reed et al. 2001).

This study also found that LOS is a significant determinant of patients' medical costs. The higher the LOS, the higher the medical costs incurred by ischemic stroke patients. The findings of this study are consistent with those of Abdo et al. (2018). According to his study, which was conducted in Lebanon, LOS is highly correlated and has a linear relationship with patients' total medical costs. He also claimed that the hospital room and board costs accounted for more than a quarter of the total costs incurred. Thus, when compared to other variables included in the regression, LOS accounted for a significant portion of the overall variance in total medical costs. Furthermore, in this study, patients' medical costs are expected to rise by 1.1 percent for every unit of LOS increase. Chow, Aung and Meyyappan (2010) used a log-linear model to study the factors influencing the cost of ischemic stroke patients in Singapore, which supports the findings of this study. According to the findings of his study, for every unit of LOS increase, the patient's medical costs would rise by 0.48 percent. Based on the findings of his study, an improved healthcare delivery system has been proposed in order to optimize the length of patient stay and the delivery of care at appropriate facilities.

According to a study conducted by Mohd Nordin et al. (2012), the severity of a stroke has a significant impact on the medical costs of stroke patients. The findings of their study are consistent with the findings of this study, which discovered that medical costs increase by 42.9 percent when patients experience a moderate stroke and by 82.4 percent when patients experience a severe stroke compared to a mild stroke. Furthermore, when compared to other factors, the level of severity was the determining factor that had the greatest impact on the medical costs of ischemic stroke patients in this study. These findings support the findings of Yoneda et al. (2003), who discovered that the total medical costs of stroke patients in Japan were strongly correlated with severity level. According to Abdo et al. (2018), severity level has a positive correlation with LOS and stroke medical costs. Patients with severe stroke had a longer LOS and higher costs than those with moderate or mild stroke. Furthermore, the higher the cost of a severe stroke, the greater the need for ICU utilisation. Besides that, Rost et al. (2016) discovered that incorporating severity level factors into stroke cost models has become a common statistical approach in stroke randomised clinical trial planning and implementation. In comparisons of regional and national stroke care systems, he also claimed that the level of stroke severity is an important predictor for estimating post-stroke costs.

Following that, this study shows that hypertension, IHD, AF, smoking habits, and alcohol consumption are the comorbid types that have a significant impact on patients' medical costs. Patients with IHD, AF, and smoking habits will have their medical costs increased by 4.6 percent, 3.5 percent, and 6.6 percent, respectively, whereas hypertension and alcohol consumption will have their medical costs reduced by 2.7 percent and 11.1 percent, respectively. The findings of this study are supported by the findings of Wang et al. (2014), who found that hypertension is a comorbidity that has a negative impact on medical costs, whereas patients with IHD have significantly higher medical costs. Furthermore, the findings of this study are supported by the findings of Fattore, Torbica and Susi (2012) and Go et al. (2014). According to Go et al. (2014), patients with comorbid factors such as IHD and AF had higher medical costs than other comorbid factors. As per Fattore, Torbica and Susi (2012), AF is associated with higher hospitalisation costs. However, no previous research has found that smoking and alcohol consumption are comorbid factors that influence the stroke medical costs.

Meanwhile, gender had no effect on the medical costs of ischemic stroke patients. These outcomes are supported by the findings of Jorgensen, Nakayama and Raaschou (1997) and Mohd Nordin et al. (2012) that gender was not a significant determinant of stroke medical costs. Besides, comorbid conditions such as diabetes and hyperlipidemia have a negligible impact on medical costs. Despite the fact that diabetes and hyperlipidemia are major risk factors for stroke patients in this study, the presence of such comorbidities had no significant effect on the patients' hospital costs.

Conclusion

The study's findings showed that patients' medical costs are influenced by their age, length of stay, severity level, and the type of comorbidities they have, such as hypertension, IHD, AF, smoking habits, and alcohol consumption. It has been discovered that younger patients have higher medical costs than older patients. This is due to the fact that younger stroke patients require more time in the hospital and have higher productivity loss costs than older patients. Following that, comorbidities such as IHD, AF, and smoking habits will raise medical costs, whereas comorbidities such as hypertension and alcohol consumption will lower medical costs. Furthermore, the patient's medical costs rise in tandem with the patient's LOS. Similarly, medical costs increased significantly with patient severity levels, with severe patients incurring the highest medical costs, followed by moderate and mild patients. In summary, medical costs for ischemic stroke patients are high and vary depending on the patient's age, length of stay, comorbidities, and severity.

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