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ESTIMATE INPATIENT'S COST OF BREAST CANCER TREATMENT FOR A SINGLE EPISODE OF CARE

(*Anggaran Kos Rawatan Kanser Payudara Pesakit Dalam untuk Satu Episod Perawatan*)

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ABSTRACT

In Malaysia, breast cancer remains the leading cause of cancer-related mortality. The cost of breast cancer treatment has been noted as a major barrier to care. The community and the healthcare system as a whole would benefit from knowing the cost of treating this illness. The goal of this study is to identify the factors that contribute to the high cost of breast cancer treatment and provide an estimate of those costs. As a result, between 2017 and 2021, a total of 1027 samples were collected from breast cancer patients at Hospital Canselor Tuanku Muhriz's (HCTM) Breast & Endocrine Unit (ENB) and International Casemix and Clinical Coding Centre (ITCC). Information gathered consists of total healthcare expenditures for a single episode of care, patient demographics like age and gender, and clinical details like disease severity, hospitalisation duration, comorbidities, metastatic status, treatments administered, and discharge status. Regression analysis was used in this research. Because treatment costs tend to be skewed, a logarithmic transformation is used to produce a more precise model for estimating those costs. The results show that age, severity, treatment, length of hospitalisation, hypertension, lung, lymph, and brain metastases, and hospital discharge status all have an impact in the total cost of treating breast cancer patients. Treatment costs are not significantly affected by the presence of liver and bone metastases or comorbidities such as cardiovascular disease, high cholesterol, or diabetes.

Keywords: breast cancer; regression analysis; treatment costs

ABSTRAK

Di Malaysia, kanser payudara kekal sebagai punca utama kematian berkaitan kanser. Kos rawatan kanser payudara dikatakan sebagai penghalang utama untuk perawatan kesihatan. Masyarakat dan sistem penjagaan kesihatan secara keseluruhan akan mendapat manfaat dengan mengetahui kos rawatan penyakit ini. Tujuan kajian ini adalah untuk mengenal pasti faktor-faktor yang menyumbang kepada kos rawatan kanser payudara dan menganggarkan kos tersebut. Justeru itu, sebanyak 1027 sampel telah dikumpul untuk tempoh daripada tahun 2017 sehingga tahun 2021 daripada pesakit kanser payudara di Hospital Canselor Tuanku Muhriz (HCTM) Unit Payudara & Endokrin (ENB) dan International Casemix and Clinical Coding Centre (ITCC). Maklumat yang dikumpul terdiri daripada jumlah perbelanjaan penjagaan kesihatan untuk satu episod perawatan, demografi pesakit seperti umur dan jantina, dan butiran klinikal seperti keterukan penyakit, tempoh kemasukan ke hospital, komorbiditi, status metastatik, rawatan yang diberikan dan status discaj. Analisis regresi digunakan dalam penyelidikan ini. Oleh kerana kos rawatan adalah bersifat terpencong maka transformasi logaritma digunakan untuk menghasilkan model yang lebih tepat untuk menganggar kos tersebut. Hasil kajian menunjukkan bahawa umur, tahap keterukan, jenis rawatan, tempoh penghospitalan, hipertensi, paru-paru, limfa dan metastasis otak, dan status discaj hospital semuanya mempengaruhi jumlah kos rawatan pesakit kanser payudara. Kos rawatan tidak dipengaruhi secara signifikan oleh kehadiran metastasis hati dan tulang atau komorbiditi seperti penyakit kardiovaskular, kolesterol tinggi atau diabetes.

Kata kunci: kanser payudara; analisis regresi; kos rawatan

1. Introduction

The number of breast cancer-related deaths is increasing worldwide, with the exception of high-income countries (Azamjah *et al.* 2019). According to the World Health Organisation (2021), in 2020 there were a total of 685 000 breast cancer-related deaths among 2,3 million patients worldwide, and 3,503 deaths among 8,418 patients in Malaysia. The country's decreased productivity will have affects on the global economy (Adanu *et al.* 2022). Based on Malaysia National Cancer Registry Report (MNCR), breast cancer was found to have the highest prevalence in Malaysia, with estimates ranging from 17.7 percent in the years 2007-2011 (Ab Manan *et al.* 2015) to 19.0 percent in the years 2012-2016 (Ab Manan *et al.* 2019). The number of new cases of breast cancer increased by 19.0% from 2007-2011 to 2012-2016, from 18,206 to 21,634. Using the age-standardized rate (ASR), which is an age-specific weighted average expressed per 100,000 population, breast cancer incidence increased from 31.1 per 100,000 population in 2007-2011 to 34.1 per 100,000 population in 2012-2016 (Ab Manan *et al.* 2019).

Ab Manan *et al.* (2019) discovered that 41.9% of breast cancer patients were between the ages of 25 and 59, 28.8% were between the ages of 60 and 74, and 16.7% were 75 or older. According to the American Cancer Society (2022), breast cancer affects women of middle age and older more frequently. According to Valderas *et al.* (2009), comorbid factors are those that exacerbate the severity of the patients' conditions and may necessitate additional treatment. After menopause, lifestyle and metabolic syndrome comorbid factors such as diabetes, hypertension, abnormal cholesterol level, and obesity increase a woman's risk of being diagnosed with breast cancer (Ayeni *et al.* 2019). Nonetheless, primary hypertension, diabetes, chronic ischemic heart disease, chronic obstructive pulmonary disease (COPD), asthma, hypertensive heart disease, and metastasis are comorbid risk factors for breast cancer (Tekin & Saygili 2019).

According to Hwa *et al.* (2011), a single episode of care costs approximately RM90,000. This expense places a burden on the economy. According to Tekin and Saygili (2019), the average cost of treatment for breast cancer patients with comorbid conditions is higher than for those without comorbid conditions (USD884.9 vs. USD968.8). The severity of breast cancer will also affect the cost of treatment. Sun *et al.* (2018) report that patients with advanced breast cancer have poorer health outcomes and will need more treatment to recover. In 2015, the average cumulative treatment costs for stages I, II, III, and IV are USD29,724, USD39,324, USD57,827, and USD62,108, respectively. This indicates that the severity of breast cancer affects the cost of treatment. Moreover, according to Downing *et al.* (2009), the length of hospitalisation is affected by treatments such as the number of surgical procedures performed as well as chemotherapy and radiotherapy. Patients, surgeons, and hospitals all have an effect on hospitalisation duration (Downing *et al.* 2009). According to Tekin and Saygili (2019), 6.1% of 126,667 breast cancer patients experience metastasis. 52.4%, 20.4%, 16.0%, and 11.2% of the 6.1% of patients, respectively, have lung, brain, liver, and bone metastasis. The average cost of treatment for breast cancer patients with metastasis is $3,251.40 compared to $2,203.90 for those without metastasis (Tekin & Saygili 2019). In addition, Hoang *et al.* (2013) and Blumen *et al.* (2016) discovered that the cost of chemotherapy has a substantial effect on the treatment costs for breast cancer patients. Chemotherapy accounts for approximately 64.9% of the total cost of treating breast cancer (Hoang *et al.* 2013). The majority of treatment costs are covered by medications (Tekin & Saygili 2019). According to Chen *et al.* (2021), breast cancer treatment is more expensive for patients who undergo surgery than for those who do not.

Therefore, this study is conducted to determine the factors that affect treatment costs and the extent to which these factors affect breast cancer treatment costs.

2. Material and Methods

This is a retrospective study of breast cancer-related hospital admissions in HCTM from 2017 to 2021. Ethical approval for the study from the hospital-based UKM Research Ethics Committee (UKM PPI/111/8/JEP-2022-444) was granted on 19 September 2022 before the data acquisition process was made to the ITCC, the centre that is responsible for the patients' data records in HCTM. The International Classification of Diseases (ICD) was used to identify breast cancer-related admissions in the Endocrine & Breast Unit, HCTM, and ITCC. This data set, which included 1027 breast cancer patients from January 1, 2017 to December 31, 2021, included only those with a breast cancer-related admission on their record. Admission and discharge dates (i.e. length of hospital stay in days), age, primary diagnosis on hospital admission, severity level, comorbid factors, metastasis type, treatment type, discharge status and treatment costs were among the information that was obtained. The purpose of this study is to learn more about the factors that influence the cost of breast cancer treatment at the Endocrine & Breast Unit, HCTM, and then use this knowledge to estimate these costs. The above predictors and a patient's treatment costs are studied using multiple linear regression (Majid *et al.* 2022; Hwang *et al.* 2019; Gregori *et al.* 2011). As mentioned by James *et al.* (2021) and Kassambara (2018), this technique is frequently used to identify linear correlations between multiple responses and predictive variables. The definition of multiple linear regression is as follow:

$$Y_i = \beta_0 + \beta_1 X_{i1} + \beta_2 X_{i2} + \cdots + \beta_k X_{ik} + \varepsilon_i. \quad (1)$$

where Y_i representing the *i*-th observation of the dependent variable which is treatment costs and X_{ik} representing the *i*-th observation of the independent variables which is age, severity level, duration of hospitalisation, comorbid factor such as hypertension, type of metastasis such as lung, lymph and brain metastasis, type of treatment such as chemotherapy, radiotherapy and no treatment, and status discharge. There are four assumptions that must be followed when testing multiple linear regression, which are as follows:

(1) the relationship between *Y* and *X* are linear,
(2) the error is normally distributed,
(3) independence of errors, and
(4) homoscedasticity where the variance is constant.

To ensure that these assumptions are followed, diagnostic tests such as plotting the residuals vs fitted plot, q-q plot, scale-location vs square root standardised residual plot, and determining the variance inflation factor (VIF) of the variables needs to be carried out.

The main issue in statistical models in healthcare costs is skewed data (Malehi *et al.* 2015). Because the distribution of hospital costs was skewed, a log transformation was applied to a regression model (Majid *et al.* 2022; Hwang *et al.* 2019; Malehi *et al.* 2015). Here is the equation for the logarithmic transformation:

$$\ln Y_i = \beta_0 + \beta_1 X_{i1} + \beta_2 X_{i2} + \cdots + \beta_k X_{ik} + \varepsilon_i \quad (2)$$

3. Results and Discussion

The frequency of breast cancer patients by gender, age group, severity level, and number of comorbidities is presented in Table 1. Following the age group as described in the MNCR report, age is divided into three categories: less than 60 years old, 60 to 74 years old, and 75 years and older (Ab Manan *et al.* 2015; Ab Manan *et al.* 2019). 606 (59.01%) of the patients

are under the age of 60, while 47 (4.58%) are 75 or older. This finding is consistent with MNCR statistics (Ab Manan *et al.* 2015; Ab Manan *et al.* 2019) indicating that the number of breast cancer patients under the age of 60 is the highest and the number of breast cancer patients over the age of 75 is the lowest. According to the data, there are only three male patients (0.29%), and they are all between 60 and 74 years old. Based on the severity level of breast cancer, 37.2% and 33.45% of patients under the age of 75, respectively, are diagnosed with mild and moderate severity levels, while the remaining patients are diagnosed with severe severity level. There are 47 patients aged 75 and older; 19 (40.43%), 17 (36.17%), and 11 (23.40%) have severe, moderate, and mild severity levels, respectively. This suggests that the severity of cancer at the time of diagnosis tends to be greater in older patients.

The mean and standard deviation of breast cancer treatment costs by severity level, age group, number of comorbidities, and length of hospitalisation are presented in Table 2. It has been discovered that the average cost of treatment increases with increasing severity. The average cost of treatment for mild severity is approximately RM5,000, with an increase of RM2,000 for moderate severity. The average treatment costs for severe level of severity are approximately twice as high as those for moderate severity. In general, regardless of age, the average treatment costs for breast cancer patients with mild level of severity are nearly the same. Patients under 75 years old with the most severe case of breast cancer incur costs that are roughly double those of patients with less severe cases.

In addition, the highest average treatment expenses for breast cancer vary by age group and severity level. Those aged 60 to 74 have the highest average treatment costs for breast cancer patients with a mild severity level (RM4766.28 ± 2240.63). Mild severity levels are associated with the lowest average treatment costs (RM4210.19 ± 1622.36) for patients aged 75 and older. The average cost of treatment for patients with moderately severe breast cancer decreases with age, with the highest costs incurred by those younger than 60 years old. (RM6427.31 ± 4304.77). Those between the ages of 60 and 74 have the highest average treatment costs (RM6306.04 ± 3890.57), followed by those aged 75 and up (RM6200.82 ± 4027.48). The highest average treatment costs for breast cancer patients with a severe severity level were incurred by those aged 75 and older (RM12170.85 ± 7162.57), while those aged 60–74 had the lowest (RM10822.8 ± 5136.13).

The highest average treatment costs (RM20126.32 ± 17617.17) are associated with breast cancer patients who are younger than 60 years old, have a severe disease stage, and have more than two significant comorbid factors. The second highest average treatment costs (RM14964.56 11359.20) are incurred by patients older than 75 years old who have a severe severity level of breast cancer but no significant comorbid factors. As shown in Table 2, the cost of breast cancer treatment increases significantly with hospital stay duration across all severity levels and age groups.

36.42 percent of breast cancer patients with a mild severity level do not have metastasis, as shown in Table 3. All breast cancer metastases were identified in one of the moderately ill breast cancer patients. 179 of 271 patients with severe breast cancer were found to have metastasis.

Table 1: Patients frequency based on categorical variables

	Number of Patients (%)								
Gender					Female				
					1024 (99.71%)				
Age Group		Age < 60			60 ≤ Age < 75			Age ≥ 75	
		606 (59.01%)			371 (36.12%)			47 (4.58%)	
Severity Level	Mild	Moderate	Severe	Mild	Moderate	Severe	Mild	Moderate	Severe
	230 (22.40%)	227 (22.10%)	149 (14.51%)	152 (14.80%)	117 (11.39%)	102 (9.93%)	11 (1.07%)	17 (1.66%)	19 (1.85%)
Number of Comorbidities									
0	174 (16.94%)	180 (17.53%)	104 (10.13%)	66 (6.43%)	60 (5.84%)	43 (4.19%)	5 (0.49%)	5 (0.49%)	7 (0.68%)
1	26 (2.53%)	31 (3.02%)	32 (3.12%)	32 (3.12%)	22 (2.14%)	30 (2.92%)	1 (0.10%)	1 (0.10%)	2 (0.19%)
2	21 (2.04%)	10 (0.97%)	10 (0.97%)	34 (3.31%)	16 (1.56%)	17 (1.66%)	4 (0.39%)	7 (0.68%)	6 (0.58%)
3 and above	9 (0.88%)	6 (0.58%)	3 (0.29%)	20 (1.95%)	19 (1.85%)	12 (1.17%)	1 (0.10%)	4 (0.39%)	4 (0.39%)

Table 2: Patients' treatment costs based on severity level, age group, number of comorbidities and duration of hospitalisation

	Cost (RM) Mean ± Standard Deviation								
Severity Level	Mild 4664.69 ± 2008.11			Moderate 6377.34 ± 4151.66			Severe 11001.47 ± 5391.06		
Age Group	Age < 60	60 ≤ Age < 75	Age ≥ 75	Age < 60	60 ≤ Age < 75	Age ≥ 75	Age < 60	60 ≤ Age < 75	Age ≥ 75
	4618.40 ± 1857.37	4766.28 ± 2240.63	4210.19 ± 1622.36	6427.31 ± 4304.77	6306.04 ± 3890.57	6200.82 ± 4027.48	10975.87 ± 5329.41	10822.80 ± 5136.13	12170.85 ± 7162.57
Number of Comorbidities									
0	4485.77 ± 1960.90	4673.71 ± 2875.21	4252.01 ± 1686.93	5899.36 ± 4001.10	5532.81 ± 3992.05	3829.25 ± 1242.19	10609.46 ± 5218.03	10517.22 ± 5544.26	14964.56 ± 11359.20
1	5235.50 ± 1501.637	4826.01 ± 1577.17	6894.00 ± 0	7513.88 ± 3899.82	5931.97 ± 3763.42	5190.00 ± 0	10840.67 ± 3791.07	11812.06 ± 5881.90	10029.49 ± 3008.76
2	4923.80 ± 1409.63	4917.02 ± 1618.34	3968.47 ± 1122.88	8730.21 ± 5427.51	7734.03 ± 3349.05	5824.43 ± 3766.40	12474.10 ± 2227.92	9368.88 ± 2472.21	10343.70 ± 2761.95
3 and above	4687.24 ± 1309.88	4729.20 ± 1609.34	2284.16 ± 0	12813.46 ± 6581.14	9268.22 ± 4741.17	10076.69 ± 5099.59	20126.32 ± 17617.17	11529.80 ± 4183.07	11093.24 ± 2127.52
Duration of Hospitalisation									
Less than 5 days	4290.14 ± 1800.90	4553.17 ± 2706.27	3672.86 ± 1006.80	5460.33 ± 3674.34	4964.92 ± 2975.42	4590.01 ± 2576.61	9406.89 ± 2290.13	10505.31 ± 2650.75	7901.97 ± 0
5 days and above	4919.29 ± 1864.71	5002.75 ± 1556.57	5150.52 ± 2212.13	7492.77 ± 4697.43	7670.28 ± 4247.38	8501.97 ± 4774.32	11612.35 ± 6043.12	10914.07 ± 5662.65	12673.07 ± 7427.60

Table 3: Number of metastasis based on the severity level

Number of Patients (%)			
Severity Level	Mild	Moderate	Severe
	395 (38.46%)	361 (35.15%)	271 (26.39%)
Number of Metastasis			
0	374 (36.42%)	142 (13.83%)	92 (8.96%)
1	20 (1.95%)	110 (10.71%)	71 (6.91%)
2	1 (0.10%)	57 (5.55%)	49 (4.77%)
3	0	35 (3.41%)	41 (3.99%)
4	0	16 (1.56%)	18 (1.75%)
5	0	1 (0.10%)	0

Table 4 shows that the majority of breast cancer patients (5.45%) have bone metastasis, with an average treatment cost of RM8103.86 ± 6147.26. The second most common metastasis diagnosed in breast cancer patients is lung metastasis (4.77%), with an average treatment cost of RM9,000.00. The treatment cost for patients with only brain and lymph metastases, brain, lung, and lymph metastases, or liver, brain, and lung metastases is RM12,157.00.

According to Table 5, the majority of patients (24.83%) have hypertension, while patients with breast cancer and heart disease have the highest average treatment costs (RM8985.41 ± 5056.55). Based on Table 6, the majority of patients (32.72%) undergo surgery, with the average treatment costing around RM8,000.00. Only two breast cancer patients are treated with chemotherapy and surgery, and the treatment cost is around RM12,000.00. The proportion of patients receiving chemotherapy (8.08%) is roughly twice that of those receiving radiotherapy (4.19%). Between 2017 and 2021, the average cost of breast cancer treatment at HCTM was determined to be RM6,938.82, with a total cost of RM7,126,169.20. Between 2017 and 2021, the average cost of breast cancer treatment at HCTM was determined to be RM6,938.82, with a total cost of RM7,126,169.20.

The regression model and ANOVA results are summarised in Tables 7 and 8. In Table 7, R^2 measures the amount of variation and the ways in which the independent variables describe the dependent variable. R^2 in this model indicates that the factors involved can explain up to 61.81 percent of the variation in the treatment costs of breast cancer patients in one episode of treatment. The built model is accepted because the *p*-value in Table 8 is less than 0.001, which is less than the 0.05 significance level set at the outset of the study. These findings indicate that the null hypothesis can be rejected and that this regression model is appropriate for use.

Table 9 shows the multiple linear regression model parameter estimates that are most appropriate for estimating the treatment costs of breast cancer patients. The regression analysis uses mild severity level as the reference category. Type of comorbidities such as heart disease, hyperlipidemia and diabetes are grouped together with the reference category which is do not have any comorbidities factor. Types of metastasis such as liver and bone metastases are also grouped with the reference category which is do not have any metastasis. The reference category for types of treatment is undergo surgery and all of the discharge status other than died are combined with the reference category which is going back to home. A diagnostic test was performed, and none of the regression assumptions were violated. Refer Figure 1.

Table 4: Metastasis incidence and breast cancer treatment costs

Metastasis	Number of Patients (%)	Cost (RM) Mean ± Standard Deviation
Liver only	34 (3.31%)	6945.77 ± 4104.72
Brain only	26 (2.53%)	5655.48 ± 3389.12
Bone only	56 (5.45%)	8103.86 ± 6147.26
Lung only	49 (4.77%)	9004.65 ± 7280.55
Lymph only	36 (3.51%)	7725.12 ± 4743.62
Liver and Brain only	4 (0.39%)	5979.01 ± 2405.75
Liver and Bone only	18 (1.75%)	7249.67 ± 2882.09
Liver and Lung only	10 (0.97%)	7075.40 ± 2930.23
Liver and Lymph only	5 (0.49%)	8800.61 ± 5222.71
Brain and Bone only	2 (0.19%)	5412.03 ± 3521.31
Brain and Lung only	4 (0.39%)	4734.03 ± 2367.14
Brain and Lymph only	1 (0.10%)	12157.00 ± 0
Bone and Lung only	38 (3.70%)	7137.41 ± 4105.68
Bone and Lymph only	10 (0.97%)	10566.31 ± 11034.44
Lymph and Lung only	15 (1.46%)	8154.99 ± 4981.90
Liver and Brain and Bone only	1 (0.10%)	7901.97 ± 0
Liver and Brain and Lung only	1 (0.10%)	12157.00 ± 0
Liver and Bone and Lung only	25 (2.43%)	6214.55 ± 3005.59
Liver and Bone and Lymph only	14 (1.36%)	8702.79 ± 4976.08
Liver and Lung and Lymph only	10 (0.97%)	8931.10 ± 4029.32
Brain and Bone and Lung only	8 (0.78%)	10240.01 ± 8303.26
Brain and Bone and Lymph only	2 (0.19%)	5190.00 ± 0
Brain and Lung and Lymph only	1 (0.10%)	12157.00 ± 0
Bone and Lung and Lymph only	14 (1.36%)	8677.80 ± 3729.81
Liver and Brain and Bone and Lung only	5 (0.49%)	7105.19 ± 1844.52
Liver and Brain and Lung and Lymph	1 (0.10%)	7901.97 ± 0
Liver and Bone and Lung and Lymph	26 (2.53%)	9136.72 ± 7347.56
Brain and Bone and Lung and Lymph only	2 (0.19%)	8673.50 ± 4926.41
Liver and Brain and Bone and Lung and Lymph	1 (0.10%)	5190.00 ± 0

Table 5: Treatment costs based on types of comorbid factors

Types of Comorbid Factors	Number of Patients (%)	Cost (RM) Mean ± Standard Deviation
Heart Disease	110 (10.71%)	8985.41 ± 5056.55
Hyperlipidemia	158 (15.38%)	7673.22 ± 4079.40
Hypertension	255 (24.83%)	7522.52 ± 4824.16
Diabetes	143 (13.92%)	7150.25 ± 4769.28

Table 6: Treatment costs based on types of treatment

Types of Comorbid Factors	Number of Patients (%)	Cost (RM) Mean ± Standard Deviation
Chemotherapy only	83 (8.08%)	7142.47 ± 5116.22
Radiotherapy only	43 (4.19%)	4937.73 ± 3180.32
Surgery only	336 (32.72%)	7511.05 ± 3750.22
Chemotherapy and Surgery only	2 (0.19%)	11186.83 ± 129.87
Radioterapi and Surgery only	1 (0.10%)	15870.00 ± 0

Table 7: Model summary

R	R^2	Adjusted R^2	Residuals Standard Error
0.7862	0.6181	0.6136	0.3588

Table 8: ANOVA results

Model	Sum of Squared	Df	Mean of Squared	F	p-value
Regression	210.7162	12	17.5597	136.4	<0.001
Residuals	130.1829	1011	0.1288	-	-
Total	340.8991	1023	-	-	-

Table 9: Estimation of parameter for multiple linear regression model

Model	Estimation of Coefficient β	Standard Error	t	p-value
Intercept	8.680	0.059	146.488	<0.001***
Age	-0.002	0.001	-1.765	0.078·
Duration of Hospitalisation	0.005	0.002	2.527	0.012*
Severity Level – Moderate	0.478	0.030	16.110	<0.001***
Severity Level – Severe	1.242	0.037	33.427	<0.001***
Hypertension	0.062	0.028	2.171	0.030*
Metastasis – Lung	-0.063	0.032	-1.977	0.048*
Metastasis – Lymph	0.073	0.035	2.091	0.037*
Metastasis – Brain	-0.096	0.051	-1.896	0.058·
Chemotherapy	-0.691	0.049	-14.181	<0.001***
Radiotherapy	-0.773	0.061	-12.604	<0.001***
No Treatment	-0.635	0.029	-21.716	<0.001***
Discharge Status - Died	-0.080	0.046	-1.741	0.082·

***, *, and · denote that the parameters are significant at the 0.001, 0.05, and 0.10 significance levels, respectively.

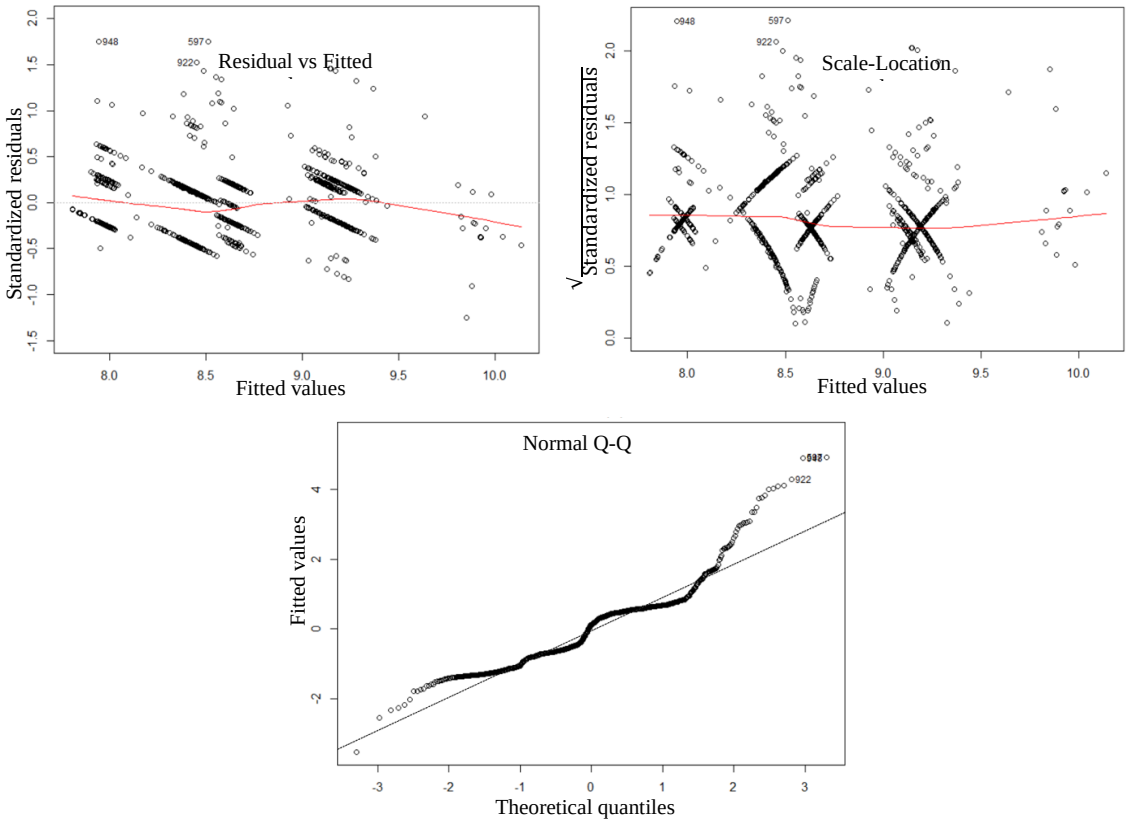

Figure 1: Diagnostic plots

Since 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 treatment costs and the factors involved. The approximate equations in exponential form are given below. Table 10 also shows the regression coefficients for each variable in exponential form, as well as the effect of their changes on *Y*.

$$Y = e^{8.680} \cdot e^{-0.002X_1} \cdot e^{0.005X_2} \cdot e^{0.478X_3} \cdot e^{1.242X_4} \cdot e^{0.062X_5} \cdot e^{-0.063X_6} \cdot e^{0.073X_7} \cdot e^{-0.096X_8} \cdot e^{-0.691X_9} \cdot e^{-0.773X_{10}} \cdot e^{-0.635X_{11}} \cdot e^{-0.080X_{12}} \quad (3)$$

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

Breast cancer patients' treatment costs are found to be significantly influenced by their age. Treatment costs decrease by 0.2 percent for every unit increase in age. This finding is supported by Capri and Russo (2017), who discovered that age is a significant determinant of breast cancer treatment costs in Italy. Furthermore, Chen *et al.* (2021) discovered the same results in Shanghai, China. Furthermore, it has been discovered that the length of hospitalisation is a significant factor in estimating the treatment costs of breast cancer patients. When the length of hospitalisation is increased by one day, treatment costs rise by 0.5 percent. This finding is supported by Chen *et al.* (2021), who state that hospitalisation duration has a positive correlation with treatment costs as well as comorbid factors. Ameri *et al.* (2022) discovered that

longer hospitalisations increase treatment costs, and that treatments such as chemotherapy and radiotherapy increase hospitalisation duration.

Table 10: Exponential regression coefficients

Model		Estimation of Coefficient β_i	exponent (β_i)	Changes to Y (%)
Intercept	β_0	8.680	5884.047	-
Age	β_1	-0.002	0.998	-0.2
Duration of Hospitalisation	β_2	0.005	1.005	0.5
Severity Level – Moderate	β_3	0.478	1.613	61.3
Severity Level – Severe	β_4	1.242	3.463	246.3
Hypertension	β_5	0.062	1.064	6.4
Metastasis – Lung	β_6	-0.063	0.939	-6.1
Metastasis – Lymph	β_7	0.073	1.076	7.6
Metastasis – Brain	β_8	-0.096	0.908	-9.2
Chemotherapy	β_9	-0.691	0.501	-49.9
Radiotherapy	β_{10}	-0.773	0.462	-53.8
No Treatment	β_{11}	-0.635	0.530	-47.0
Discharge Status - Died	β_{12}	-0.080	0.923	-7.7

Following that, the findings revealed that severity level has a significant influence on treatment costs. When comparing moderate and severe severity levels of breast cancer, treatment costs increase by 61.30 and 246.3 percent, respectively, when compared to mild severity levels. This finding is supported by Reddy *et al.* (2022), who discovered that treatment costs rise as patients' severity levels rise. Sun *et al.* (2018) stated that patients with higher severity levels have higher treatment costs because they require more treatments than patients with lower severity levels.

Furthermore, the results show that hypertension is a significant comorbid factor in terms of treatment costs. Breast cancer patients with hypertension will incur a 6.4 percent increase in treatment costs. This finding is consistent with Tekin and Saygili's (2019) discovery that patients with comorbid factors have higher treatment costs. Also, it has been discovered that breast cancer patients with lung, lymph, and brain metastases have a significant impact on treatment costs. Patients with lymph node metastasis raise treatment costs by 7.6 percent. Tekin and Saygili (2019) support this finding by stating that patients with metastasis will incur higher treatment costs. Patients with lung and brain metastases, on the other hand, will save 6.1 and 9.2 percent on treatment costs, respectively.

In addition, the study discovered that breast cancer patients who receive chemotherapy, radiotherapy, or no treatment at all have a significant impact on treatment costs. Patients who receive chemotherapy, radiotherapy, or no treatment save 49.9, 53.8, and 47.0 percent on treatment costs, respectively. This finding is contradicted by Hu *et al.* (2020), Blumen *et al.* (2016), and Hoang *et al.* (2013), who discovered that chemotherapy has the greatest influence on treatment costs. According to Hu *et al.* (2020), the cost of chemotherapy accounts for approximately 25.9 percent of the total treatment costs for breast cancer patients.

This study must be viewed with an awareness of its limitations. Cancer treatment is a journey. Patients diagnosed with cancer are likely to go through multiple treatments for outpatient or inpatient care. This study relied solely on hospital inpatient data. Another limitation of the study is that it focuses on a single treatment episode rather than the total cost of cancer care treatment after diagnosis.

4. Conclusion

In conclusion, the treatment costs of patients are influenced by their age, length of stay in the hospital, severity level, and type of comorbidities such as hypertension, as well as metastasis types such as lung, lymph, and brain metastases. The treatment costs for breast cancer patients were influenced by treatment types such as chemotherapy, radiotherapy, and no treatment, as well as discharge status - died. Furthermore, treatment costs rise as the length of hospitalisation and severity level increase. Comorbid conditions like hypertension and metastasis types like lymph metastasis will raise treatment costs for breast cancer patients, whereas lung and brain metastases will lower treatment costs. Also, treatment options such as chemotherapy, radiotherapy, and no treatment - death will lower treatment costs.

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