



Application of Binary Logistic Regression Method in Diagnosing Ischemic Stroke Disease at Petala Bumi Hospital, Riau Province

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ABSTRACT

Stroke occurs suddenly when blood flow is obstructed while supplying blood to the brain. Ischemic stroke is a type of stroke that often occurs and is a major cause of disability and even death. The large number of ischemic stroke incidents is the result of ignorance of the risk factors that lead to the emergence of ischemic stroke events. The purpose of this study was to determine the risk factors that significantly influence ischemic stroke and to determine the chances of thrombotic and embolic ischemic stroke by involving several independent variables. Factors that are thought to influence the occurrence of ischemic stroke in this study were age, gender, hypertension status, diabetes mellitus status, hypercholesterolemia status, obesity, triglycerides, body mass indeks, diet, and smoking habits. The method used in this research is binary logistic regression. Parameter significance testing is carried out using simultaneous testing using the Likelihood Ratio Test and Partial testing using the Wald test. The results of the analysis show that age and hypertension status have a significant effect on ischemic stroke with a classification accuracy of 74% the rest is influenced by other factors.

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1. INTRODUCTION

The brain is a vital organ in the human body, the brain will experience a lack of oxygen and experience physical disorders if blood circulation to the brain is disrupted [1]. Blockage of blood vessels in the brain or rupture of blood vessels in the brain can result in impaired blood circulation to the brain [2]. Impaired blood circulation to the brain causes neurological problems that manifest as loss of additional muscle movement, weakness of the swallowing muscles, weakness in speech, visual disturbances, impaired consciousness, and can even lead to death [3]. Stroke is a disease of nervous system dysfunction where there is a lack of oxygen to brain cells that occurs suddenly and quickly, resulting from the cessation of blood supply to the brain [4][5]. In Indonesia, based on the diagnosis of health workers, the prevalence of stroke is estimated at 1,236,825 people or 7.0 per 1,000 population. Meanwhile, based on the diagnosis of health workers, stroke symptoms are estimated at 2,137,941 people or 12.1 per 1,000 population [6].

Broadly speaking, stroke is classified into two types, namely ischemic stroke and hemorrhagic stroke. Ischemic stroke is the most common stroke occurrence with a percentage of 85%, which is caused by blockage of blood vessels with symptoms according to the affected part of the brain that can be completely healed, healed with defects, and even death [7]. Where ischemic stroke is grouped into two, namely thrombotic ischemic stroke is a stroke that occurs due to blood clots in the arteries that supply blood to the brain. While an embolic ischemic stroke is a stroke caused by a blood clot that forms in other organs of the body flowing into the blood vessels so that it blocks blood flow to the brain [8]. In 2018 the Rakerkesda event recorded that stroke in Riau Province almost increased up to 2 times [9]. In 2019, based on the medical record report of Petala Bumi

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Hospital, Riau Province, ischemic stroke was ranked 3rd in the most non-communicable diseases after dengue fever and typhoid fever [10]. Based on the mass media, the development of ischemic stroke in the last five years in Riau Province is ranked 4th and from the results of an interview with one of the employees at Petala Bumi Hospital, it is stated that at the age of 18 there are already people affected by stroke.

The danger and increase in the percentage of ischemic stroke disease is a phenomenon that cannot be ignored, therefore to be able to reduce the increase in the incidence of ischemic stroke, it is necessary to know the factors that are assumed to affect the increase. These factors include factors that can be changed and cannot be changed, where factors that can be changed are hypertension status, diabetes mellitus status, hypercholesterol status, obesity, triglycerides, BMI, diet, and smoking habits, while factors that cannot be changed are gender and age [11][12]. From these assumed factors, an appropriate method is needed to determine the driving factors for the significant increase in the incidence of ischemic stroke where ischemic stroke is classified into two categories, namely thrombotic ischemic stroke and embolic ischemic stroke, so the method used is the binary logistic regression method. A statistical technique known as binary logistic regression is used to describe the relationship between a number of independent variables and dependent variables [13]. In this case, the dependent variable is dichotomous with two categories, namely 0 and 1. According to [14]. The independent variable in logistic regression does not have to be interval, the assumption of normality, multivariation, and homoscedasticity does not exist, and by predicting the odds of the logistic regression ratio can select the relationship between the independent and dependent variables.

Based on research [11] In 2022, regarding the factors influencing ischemic stroke cases in Southeast Sulawesi province using binary logistic regression, the results showed that factors or variables of hypertension and BMI status have an effect on ischemic stroke cases. Further research by [15] In 2018, the risk factors for stroke in hospitals showed that gender and food are risk factors for stroke. Next by [16] in 2019 regarding the description of risk factors and risk levels of ischemic stroke based on the stroke risk scorecard at Klungkung Hospital showed that BMI, blood pressure, smoking history, diabetes history, and cholesterol levels were at risk for the occurrence of ischemic stroke. Further research [17] In 2021, regarding the relationship between age group and stroke by taking into account BMI and glucose levels, the results of the study were obtained that there was a correlation between the elderly group and stroke disease, where the elderly group had a greater chance of developing ischemic stroke compared to the productive age group. In the research [18] Regarding the relationship between metabolic syndrome and stroke incidence, the results showed a significant relationship between the first criterion metabolic syndrome (abdominal obesity, triglyceride levels, and cholesterol levels with stroke incidence. Further research by [19] In 2022, regarding the proportion of central obesity and stroke by province in Indonesia, in 2018 there was a correlation between the proportion of central obesity and stroke. Based on the description above, we are interested in studying what factors have a significant influence on ischemic stroke at Petala Bumi Hospital, Riau Province using a binary logistic regression model.

2. METHOD

The bound variable used as the object in this study is ischemic stroke which is categorized into thrombotic ischemic stroke ($y = 0$) and embolic ischemic stroke ($y = 1$)[12]. The independent variables studied were age, gender, hypertension status, diabetes mellitus status, hypercholesterol status, obesity, triglycerides, BMI, diet, and smoking habits. The data was obtained from the medical records of the Petala Bumi Hospital, Riau Province. The age variable is categorized into two, namely under 55 years old and over 55 years old [20][21], gender variables are categorized into female and male [22][23], hypertension status variables are categorized into non-hypertension and hypertension [24][25], the diabetes mellitus status variables are categorized into low diabetes mellitus and high diabetes mellitus [26][27], hypercholesterol status variables are categorized into non-hypercholesterol and hypercholesterol [12][28], obesity variables are categorized into non-obesity and obesity [29][30], triglyceride variables are categorized into low triglycerides and high triglycerides [12][31][32], BMI variables are categorized into underweight and overweight [12][33], dietary variables are categorized into healthy eating patterns and unhealthy eating patterns [34], and the smoking habit variables were categorized into non-smoking and smoking [35][36]. The analysis method used in this study is Binary Logistic Regression.

2.1. Binary logistic regression

Binary logistic regression is a division of the Logistic Regression method, where the dependent variable is dichotomous. This method is used to determine the pattern of relationships between polychotomy independent variables and dichotomous dependent variables [37]. The outcome of the failure event is represented by the dependent variable ($y = 0$) and the outcome of the success event is represented by the dependent variable ($y = 1$), where the dependent variable (y) follows the Bernoulli distribution. The Bernoulli distribution is a distribution that only has two categories on its random variables, for example success or failure, yes or no, and others[11].

The specific forms of the binary logistic regression model are as follows:

$$\pi(x_i) = \frac{e^{(\beta_0 + \beta_1 x_1 + \beta_2 x_2 + \dots + \beta_j x_j)}}{1 + e^{(\beta_0 + \beta_1 x_1 + \beta_2 x_2 + \dots + \beta_j x_j)}} \quad (1)$$

According to [37] The logical form of Equation (1) is as follows:

$$g(x_i) = \ln \left(\frac{\pi(x)}{1 - \pi(x)} \right) = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \dots + \beta_j x_j \quad (2)$$

In logistic regression to obtain possible parameters of a model is carried out using the *Maximum Likelihood Estimation* (MLE) [38]. After the parameters are obtained, it is carried out significant testing of parameters to obtain results on whether the parameters of the model affect the bound variables and to obtain results on how much each parameter affects the model [38]. Parameter significance testing is carried out using simultaneous testing using the Likelihood Ratio Test and Partial testing using the Wald test. Furthermore, to find out whether the resulting logistic regression model is feasible or not, a model fit test is carried out [39]. In the logistic regression model, the interpretation of the model is carried out by looking at the results *Odds Ratio* (OR). OR is a comparison of the probability of an event occurring with the probability of not occurring an event [39]. To ensure that the data has been classified correctly or not, it is necessary to carry out the accuracy of the classification of the model using the classification accuracy table. According to [40] The classification precision table is a two-way frequency table between the actual and predicted data groups. According to [41] The classification procedure used in logistic regression is *Apparent Error Rate* (APER). The APER value states the proportion of samples that are incorrectly classified by the classification function, So that according to [42] To obtain the classification accuracy value, 1-APER can be used

Table 1. Descriptive Research Data

Stroke Ischemic				
Variable		Stroke Ischemic		Total
		Thrombotic	Embolic	
Age	< 55 Years	21	3	24
	≥ 55 years	41	35	76
Total		62	38	100
Gender	Woman	25	9	34
	Man	37	29	66
Total		62	38	100
Hypertension Status	No Hypertension	18	16	34
	Hypertension	44	22	66
Total		62	38	100
Status Diabetes Melitus	Low Diabetes Mellitus	51	21	72
	High Diabetes Mellitus	11	17	28
Total		62	38	100
Status Hipercholesterol	No Hypercholesterol	50	22	72
	Hiper cholesterol	12	16	28
Total		62	38	100
Obesity	No Obesity	54	26	80
	Obesity	8	12	20
Total		62	38	100
Triglycerides	Low Triglycerides	49	21	70
	High Triglycerides	13	17	30
Total		62	38	100
Body Mass Index	Underweight	43	21	64
	Excess Weight	19	17	36
Total		62	38	100
Diet	Healthy Diet	43	20	63
	Unhealthy Diet	19	18	37
Total		62	38	100

Smoking Habits	No Smoking	34	18	52
	Smoke	28	20	48
Total		62	38	100

3. RESULTS AND DISCUSSION

This research was conducted at Petala Bumi Hospital, Riau Province by taking secondary data from the results of the patient's medical records. The data used is ischemic stroke data as a dependent variable with thrombotic ischemic stroke ($y = 0$) and embolic ischemic stroke ($y = 1$). The independent variables observed were age (x_1), sex (x_2), hypertension (x_3), diabetes mellitus (x_4), hypercholesterol (x_5), obesity (x_6), triglycerides (x_7), body mass index (x_8), diet (x_9), and smoking habits. (x_{10}). The sample in this study was 100 patients, of the 100 patients there were 38 patients diagnosed as embolic ischemic stroke and 62 patients diagnosed as thrombotic ischemic stroke. For a description of each independent variable can be seen in the Table 1.

Table 2. Parameter Estimation Results

Variable	β	S.E	df	Mr.
x_1	2,040	0,737	1	0,006
x_2	-0,244	0,875	1	0,781
x_3	-1,575	0,762	1	0,039
x_4	0,406	0,770	1	0,598
x_5	0,175	0,787	1	0,824
x_6	0,963	0,996	1	0,333
x_7	0,690	0,592	1	0,243
x_8	-0,144	0,947	1	0,879
x_9	0,678	0,958	1	0,479
x_{10}	0,210	0,810	1	0,795
constans	-1,843	0,828	1	0,026

The first step in the analysis process using the binary logistic regression method is to find the estimated value of the parameter ($\beta_0, \beta_1, \dots, \beta_{10}$) significant to obtain the best model [38], by looking at significant values. If the value of the sig is concerned, the related independent variable can be said to have an effect on the dependent variable that is used as the object of research. Parameter estimates of ten independent variables ($\beta_0, \beta_1, \dots, \beta_{10}$) presented in Table 2:

Table 3. Partial Test Results

Variable	β	S.E	Forest	df	Mr.
x_1	2,040	0,737	7,667	1	0,006
x_2	-0,244	0,875	0,078	1	0,781
x_3	-1,575	0,762	4,270	1	0,039
x_4	0,406	0,770	0,277	1	0,598
x_5	0,175	0,787	0,049	1	0,824
x_6	0,963	0,996	0,935	1	0,333
x_7	0,690	0,592	1,361	1	0,243
x_8	-0,144	0,947	0,023	1	0,879
x_9	0,678	0,958	0,500	1	0,479

x_{10}	0,210	0,810	0,067	1	0,795
constans	-1,843	0,828	4,953	1	0,026

From Table 2 above, it can be seen that there are two independent variables that are significant to ischemic stroke, namely age variable (x_1) and hypertension status (x_3) with parameters $\beta_0 = -1,843$, $\beta_1 = 2,040$, and $\beta_3 = -1,575$. Furthermore, a parameter significance test was carried out, namely simultaneous test and partial test, from the results of the Likelihood Ratio Test analysis, the values of $L_0 = 132,813$ and $L_1 = 105,350$ were obtained where the Likelihood Ratio Test statistics were distributed chisquare so that the difference between $L_0 = 132,813$ and $L_1 = 105,350$ is the calculated chisquare value, then the value of $X^2 Count = 27,463$ and the value of $X^2 tab (0,05; 10) = 18,307$. The value of $X^2 Count = 27,463 > X^2 tab (0,05; 10) = 18,307$, then the decision that can be taken is to reject H_0 , which means that overall the independent variables have an effect on the dependent variable. Similar to the simultaneous test, the test statistic used in the partial test is the Wald test. Table 3 below shows the results of the Wald test for each independent variable.

Based on Table 3 above, with $\alpha = 0,05$, $df=1$, the value of $X^2 table = 3,841$ is obtained. The results of the Wald test on variables $x_1 = 7,667$ and $x_3 = 4,270 >$ the value of $X^2 table = 3,841$, while the variables $x_2, x_4, x_5, x_6, x_7, x_8, x_9, x_{10} <$ the value of $X^2 table$, so it was decided to reject H_0 , which means that the variables age (x_1) and hypertension status (x_3) have a significant effect on ischemic stroke, from the results of the test above a binary logistic regression model will be formed. The coefficient values of the two variables are table 4:

Table 4. Parameter Coefficient

Variable	β
x_1	2,040
x_3	-1,575
Constans	-1,843

Based on Table 4, the binary logistic regression model is obtained as follows:

$$g(x) = -1,843 + 2,040x_1 - 1,575x_3 \quad (3)$$

After the model is formed, then a model fit test is carried out using *Goodness of Fit test statistics*, the results of the model fit test can be seen in the table below:

Table 5. Model Fit Test Results

\hat{C}	Chi-square	df	Mr.
0,1778	9,473	7	0,220

From Table 5, the value of $\hat{C} = 0,1778$ and the value of $X^2 table = 9,473$, which means that the value of $\hat{C} = 0,1778 <$ the value of $X^2 table = 9,473$, so the decision taken for this test is to accept H_0 which means there is no difference between the results of observations and predictions or it can be said that the model formed is appropriate and suitable for use. Next, interpret the parameter coefficients of each independent variable that influences the odds ratio value obtained on the age variable (x_1) and the hypertension status variable (x_3). Table 6 is the result of the odds ratio value of the age and hypertension status variables:

Tabel. 6 Hasil *Odd Ratio* (OR)

Variable	β	XP (β)
x_1	2,040	7,688
x_3	-1,575	0,207

The OR value of the age variable is 7.688 which means that ischemic stroke patients who are over 55 years old have a greater chance of experiencing an embolic ischemic stroke. The OR value of the hypertension status variable is 0.207, which means that ischemic stroke patients who have hypertension status (high blood pressure) are less likely to experience an embolic ischemic stroke. The final stage of the binary logistic regression method is to perform classification accuracy. The percentage of classification accuracy is the relationship between the number of observations correctly classified by the model and the total number of observations. Table 7 is the result of classification accuracy. By [41] from Table 7, the classification error value

was obtained of 26% and from [42], obtained a classification accuracy value of 74%, so it can be said that the binary logistic regression model formed is quite good.

Table 7. Classification Accuracy Results

Current	Predictions	
	$\hat{y} = 0$	$\hat{y} = 1$
$y = 0$	53	9
$y = 1$	17	21

4. DISCUSSION

Ischemic stroke is a type of stroke that is often experienced in the form of nervous system dysfunction that occurs suddenly and lasts quickly due to an obstruction of blood supply to the brain [4]. This is of course influenced by several factors, both modifiable factors and genetic factors. In this study, the factors observed were age, gender, hypertension status, diabetes mellitus status, hypercholesterol status, obesity, triglycerides, body mass index, diet, and smoking habits. Based on the results of the analysis conducted using the binary logistic regression method, two factors were obtained that significantly affected ischemic stroke, namely age factor and hypertension status.

The results of this study are in line with the research [11] in 2022 with the title of the study, namely Factors Affecting Ischemic Stroke Cases in Southeast Sulawesi Province Using Binary Logistic Regression which showed the results that hypertension status factors affect ischemic stroke, then research [16] in 2019 with the title of the study, namely an overview of risk factors and risk levels of ischemic stroke based on stroke *risk scorecard* at Klungkung Hospital which obtained results that blood pressure (tension) is at risk of ischemic stroke. Further research [17] In 2021, with the title of the study, namely the relationship between age groups and stroke by taking into account BMI and glucose levels, the results of the study showed that there was a correlation between the elderly group and stroke disease, where the elderly group had a greater chance of developing ischemic stroke compared to the productive age group

5. CONCLUSION

The results of the analysis carried out on parameter testing involving simultaneous tests (using the likelihood ratio test) and partial tests (Wald Test) are factors that significantly influence ischemic stroke disease at Petala Bumi Hospital, Riau Province, namely age factors and hypertension status. The binary logistic regression model generated from Ischemic Stroke Disease data at Petala Bumi Hospital, Riau Province is $g(x) = -1,843 + 2,040x_1 - 1,575x_3$ with a classification accuracy of 74% and the rest is influenced by other factors. This means that the binary logistic regression model formed is good for providing a classification of ischemic stroke disease in the thrombotic or embolic category.

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