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BINARY LOGISTICS REGRESSION MODEL TO IDENTIFY FACTORS ASSOCIATED WITH LOW BIRTH WEIGHT (LBW) (CASE STUDY: BABY DATA AT DR. M. HAULUSSY HOSPITAL AMBON)

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Abstract. Low birth weight (LBW) is one of the risk factors for increasing baby mortality. LBW is characterized by a baby's birth weight of fewer than 2500 grams which is weighed within the first hour after birth. The case of LBW is of special concern because it can have a serious impact on the quality of future generations, which will slow down the growth and development of children and affect the decline in intelligence. In this study, identification was carried out to determine the factors that influence the status of BBL in RSUD Dr. M. Haulussy Ambon in 2020, the data used in this study is medical record data from RSUD Dr. M. Haulussy Ambon in 2020 with a total sample of 183 respondents with predictor variables covering nine variables and one response variable. The analysis used is a binary logistic regression method with the response variables of BBL status which are categorized as normal and low. The results of this study obtained a binary logistic regression model in which the factors that influence the case of low birth weight are maternal gestational age $(X_4)$and parity $(X_5)$with a classification accuracy of 91.8.

Keywords: *Binary Logistic Regression Analysis, Low birth weight (LBW), Factors of LBW.*

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1. INTRODUCTION

The problem of the occurrence of low birth weight (LBW) is considered an indicator of public health because it is closely related to mortality, morbidity, and the occurrence of malnutrition in the future. [**1**]LBW is a baby's weight at birth which is less than 2,500 grams where weight measurement is carried out within a period of 1 hour after birth regardless of gestational age (37 to 42 weeks of gestation) [**2**] [**3**] [**4**]. The term premature baby has been changed by the World Health Organization (WHO) to low birth weight. In addition to changing terms, WHO also changed the criteria for LBW from ≤ 2.500 grams to <2,500 grams [**5**].

According to data from the World Health Organization, the prevalence of LBW in the world is 20 million, or about 15.5% of babies born each year, and developing countries are the biggest contributors, which is around 96.5% [**6**]. Indonesia is one of the developing countries that ranks third as a country with a high prevalence of LBW (11.1%), after India (27.6%) and South Africa (13.2%). In addition, Indonesia is also the second country with the highest prevalence of LBW among other ASEAN countries, after the Philippines (21.2 %) [**7**].

Several things affect LBW, including if the mother's gestational age is less than normal, it will cause stunted fetal growth and will affect the birth weight of the baby. The younger the gestational age, the less likely the baby is to live because babies with low birth weight will experience complications due to imperfections in their organs due to gestational age being too young. Another risk factor, namely high parity will have an impact on the emergence of various health problems for both mother and baby due to a high frequency of pregnancy, in addition to relaxing the uterine muscles, it can also cause problems in the baby's placenta as the barrier of the blood circulation system is disrupted so that fetal development is hampered [**8**]. The results of research conducted by Nadhifah and colleagues about the factors that affect LBW with a logistic regression analysis model at the Semarang City Hospital show that from the five variables two variables influenced birth weight (BW) in Semarang City Hospital, namely age and Hb level [**9**].

Research using binary logistic regression conducted by Muiminah and Sri on the stratified binary logistic regression model on women's economic participation in East Java province concluded that there are 3 significant variables, namely marital status, family status, and education [**10**]. Ernawati conducted a study using binary logistic regression analysis to predict visitor satisfaction at the Majene regional general hospital and got a significant variable on patient satisfaction, namely the tangibles variable with a regression coefficient value of 0.367 or 36.7% and the empathy variable with a regression coefficient value of 0.403 or 40.3% [**11**].

The occurrence of LBW is based on research collected by the Maluku Provincial Health Office in 2014, it is obtained that the percentage of children under five (0-59 months) with LBW was 1.6% (292 babies), the highest percentage of LBW was in the Aru Islands at 3.2%, countably 31 LBW babies from 967 babies who were weighed at birth, the percentage of LBW in Ambon city was 2% and the lowest was in South Buru district at 0.3%, namely 4 babies out of 1211 babies who were weighed at birth [**12**]. Babies born with LBW will experience the occurrence of neonatal death 18 times higher than babies who did not experience LBW. This is because the organs of the baby who is born have not functioned perfectly to be able to live outside the mother's uterus [**13**]. The number of neonatal deaths in Maluku Province is 79 cases in 2017, 87 cases in 2018, and 22 cases in the January-April 2019 period [**14**]. Based on the results of research conducted by Magdalena Paunno in the period November-December 2019, there are 51 cases, namely, 16 cases of neonatal deaths at Dr.M. Hospital. Haulussy Ambon is caused by LBW (31.4%), 15 cases of Asphyxia (29.4%), 14 cases of Sepsis (27.5 %), and 4 cases of respiratory disorders (7.8%), and 2 cases of Atresia ani (3.9%). Therefore, it can be seen that LBW is the highest factor in baby neonatal mortality in 2019 [**15**]. LBW is a public health problem because it is one of the causes of the high baby mortality rate [**16**].

To overcome this condition, the Ambon City government has sought health development to reduce the occurrence of babies with LBW by providing quality, equitable and affordable health services and providing education through the MCH program, integrated management of easy babies (MTBM), 4T KIE and posyandu services. However, based on the data, the number of occurrences of LBW continues to increase and there is still a lack of knowledge and skills among mothers [**17**].

So, in this study, a study was conducted on the factors that were assumed to affect the status of birth weight (BW) in the city of Ambon. The case study used in this research is birth weight in RSUD Dr. M. Haulussy Ambon which is the largest hospital in Ambon city and a referral center. The analytical method used is binary logistic regression, where the response variable is normal and low birth weight status with the predictor variables used including nine variables that are thought to affect birth weight status, namely maternal age at delivery, mother's employment status, last education completed. mother, gestational age at delivery, gestational interval, type of delivery, delivery complications, Hb levels, and parity. Binary logistic regression was used to determine the relationship pattern of BBL in RSUD Dr. M. Haulussy Ambon with the factors that influence it.

2. RESEARCH METHODS

In this study, the data that will be used are data on newborns and the factors that influence LBW, which are secondary data from RSUD Dr. M. Haulussy Ambon in 2020. The total population in this study is 305 babies using the error limit or standard error of 0.05. The sampling method in this study will use the Non Probability Sampling method. Non-probability sampling is a sampling technique that does not provide equal opportunities/opportunities for each element or member of the population to be selected as a sample [**18**]. So, to find out the research sample calculations are done using the Slovin method as follows:

$$n = \frac{N}{(1+N.e^2)}$$

$$= \frac{305}{(1 + 305.\,0{,}05^2)}$$

$$= 173{,}04965$$
$$\approx 174$$

Based on the sample calculation above, the minimum number of samples (*n)* is 174 babies, so in this study several *n* samples can be added. In this study, the sample (*n)* that will be used is 183 babies.

Table 1. Research Variables

variable	Information	Category	Operational Definition	Scale
Y	Birth Weight Status (BW)	0 : normal	baby's weight at birth is more than equal to 2500 grams	Nominal
		1: low	baby weight at birth less than 2500 grams	
X_1	Mother's Age at Childbirth	1 : < 20 yrs	Maternal age at delivery less than 20 years	Ordinal
		2: 20 – 35 years old	the age of the mother at the time of delivery is between 20-35 years	
		3: > 35 yrs old	The mother's age at delivery is more than 35 years	
X_2	Mother's Employment Status	1: Not Working	during pregnancy, the mother does not work or do strenuous activities	Nominal
		2: Work	during pregnancy, the mother has a job	
X_3	Mother's Last Education	1: SD	The mother's last formal education level is SD	Ordinal
		2: Middle School	The mother's last formal education level is a junior high school	
		3: high school	The mother's last formal education level is a high school	
		4: PT	Mother's last formal education level is a university	
X_4	Gestational Age at Childbirth	1: <37 weeks	Gestational age is calculated from the first day of the last menstrual period (LMP) to the time of delivery more than equal to 37 weeks	Nominal
		2: ≥37 weeks	Gestational age is calculated from the first day of the last menstrual period (LMP) to the time of delivery more than equal to 37 weeks	
X_5	Pregnancy Distance	1: none	first childbirth	Nominal
		2: ≤2 years	the distance between the first pregnancy and the next pregnancy is equal to two years	

variable	Information	Category	Operational Definition	Scale
		3: >2 years	the distance between the first pregnancy and the next pregnancy is more than two years	
X_6	Type of Delivery	1: normal	Vaginal delivery without the use of certain tools	Nominal
		2: not normal	The process of giving birth through surgery and using certain aids	
X_7	Pregnancy Complications	1: No 2: Yes	no infection during pregnancy experiencing infections during pregnancy such as the threat of premature labor, dengue fever, malaria, and so on	Nominal
X_8	Hb. level	1: normal 2: anemia	Hb level more than equal to 11 g% Hb level less than 11 g%	Nominal
X_9	Parity	1:< 4 kids	the number of children who have been born to the mother, both live and stillborn, is less than four	Nominal
		2: ≥4 kids	the number of children who have been born to mothers, both live births and stillbirths, is more than equal to four	

The stages in this research are as follows:

1. This study began by taking data obtained from the results of patient medical records in 2020 that had received permission from the RSUD. Dr. M. Haulussy Ambon
2. Describing the characteristics of the LBW response variables and their predictor variables and presenting the data in descriptive statistics
3. Estimating parameters on the factors that affect the status of birth weight (BW) in Dr. RSUD. M. Haulussy Ambon
4. Conducting Simultaneous Tests to find out whether the predictor variables together have a significant effect on the response variable (if a decision is obtained to reject H_0then proceed to step 4 if it fails to reject H_0 then return to step 1 to take a new variable)
5. Conducting a Partial Test to find out which predictor variables have a significant effect on the response variable
6. Conducting Model Fitment Test to find out whether the model in the data on birth weight status (BW) at RSUD Dr. M. Haulussy Ambon is appropriate or not
7. Interpreting the Binary Logistics Regression Model (Odds Ratio*)*
8. Calculating the magnitude of classification accuracy
9. Concluding and providing suggestions from the research results obtained.

3. RESULTS AND DISCUSSION

3.1 Description of Low Birth Weight (LBW) Status

Descriptive analysis was conducted to provide a general description of the factors that influence LBW in RSUD Dr. M. Haulussy Ambon. The descriptive status of low birth weight (LBW) in RSUD Dr. M. Haulussy Ambon is described by a *pie chart* as follows.

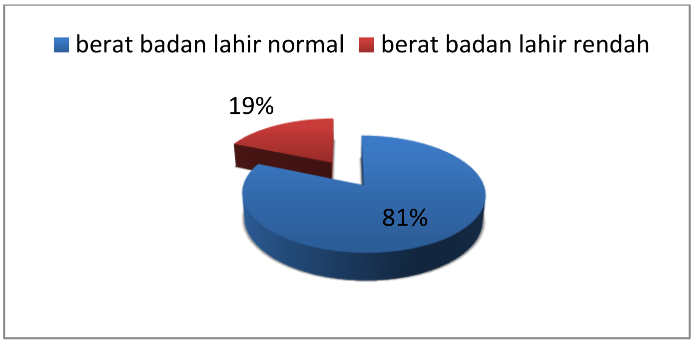

Figure 1. The proportion of Birth Weight

In the study, it was found that 81% of babies from 183 samples of babies taken were classified as having normal weight, meaning that 81% of babies had a birth weight of more than 2500 grams. While the other 19% of babies were classified as low, meaning that 19% of the babies weighed less than or equal to 2500 grams. This condition requires the identification of the factors that affect the status of birth weight (BBL).

The characteristics of the explanatory variables in this study include: maternal age at delivery, mother's employment status, mother's latest education, gestational age at delivery, gestational age, type of delivery, pregnancy complications, HB levels, and parity, in full are shown in Table 2, below:

Table 2. Cross-tabulation of Maternal Characteristics with Birth Weight Status

Mother Characteristics	Birth Weight Status					
	Normal		Low		Amount	
	N	%	N	%	N	%
Mother's Age at Childbirth (X_1)						
20 years	3	42.9	4	57.1	7	100
20 – 35 years	122	84.7	22	15.3	144	100
>35 years old	24	75	8	25	32	100
Mother's Employment Status (X_2)						
Not working	100	80	25	20	125	100
Working	49	84.5	9	15.5	58	100
Mother's Last Education (X_3)						
Elementary School	1	33.3	2	66.7	3	100
Junior High School	2	50	2	50	4	100
Senior High School	89	83.2	18	16.8	107	100
College	57	82.6	12	17.4	69	100
Gestational Age at Childbirth (X_4)						
<37 weeks	8	24.2	25	75.8	33	100
≥37 weeks	141	94	9	6	150	100
Pregnancy Distance (X_5)						
None	63	77.8	18	22.2	81	100
≤2 years	29	80.6	7	19.4	36	100
>2 years	57	86.4	9	13.6	66	100
Type of Labor (X_6)						
Normal	52	83.9	10	16.1	62	100
Abnormal	97	80.2	24	19.8	121	100
Pregnancy Complications (X_7)						
None	82	80.4	20	19.6	102	100
Exist	67	82.7	14	17.3	34	100

Mother Characteristics	Birth Weight Status					
	Normal		Low		Amount	
	N	%	N	%	N	%
HB level(X_8)						
Normal	79	84	15	16	94	100
Anemia	70	78.7	19	21.3	89	100
parity(X_9)						
<4 children	141	81	33	19	174	100
≥4 children	8	88.9	1	11.1	9	100

Table 2 shows that in general, the majority of babies born with low body weight occur to mothers aged 20-35 years, with the work status of not working, the last education completed of high school, gestational age of fewer than 37 weeks, gestational age of zero or giving birth to their first child., the type of delivery of abnormal, did not experience pregnancy complications, low Hb level or could be said to have anemia and parity of fewer than four children.

3.2 Model Parameter Significance Test

The parameter estimation test is used to determine whether there is an effect between the response variable (Y) and the predictor variable (X) [**19**]. The parameter estimation test consists of two parts, namely simultaneously and partially.

3.2.1 Simultaneous Parameter Significance Test

Testing the significance of the parameters simultaneously using the Likelihood Ratio Test.

The hypothesis used is as follows.
$H_0: \beta_1 = \beta_2 = \cdots = \beta_9 = 0$(all variables are not significant to birth weight)
H_1:one $\beta_j \neq 0$(at least one significant variable on birth weight) with $j = 1,2,..,9$.

Table 3. Parameter Estimation Simultaneously with All Variables

Chi-square	$\chi^2_{(0,05,13)}$	**P-value**
94.704	22,362	0.000

Based on Table 3 above, it is obtained the test statistic $G = 94{,}704 > \chi^2_{(0,05,13)} = 22{,}362$value and p-value = 0.000 by using α of 5%, the decision to reject $H_0$and accept H_1shows that there is at least one significant variable simultaneously affecting birth weight status (BW). Thus, a partial parameter test was conducted to determine which predictor variables had a significant effect on BW status.

3.2.2 Parameter Significance Test Partially

The test statistic used by the partial test is the Wald test. The hypothesis used is as follows.
$H_0: \beta_J = 0$, with $j = 1,2, \ldots 9$(jth predictor variable not significant for birth weight)
$H_1: \beta_j \neq 0$, with $j = 1,2, \ldots 9$(at least one significant predictor variable of birth weight).

Table 4. Partial Parameter Estimation with All Variables

Variable	B	SE	Wald	Sig.	Exp(B)
Maternal age at delivery (X_1)(1)	0.997	1,595	0.391	0.532	2,711
Maternal age at delivery (X_1)(2)	-1,225	0.841	2,121	0.145	0.294
Mother's Employment Status (X_2)(1)	-0.416	0.802	0.269	0.604	0.660
Mother's last completed education (X_3)(1)	3,372	1,679	4,034	0.045	29,140
Mother's last completed education (X_3)(2)	1,681	1,751	0.922	0.337	5,369

Variable	B	SE	Wald	Sig.	Exp(B)
Mother's last completed education $(X_3)(3)$	-0,672	0.784	0.734	0.392	0.511
Gestational age at delivery $(X_4)(1)$	4,993	0.761	43,036	0.000	147.392
Pregnancy spacing $(X_5)(1)$	0.966	0.780	1.535	0.215	2,628
Pregnancy spacing $(X_5)(2)$	1.398	0.909	2,362	0.124	4.045
Type of delivery$(X_6)(1)$	0.724	0.716	1.023	0.312	2.062
Pregnancy complications $(X_7)(1)$	-0.092	0.639	0.021	0.886	0.912
Hb Level $(X_8)(1)$	-0.835	0.653	1,632	0.201	0.434
parity $(X_9)(1)$	5,804	2,174	7,128	0.008	331,619
Constant	-7,919	2,365	11.209	0.001	0.000

Based on Table 4, shows that by using α5%, it can be concluded that the variable maternal gestational age at delivery $(X_4)$and parity (X_9)individually significantly affect birth weight because it has a p-value of less than 0.05. The binary logistic regression model for the factors that affect birth weight by involving all predictor variables are:

$$\pi(X)$$

$$= \frac{\exp(-7{,}919 + 0{,}997X_1(1) - 1{,}225X_1(2) - 0{,}416X_2(1) + 3{,}372X_3(1) + 1{,}681X_3(2) - 0{,}672X_3(3) +}{1 + \exp\,(-7{,}919 + 0{,}997X_1(1) - 1{,}225X_1(2) - 0{,}416X_2(1) + 3{,}372X_3(1) + 1{,}681X_3(2) - 0{,}672X_3(3) +}$$

$$\frac{4{,}993X_4(1) + 0{,}966X_5(1) + 1{,}398X_5(2) + 0{,}724X_6(1) - 0{,}092X_7(1) - 0{,}835X_8(1) + 5{,}804X_9(1))}{4{,}993X_4(1) + 0{,}966X_5(1) + 1{,}398X_5(2) + 0{,}724X_6(1) - 0{,}092X_7(1) - 0{,}835X_8(1) + 5{,}804X_9(1))}$$

3.2.3 Simultaneously Test the Significance of Parameters Significant Variables

After knowing the significant variables, the analysis is carried out again by entering only the significant variables, so it is necessary to test the parameter estimates again. The following hypothesis is used.
H_0: $\beta_4 = \beta_9 = 0$(variables of maternal gestational age at delivery and parity are not significant to BW status)
H_1:there is at least one $\beta_j \neq 0$(there is at least one variable between the variable of maternal gestational age at delivery and significant parity with BW status) with j = 4 and 9

Table 5. Simultaneous Estimation of Parameters with significant variables

Chi-square	$\chi^2_{(0,05,2)}$	P-value
77.037	5,991	0.000

Based on the test results in Table 5, the conclusion is to reject H_0 because $G = 77{,}037 > \chi^2{}_{(a,df)} = 5{,}991$. This shows that there is one value variable between the variable of maternal gestational age at delivery and parity which is significant to BBL status.

3.2.4 Parameter Significance Test Partially Significant Variables

Subsequently, a partial parameter test was conducted to determine which independent variables had a significant effect on BBL status. The hypothesis used is as follows
H_0 : $\beta_4 = 0$(variable gestational age at delivery is not significant to birth weight status)
H_1: $\beta_4 \neq 0$(variable gestational age at delivery is significant to birth weight status)
H_0 : $\beta_9 = 0$(parity variable is not significant to birth weight status)
H_1: $\beta_9 \neq 0$(significant parity variable on birth weight status)
The results of the partial parameter significance test are shown in the table below.

Table 6. Partial Parameter Estimation with significant variables

Variable	B	SE	Wald	Sig.	Exp(B)
Gestational age at delivery $(X_4)(1)$	4,292	0.599	51,386	0.000	73.112
parity $(X_9)(1)$	2,702	1.242	4,735	0.030	14,912
Constant	-5,420	1,286	17,778	0.000	0.004

Based on Table 6 above, it can be seen that by using α of 5%, it can be concluded that the variable gestational age at delivery $(X_4)$and parity (X_5)significantly affect the baby's weight because the p-value is less than 0.05. So that the binary logistic regression model is as follows:

$$\pi(X)=\frac{exp(-5,420+4,292X_4+2,702X_9)}{1+exp(-5,420+4,292X_4+2,702X_9)}$$

Table 7. ***Model Summary***

Step	-2 Logs likelihood	Cox & Snell R Square	Nagelkerke R Square
1	98,666 [a]	0.344	0.557

Based on Table 7, shows how much the predictor variable affects the response variable. According to test *Cox* and *Snell*R^2, it was found that the predictor variable affected the response variable by 34.4% while according to the *Nagelkerke test* R^2 it was found that the predictor variable affected the response variable by 55.7%.

3.3 Model Fit Test

The suitability test of this model was carried out using the *Hosmer-Lemeshow test.* The hypothesis used is as follows.

H_0 : The model fits (there is no significant difference between the observed results and the possible predictions of the model)

H_1: The model does not fit (there is a significant difference between the observed results and the possible predictions of the model)

Table 8. Results of the *Hosmer-Lemeshow Test*

$\hat{C}$	df	$X^2{}_{(0,05,4)}$	Sig.
0.023	2	5,991	0.989

Table 8 shows that the results of the model suitability test obtained a *p-value* of more than 0.05, which is 0.989, and a value $\hat{C}=0{,}023<X^2{}_{(0,05,2)}$so that it can be decided to fail H_0, which means there is no difference between the results of observations and the results of the predictions of the model, in other words, the model is suitable.

3.4 Binary Logistics Regression Model Interpretation (Odds Ratio)

The logit model that is formed from significant variables and becomes the best model is as follows.

$$g(x)=-5,420+4,292X_4+2,702X_9$$

The probability of a baby being born with a low birth weight based on the last education level completed by the mother with a gestational age of less than 37 weeks and the number of deliveries (parity) that the mother has done is as follows.

$$\pi(x)=\frac{e^{g(x)}}{1+e^{g(x)}}$$

$$\pi(x)=\frac{e^{(-5,420+4,292X_4+2,702X_9)}}{1+e^{(-5,420+4,292X_4+2,702X_9)}}$$

$$=\frac{e^{(-5,420+4,292X_4+2,702X_9)}}{1+e^{(-5,420+4,292X_4+2,702X_9)}}$$

$$=\frac{4,82591}{1+4,82591}$$

$$=0,828353$$

To interpret the model, the *Odds Ratio value can be used.* The *Odds Ratio value* is obtained from Table 6, which is then explained as follows:

1. The value of Exp(B) on the variable of maternal gestational age at delivery $X_4$is 73,112, which means that mothers who have a gestational age calculated from the first day of menstruation to the time of

delivery which is less than 37 weeks are more at risk of giving birth to babies with LBW who are 73,112 times higher than mothers who have low birth weight. have a gestational age of more than equal to 37 weeks. The value of the beta coefficient (B) shows a positive value, which means that the mother's gestational age at delivery has a positive relationship to LBW.

2. The value of Exp(B) on the parity variable $X_9$is 14,912, which means that mothers who have many children born both live and stillborn with less than four children are more at risk of giving birth to babies with low birth weight by 14,912 when compared to mothers who have more than the same number of children. with four. The value of the beta coefficient (B) shows the value positive means that the number of maternal deliveries (parity) has a positive relationship to LBW.

3.5 Model Classification Accuracy

The determination of classification accuracy uses the apparent error rate (APER) value, which means that this value represents the value of the proportion of sample values that are misclassified by the classification function [**20**].

Table 9. Model Classification Accuracy

Observation	Estimate		
	Baby Weight		Classification Accuracy
Baby Weight	Normal	Low	
Normal	144	5	96.6%
Low	10	24	70.6%
	Overall Percentage		91.8%

The following is the calculation of the *apparent error rate* (APER)

$$\text{APER}(\%) = \frac{n_{12}+n_{21}}{n_{11}+n_{12}+n_{21}+n_{22}}$$

Classification Accuracy =100% - APER(%)

$$\text{APER} = \frac{5+10}{144+5+10+24} = 0{,}0819672$$
$$= 8{,}19672\%$$
$$\approx 8{,}2\%$$

$$\text{Classification Accuracy} = 100\% - 8{,}2\%$$
$$= 91{,}8\%$$

Table 9 shows that from 149 babies with normal weight, 144 babies were classified correctly, namely with normal weight. While the other 5 babies were classified incorrectly, namely with low body weight. Meanwhile, of the 34 babies with low body weight, 24 were classified as correct, namely with low body weight, while the other 10 babies were classified incorrectly, namely with normal weight. So that we get a binary logistic regression model with an accuracy value of 91.8%.

4. CONCLUSION

From this study, a binary logistic regression model was obtained that was suitable for describing the status of low birth weight babies in Dr. Hospital. M. Haulussy Ambon is as follows:

$$\pi(x) = \frac{e^{(-5{,}420+4{,}292X_4+2{,}702X_9)}}{1 + e^{(-5{,}420+4{,}292X_4+2{,}702X_9)}}$$

And the factors that significantly influence low birth weight in RSUD Dr. M. Haulussy Ambon are the gestational age at delivery $(X_4)$and the number of maternal deliveries (parity) $(X_9)$with a classification accuracy of 91.8 percent.

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