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Modelling the Recovery of Malaria Patients in West Lombok District Using Cox Regression

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ABSTRACT

Malaria is one of the health problems in West Lombok Regency. There are 413 positive malaria cases, so it is necessary to research the models and factors affecting malaria sufferers' recovery. The analysis used is survival analysis using the Cox Proportional Hazard Regression method. The data used in this study is in the form of secondary data obtained from medical record data from all patients with malaria disease in West Lombok Regency from 2019 to 2020, with dependent variables in the form of recovery time of malaria patients and nine independent variables that are suspected of affecting the recovery of malaria sufferers. This study aims to determine a recovery model for malaria sufferers based on Cox regression and determine the factors that influence the recovery of malaria sufferers in West Lombok Regency. Based on the survival analysis results with the Cox Proportional hazard Regression method, the best model was obtained with two significant variables affecting the recovery time of malaria patients: the parasite type variable and the incidence of pregnancy or not getting pregnant. The model can be interpreted based on hazard ratio values that the variable type of parasite category *Plasmodium vivax* has a probability of being able to recover within one month of treatment by 2,542 times faster than *Plasmodium falciparum*. In comparison, the type of parasite in the *Plasmodium mix* category has a probability of being able to recover within one month of treatment 1.108 times faster than *Plasmodium vivax*, and for the pregnant or non-pregnant variables for the category of pregnant patients had a 2,307 times faster probability of recovery within one month of treatment compared to non-pregnant patients.

Keywords: Cox Proportional Hazard Regression, Hazard Ratio, Malaria, Survival Analysis.

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1. Introduction

Malaria is a disease caused by parasites, spread through the bites of mosquitoes infected with parasites, and can be deadly if not treated properly. Malaria is transmitted by Anopheles mosquitoes, which contain *Plasmodium* in their bodies. Malaria is still a health problem, especially in West Lombok District. Most positive malaria cases remain in coastal, mountainous, and plantation areas. In 2019, in West Lombok Regency, 413 positive malaria cases were detected. Based on a survey conducted by the West Lombok District Health Office in 2019, namely the number of cases in the work area of the *puskesmas* (community health centres), there were 413 positive cases of malaria, 25 positive cases of malaria at the Lingsar Health Center, 38 positive cases of malaria at the Sigerongan Health Center, 29 cases at the Health Center Gunungsari, 295 cases at the Penimbung Health Center and 24 cases at the Meninting Health Center. Therefore, examining the factors that influence the recovery rate of malaria sufferers in the West Lombok Regency is necessary. Survival analysis determines the factors affecting malaria sufferers' recovery rate (West Nusa Tenggara Provincial Health Office, 2019).

Survival analysis is a collection of statistical procedures for analyzing data whose final variable is the time until an event occurs. Events in resilience analysis can be death, disease recurrence, treatment or others. The purpose of robustness analysis is to determine the relationship between the time of the event and the explanatory variables that were measured when the research was conducted. In survival analysis, a regression model, namely proportional failure regression, is often used. Cox proportional failure regression, better known as Cox regression, determines the relationship between the dependent and independent variables. In proportional failure regression, no distribution assumptions are required. Failure in individuals from the first group and the other groups is assumed to be proportional to time (Gayatri, 2005; Kleinbaum and Klein, 2012; Rinni et al., 2014).

Several studies regarding Cox regression in medical science include research conducted by Rinni et al. (2014), explained that the factors that most influence the recovery rate of patients suffering from typhoid fever are age, where patients aged more than 15 years have a recovery rate 4,290 times that of patients aged less than 15 years, which means patients aged less than 15 years has a faster healing rate, meanwhile, in research conducted by Qomaria et al. (2019) on the survival case of stroke patients at Balung Hospital. The best model will be selected using backward elimination based on the smallest AIC value. This research was conducted to find out how gender, age, hypertension status, cholesterol status, diabetes mellitus status, type of stroke, and body mass index can influence the survival of stroke patients. Therefore, it can be concluded that the factors that influence the survival of stroke patients at RSD Balung are age, diabetes mellitus status, and type of stroke.

Based on previous studies, this research aims to determine a recovery model for malaria sufferers based on Cox regression and the factors that influence the recovery of malaria sufferers in West Lombok Regency. The study is expected to analyze the recovery rate of malaria sufferers, in this case, survival analysis with the Cox Proportional Hazard regression method, which provides the chance of recovery for each incident so that the likelihood of recovery for each malaria sufferer can be known.

2. Research Methods

Based on the data and results to be achieved, this research is a type of applied research using SPSS software. This study used secondary data from the Sigerongan Health Center and the Penimbung Health Center. This data is medical record data for patients with malaria in West Lombok Regency from 2019 to 2020 obtained from the Sigerongan Health Center and the Penimbung Health Center. The research variable used was the dependent variable, namely the recovery time of malaria patients (Y) and the independent variables, age (X_1), sex (X_2), type of parasite (X_3), DHP tablets (X_4), primaquine tablets (X_5), treatment (X_6), occupation (X_7), distance from the village to a health centre (X_8), and pregnant or not pregnant (X_9).

The data analysis steps carried out in this research are as follows.

1. Collecting data obtained from this research is data on the length of recovery time for patients suffering from malaria acquired from medical records at the Sigerongan Health Center and Penimbung Health Center in West Lombok Regency in 2019-2020.
2. Describing the characteristics of patients suffering from malaria based on survival time and factors that influence patient recovery.
3. Carrying out a test using the Kaplan Meier method to estimate the resilience function with Equation (Gayatri, 2005; Rinni et al., 2014):

$$\hat{S}(t) = \prod_{j=1}^{k} \left(\frac{n_j - m_j}{n_j} \right) \tag{2.1}$$

and failure function with Equation:

$$\hat{h}(t) = \frac{m_j}{n_j \tau_j} \quad (2.2)$$

Time interval,

$$t_k \leq t < t_{(k+1)},\ k = 1,2,\ldots,r$$

for estimating the survival function and time interval,

$$t_{(j)} \leq t < t_{(j+1)},\ j = 1,2,\ldots,r$$

for estimating the failure function, with:

n_j = number of individuals who get sick before the time $t_{(j)}$

m_j = number of individuals who recovered at the time $t_{(j)}$

$t_{(j)}$ = j-th time sequence of healing resistance, $j = 1,2,\ldots,r$

r = time sequence of healing resistance

τ_j = $t_{(j+1)} - t_{(j)}$

Followed by testing the difference in survival curves for patients with malaria based on the results in the second step using the Log Rank test with equality:

$$Log - Rank\ Statistic = \frac{(O_i - E_i)^2}{var\ (O_i - E_i)} \quad (2.3)$$

for variables with two categories and Equation:

$$Log - Rank\ Statistic = \mathbf{d'V^{-1}d} \quad (2.4)$$

Or with the *Log Rank* statistical approach formula is as follows:

$$\chi^2 = \frac{(O_i - E_i)^2}{E_i} \quad (2.5)$$

with :

$$e_{ij} = \left(\frac{n_{ij}}{n_j}\right) \times m_j \quad (2.6)$$

$$n_j = \sum_{i=1}^{G} n_{ij} \text{ and } m_j = \sum_{i=1}^{G} m_{ij} \quad (2.7)$$

Then,

$v_i = Var(O_i - E_i)$ and

$v_{il} = Var(O_i - E_i, O_l - E_l)$.

for $i = 1,2,\ldots,G; j = 1,2,\ldots,G-1$

Details:

O_i = i-th group individual observation value

E_i = i-th group individual expectation value

m_{ij} = number of recovered subjects in the i-th group at the time t_j

n_{ij} = number of subjects at risk of recovery in the i-th group at the time t_j

e_{ij} = i-th group individual expectation value at the time t_j

Decision making is seen if hypothesis H_0 is rejected if:

$$Log - Rank\ Statistic > \chi^2_{(\alpha;G-1)}$$

with degrees of freedom equal to $G-1$ (Kleinbaum and Klein, 2012).

4. Testing the Proportional Hazard assumption. Testing was done by looking at the results using the Kaplan Meier method and the Log Rank test.
5. Create a Cox Proportional Hazard regression model using Equation (Hutahaean et al., 2014; Pahlevi et al., 2016; Rahmadeni dan Ranti, 2016; Austin et al., 2017):

$$\begin{aligned} h_i(t) &= h_0(t) \cdot \exp(\beta_1 x_1 + \beta_2 x_2 + \cdots \\ &\quad \cdots + \beta_p x_p) \\ &= h_0(t) e^{\sum_{j=1}^{p} \beta_j x_j} \\ &= h_0(t) \exp(\beta' x) \end{aligned} \quad (2.14)$$

with:

$h_i(t)$: individual failure of the i-th function

$h_0(t)$: basic failure function

x_j : the value of the j-th variable, with $j = 1,2,\dots,p$

β_j : the j-th regression coefficient, with $j = 1,2,\dots,p$

6. Carring out parameter tests with the Likelihood Ratio test using the formula in Equation (Pahlevi et al., 2016):

$$G = -2\left[\ln L(0) - \ln L(\beta_j)\right] \quad (2.15)$$

where,

$L(0)$: *likelihood* function value without independent variables

$L(\beta_j)$: *likelihood* function value with independent variables

j : number of parameters β

and the Wald test uses the formula in the Equation:

$$z^2 = \left(\frac{\widehat{\beta_J}}{SE\,(\widehat{\beta_J})}\right)^2 \quad (2.16)$$

$$SE\,(\widehat{\beta_J}) = \sqrt{var\,(\widehat{\beta_J})} \quad (2.17)$$

where,

$SE\,(\widehat{\beta_J})$: standard deviation of $\widehat{\beta_J}$

$var\,(\widehat{\beta_J})$: variance of $\widehat{\beta_J}$

7. Choosing the best model. The selection is carried out using enter elimination with the help of SPSS software, and the model is generated based on the calculation results of the parameter tests carried out in step 6.
8. Interpreting the Cox Proportional Hazard regression model.
9. Calculating the Hazard Ratio using Equation (Rinni et al, 2015):

$$\widehat{HR} = \frac{h_0(t)e^{\sum_{j=1}^{p}\beta_j x_j^*}}{h_0(t)e^{\sum_{j=1}^{p}\beta_j x_j}} \quad (2.18)$$

$$\widehat{HR} = \exp\sum_{j=1}^{p}\hat{\beta}_j\left(x_j^* - x_j\right)$$

HR is the hazard ratio, $x^* = \left(x_1^*, x_2^*, \dots, x_p^*\right)$ as the value of the independent variable for one group of individuals, and $x = \left(x_1, x_2, \dots, x_p\right)$ shows the value of the independent variable for another group of individuals and β is a regression parameter (Rinni *et al* ., 2014).

10. Drawing conclusions and providing suggestions.

3. Results and Discussion

This study used descriptive statistical analysis to explain the number of patients in each category for each variable. The results of the descriptive statistical analysis are presented as follows.

Table 1 – Summary of patient data with malaria.

Cure time (days)(Y)	Frequency	Percentage (%)
3	205	49.6
14	199	48.2
28	9	2.2
Total	413	100.0

In Table 1, it can be seen that the number of patients with malaria in West Lombok Regency in 2019-2020 was 413 patients. Two hundred five (205) registered patients took treatment for three days to cure malaria, with a percentage of 49.6%. One hundred ninety-nine (199) patients registered took treatment for 14 days to cure malaria, with a percentage of 48.2%. Nine patients took treatment until day 28 to cure malaria, with a percentage of 2.2%.

Table 2 – Percentage of patient status with malaria

Event Information	Category	Frequency	Percentage (%)
Observed	0	410	99.3
Censored	1	3	0.7
Total		413	100.0

Table 2 shows that the number of patients with malaria who received treatment and recovered were 410 patients, or 99.3%. Meanwhile, the number of patients with malaria who were censored or patients who had not recovered (did not continue treatment until finished or recovered) was three patients or 0.7%.

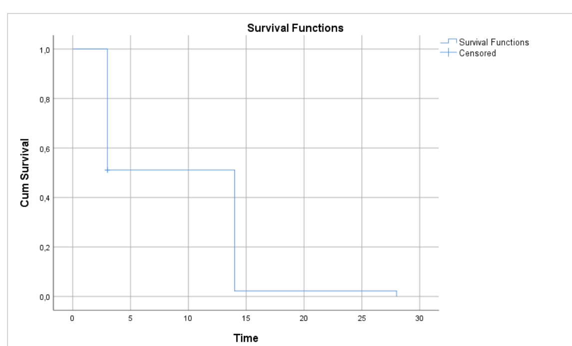
Table 3 – Descriptive analysis of all independent variables

Variable	Category	Amount	Percentage (%)
Age (X_1)			
Children (1-10 years) (X_{10})	0	103	24.9
Teenagers (11-19 years) (X_{11})	1	69	16.8
Adult (20-60 years) (X_{12})	2	228	55.2
Elderly (< 60 years) (X_{13})	3	13	3.1
Gender (X_2)			
Man (X_{20})	0	199	48.18
Woman (X_{21})	1	214	51.82
Type of Parasite (X_3)			
Plasmodium falciparum (X_{30})	0	189	45.76
Plasmodium Vivax (X_{31})	1	56	13.56
Plasmodium Mix (X_{32})	2	168	40.68
DHP Tablets (X_4)			
Low Dosage (0.7-4.5 tablets) (X_{40})	0	44	10.7
Moderate Dosage (4.6-8.4 tablets) (X_{41})	1	105	25.4
High Dosage (8.5-12.3 tablets) (X_{42})	2	264	63.9
Primaquine Tablets (X_5)			
Low Dosage (0-4.7 tablets) (X_{50})	0	213	51.6
Moderate Dosage (4.8-9.5 tablets) (X_{51})	1	63	15.3
High Dosage (9.6-14.3 tablets) (X_{52})	2	137	33.1
Maintenance (X_6)			
Outpatient (X_{60})	0	395	95.64
Inpatient (X_{61})	1	18	4.36
Work (X_7)			
Doesn't work (X_{70})	0	30	7.26
Housewife (X_{71})	1	73	17.68
Student (X_{72})	2	138	33.41
Gardening (X_{73})	3	14	3.40
Farmer (X_{74})	4	154	37.29
Trader (X_{75})	5	2	0.48
Forest Encroachment (X_{76})	6	2	0.48
Distance from village to health centre (X_8)			
Near (0.4-3.6 Km/Hour) (X_{80})	0	202	48.9
Moderate (3.7-6.9 Km/Hour) (X_{81})	1	207	50.1
Far (7.0-10.2 Km/Hour) (X_{82})	2	4	1.0
Pregnant or Not Pregnant (X_9)			
Not pregnant (X_{90})	0	404	97.82
Pregnant (X_{91})	1	9	2.18

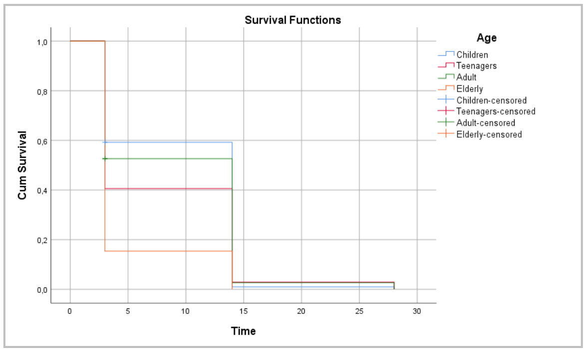
Table 3 shows the percentage of patients with malaria in West Lombok Regency in 2019-2020. The variable with the highest number of patients is the non-pregnant category, namely 404 patients with a percentage of 97.82%, and the category with the least number of patients is the distance category. The village to the health centre with a long distance of 6 patients with a percentage of 1.0%. Details can be seen in Table 3.

Assumptions checking

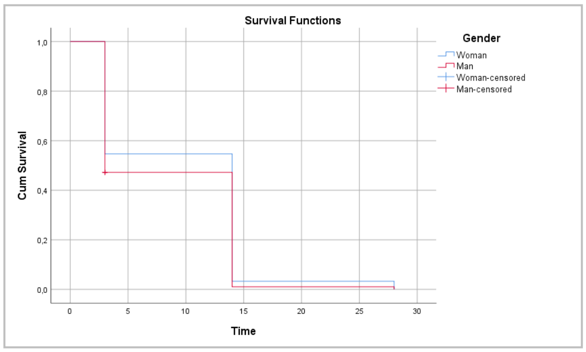
Figure 1 below represents the Kaplan-Meier survival curve for all independent variables.



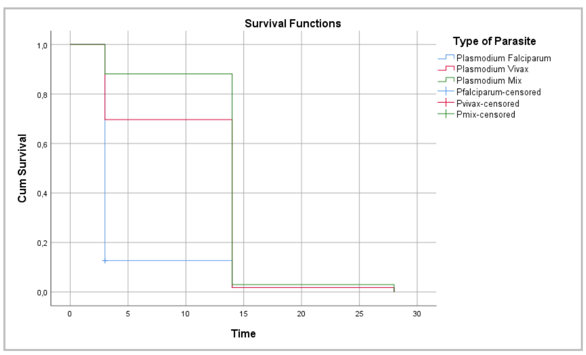
(a)


Survival Functions
Age
Children
Teenagers
Adult
Elderly
Children-censored
Teenagers-censored
Adult-censored
Elderly-censored
Cum Survival
Time

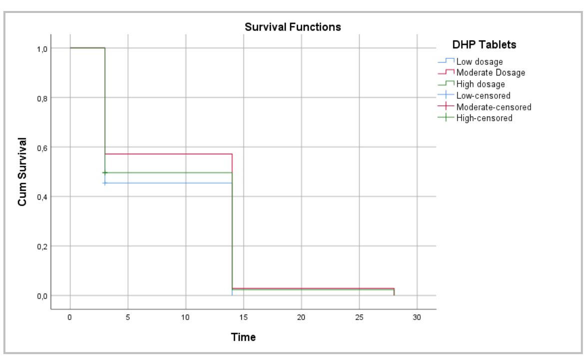
(b)


Survival Functions
Gender
Woman
Man
Woman-censored
Man-censored
Cum Survival
Time

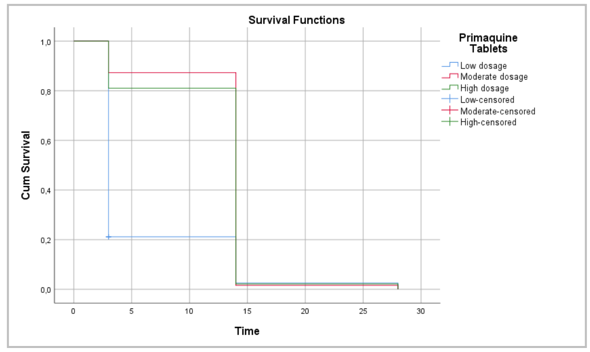
(c)


Survival Functions
Type of Parasite
Plasmodium Falciparum
Plasmodium Vivax
Plasmodium Mix
Pfalciparum-censored
Pvivax-censored
Pmix-censored
Cum Survival
Time

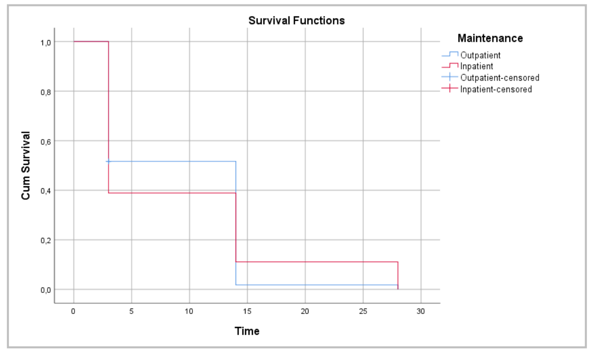
(d)


Survival Functions
DHP Tablets
Low dosage
Moderate Dosage
High dosage
Low-censored
Moderate-censored
High-censored
Cum Survival
Time

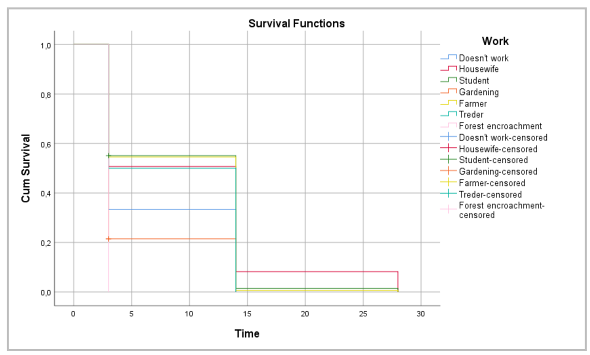
(e)


Survival Functions
Primaquine Tablets
Low dosage
Moderate dosage
High dosage
Low-censored
Moderate-censored
High-censored
Cum Survival
Time

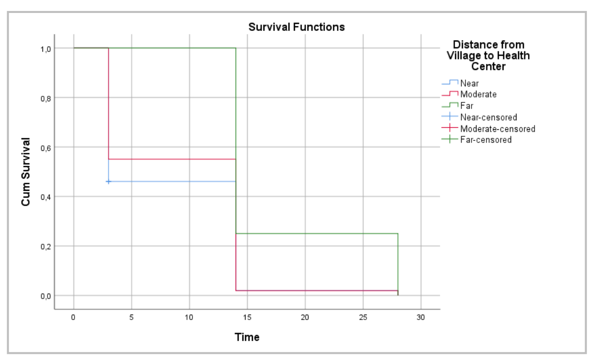
(f)


Survival Functions
Maintenance
Outpatient
Inpatient
Outpatient-censored
Inpatient-censored
Cum Survival
Time

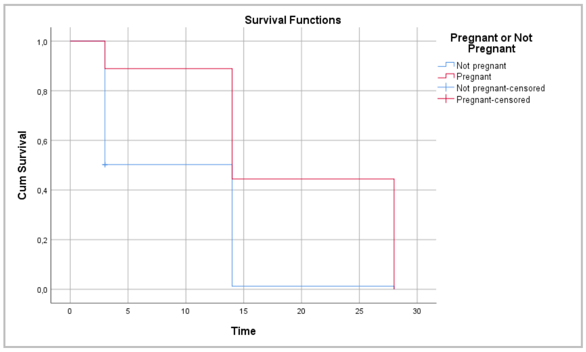
(g)


Survival Functions
Work
Doesn't work
Housewife
Student
Gardening
Farmer
Treder
Forest encroachment
Doesn't work-censored
Housewife-censored
Student-censored
Gardening-censored
Farmer-censored
Treder-censored
Forest encroachment-censored
Cum Survival
Time

(h)


Survival Functions
Distance from Village to Health Center
Near
Moderate
Far
Near-censored
Moderate-censored
Far-censored
Cum Survival
Time

(i)



(j)

Figure. 1 –Kaplan Meier survival curve.

Figure 1 – (a) Kaplan Meier survival curve; (b) Kaplan Meier survival curve based on age factor; (c) Kaplan Meier survival curve based on sex factor; (d) Kaplan Meier survival curve based on parasite type factor; (e) Kaplan Meier survival curve based on tablet DHP factor; (f) Kaplan Meier survival curve based on tablet primaquine factor; (g) Kaplan Meier survival curve based on treatment factor; (h) Kaplan Meier survival curve based on occupational factors; (i) Kaplan Meier's survival curve based on the distance factor from the village to the health centre; (j) Kaplan Meier survival curve based on pregnancy or non-pregnancy factors.

Based on the illustration of the Kaplan-Meier graph, seen from the probability value of each category for each variable, it can be assumed that there are differences in the survival curve for each category for each variable. Therefore, the variables that are suspected of being different for each category in each variable are age, type of parasite, primaquine tablets, occupation, distance from the village to a health centre, and pregnant or not pregnant. This is still the result of estimating whether or not there is a difference in the survival curve. Therefore, to support the hypothesis on the Kaplan-Meier survival curve that has been presented, it is necessary to test it using the log-rank test.

A log-rank test was conducted to find out whether there was a significant difference between the *survival* curves in the category groups for each variable, namely Variables Age, Gender, Parasite Type, DHP Tablets, Primaquine Tablets, Care, Occupation, Distance from Village to Health Center and Pregnant or Not Pregnant.

Hypothesis:

H_0: There was no difference between *survival curves*

H_1: There is at least one difference between the *survival curves*

The significance level used is $\alpha = 0.05$, along with test statistics, carried out using Equation (2.3) for variables with two categories and Equation (2.4) for variables with more than two categories. Below is a summary of the results of the Log Rank test for all independent variables (Kleinbaum and Klein, 2012).

The following is a summary of the results of the Log Rank test for all independent variables.

Table 4 – Log Rank test results based on the factors of each variable

Variable	*Log Ranks*	Free degrees	*Error*	Decision
X_1	10.920	3	0.012	Reject H_0
X_2	3.300	1	0.069	Fail to reject H_0
X_3	192.843	2	0.000	Reject H_0
X_4	2.678	2	0.262	Fail to reject H_0
X_5	135.449	2	0.000	Reject H_0
X_6	0.054	1	0.816	Fail to reject H_0
X_7	12.773	6	0.047	Reject H_0
X_8	9.463	2	0.009	Reject H_0
X_9	19.715	1	0.000	Reject H_0

The decision can be obtained if the value of the test statistic is greater than the value of $\chi^2(\alpha; G-1)$, with a p-value less than α, then the Log Rank test results in a decision to reject H_0meaning that there is a difference in survival time between the variables. Based on Table 4, six variables meet the decision criteria for rejecting H_0, namely the variables Age, Type of Parasite, Primaquine Tablet, Occupation, Village Distance to Health Center, and Pregnant or Not Pregnant. Meanwhile, for the variables, Gender, DHP Tablets, and Treatment, the statistical test values were lower than the value of $\chi^2(\alpha; G-1)$, with a *p-value* greater than α. So this test results in a failed decision to reject H_0meaning that there is no difference in survival time between the three variables.

The results of the analysis of the proportional hazard assumption test using the Kaplan-Meier method showed that six independent variables were categorical that met the proportional hazard assumption, namely variables, X_1, X_3, X_5, X_7, X_8, and X_9meanwhile, the other three variables X_2, X_4, and X_6did not meet the proportional hazard assumption.

Therefore, the six independent variables that have differences for each category can be included in this study's Cox proportional hazard regression model.

Parameter Estimation of Cox Proportional Hazard Regression Analysis

After the proportional hazard assumption test is fulfilled, a parameter estimation test is performed to obtain the Cox Proportional Hazard regression model using Equation (2.14).

Table 5 – Parameter Estimation of the Cox Proportional Hazard Regression Model

Variable	$\hat{\beta}$
$\boldsymbol{X_1}$	
X_{11}	-0.297
X_{12}	-0.120
X_{13}	-0.278
$\boldsymbol{X_3}$	
X_{31}	0.933
X_{32}	0.102
$\boldsymbol{X_5}$	
X_{51}	0.032
X_{52}	-0.042
$\boldsymbol{X_7}$	
X_{71}	-0.080
X_{72}	-0.358
X_{73}	-0.339
X_{74}	-0.262
X_{75}	-0.320
X_{76}	-0.312
$\boldsymbol{X_8}$	
X_{81}	0.828
X_{82}	0.770
$\boldsymbol{X_9}$	0.836

Parameter Testing

Parameter testing was carried out in two stages: simultaneous testing with the likelihood ratio test and partial testing with the Wald test. The hypothesis used for simultaneous testing is as follows:

Hypothesis:

H_0 : $\beta_1 = \beta_2 = \cdots = \beta_p = 0$

(the model does not match)

H_1 : at least $1, \beta_j \neq 0,$ for $j = 1,2, \dots, p$

(the model is suitable)

with a significance level $\alpha = 5$ %(0.05). The test statistic used is the following Equation.

$$G = -2\left[\ln L\,(0) - \ln L\left(\beta_j\right)\right]$$
$$= 80{,}656$$

Based on the results of parameter testing simultaneously, $G \geq \chi^2(\alpha; df = p)$ is 80.656 ≥ 26.2962 or *p-value* <α, i.e. 0.00 <0.05 so that the decision to reject H_0 is obtained, which means that there is at least one variable that has a significant effect on the recovery of malaria patients in the district. West Lombok.

After testing the parameters simultaneously, a partial test was carried out with the Wald test. The hypothesis used for the partial test is as follows:

Hypothesis:

$H_0: \beta_j = 0,$ for $j, j = 1,2, \dots, p$

(the parameter is not significant)

$H_1: \beta_j \neq 0,$ for $j, j = 1,2, \dots, p$

(the parameter is significant)

with a significance level $\alpha = 5$ %(0.05). The test statistic used is the following Equation.For example, on the variable X_{11}:

$$Z^2 = \left(\frac{\hat{\beta}_{11}}{SE\left(\hat{\beta}_{11}\right)}\right)^2 = \left(\frac{-0{,}297}{0{,}376}\right)^2 = 0{,}624$$

The full results can be seen in Table 6. The rejection area of this partial test is H_0, if $Z^2 \geq \chi^2(\alpha; df = 1)$.

Table 6 – Cox Proportional Hazard Regression results

Variable	Estimator $\hat{\beta}$	Standard Error	Z^2	Degree of Freedom (df)	*Error*	$exp(\hat{\beta})$	Decision
X_1			2.116	3	0.549		Fail to reject H_0
X_{11}	-0.297	0.376	0.624	1	0.429	0.743	Fail to reject H_0
X_{12}	-0.120	0.360	0.111	1	0.740	0.887	Fail to reject H_0
X_{13}	-0.278	0.292	0.907	1	0.341	0.757	Fail to reject H_0
X_3			12.169	2	0.002		Reject H_0
X_{31}	0.933	0.268	12.146	1	0.000	2.542	Reject H_0
X_{32}	0.102	0.159	0.410	1	0.522	1.108	Fail to reject H_0
X_5			0.083	2	0.959		Fail to reject H_0
X_{51}	0.032	0.280	0.013	1	0.910	1.032	Fail to reject H_0
X_{52}	-0.042	0.206	0.042	1	0.838	0.959	Fail to reject H_0
X_7			1.360	6	0.968		Fail to reject H_0
X_{71}	-0.080	0.774	0.011	1	0.918	0.923	Fail to reject H_0
X_{72}	-0.358	0.723	0.245	1	0.621	0.699	Fail to reject H_0
X_{73}	-0.339	0.750	0.205	1	0.651	0.712	Fail to reject H_0
X_{74}	-0.262	0.765	0.117	1	0.732	0.770	Fail to reject H_0
X_{75}	-0.320	0.718	0.198	1	0.656	0.726	Fail to reject H_0
X_{76}	-0.312	1.006	0.096	1	0.757	0.732	Fail to reject H_0
X_8			2.664	2	0.264		Fail to reject H_0
X_{81}	0.828	0.524	2.499	1	0.114	2.290	Fail to reject H_0
X_{82}	0.770	0.524	2.158	1	0.142	2.160	Fail to reject H_0
X_9	0.836	0.403	4.314	1	0.038	2.307	Reject H_0

Based on simultaneous estimation and parameter testing results, the six independent variables significantly influence the model. Therefore, a model is obtained as follows.

$$h(t|X) = h_0(t)\, exp(-0,297X_{11} + (-0,120)X_{12} + (-0,278)X_{13} + 0,933X_{31} + 0,102X_{32} + 0,032X_{51} + (-0,042)X_{52} + (-0,080)X_{71} + (-0,358)X_{72} + (-0,339)X_{73} + (-0,262)X_{74} + (-0,320)X_{75} + (-0,312)X_{76} + 0,828X_{81} + 0,770X_{82} + 0,836X_{91})$$

with,

X_{1i}: Age, $i = 0,1,2,3$

$X_{10} =$ children,
$X_{11} =$ teenager,
$X_{12} =$ adult,
$X_{13} =$ elderly

X_{3i}: Parasite type $i = 0,1,2$

$X_{30} =$ *plasmodiun falciparum*,
$X_{31} =$ *plasmodium vivax*,
$X_{32} =$ *plasmodium mix*

X_{5i}: Primaquine tablets, $i = 0,1,2$

$X_{50} =$ low dosage,
$X_{51} =$ moderate dosage
$X_{52} =$ high dosage

X_{7i}: Work, $i = 0,1,2,3,4,5,6$

$X_{70} =$ doesn't work
$X_{71} =$ housewife
$X_{72} =$ student
$X_{73} =$ gardening
$X_{74} =$ farmer
$X_{75} =$ treder
$X_{76} =$ forest encroachment

X_{8i}: Distance from village to health center,

$i = 0,1,2$
$X_{80} =$ near
$X_{81} =$ moderate
$X_{82} =$ far

X_{9i}: Pregnant or not pregnant, $i = 0,1$

$X_{90} =$ not pregnant
$X_{91} =$ pregnant

Failure Ratio (Hazard Ratio)

After obtaining the Cox proportional hazard regression model, we calculate the hazard ratio for significant variables to determine how quickly malaria sufferers recover in West Lombok Regency.The following table shows the results of hazard ratio calculations for all significant variables.

Table 7 - Estimation of Significant Parameters

Variable Name	$\hat{\beta}$	$exp(\hat{\beta})$
$Plasmodium\ Vivax(X_{31})$	0.933	2,542
$Plasmodium\ Mix(X_{32})$	0.102	1.108
Pregnant(X_{91})	0.836	2,307

Table 7 shows the hazard ratio results which conclude that, for the parasite type variable in the plasmodium vivax category, the probability of recovery within one month of treatment is 2.542 times faster than that of plasmodium falciparum. Meanwhile, the parasite type in the plasmodium mix category has a probability of recovery of 1.108. times faster than *Plasmodium vivax*. Moreover, for the category of pregnant patients, the possibility of recovery within one month of treatment is 2.307 times faster than for patients who are not pregnant.

4. Conclusion

Based on the Cox proportional hazard regression results, the variables that partially significantly affect the recovery of malaria sufferers in West Lombok Regency are the type of parasite and the variable being pregnant or not pregnant. Based on the *hazard* ratio value, it can be seen that the variable type of parasite in the *plasmodium vivax* category with a hazard ratio of 2.542 means that the possibility of recovery within one month of treatment is 2.542 times faster than that of *plasmodium falciparum;* meanwhile, the type of parasite in the *plasmodium mix category* has the possibility can recover within one month of treatment by 1.108 times faster than *Plasmodium vivax*. For the variable pregnant or not pregnant for the category of pregnant patients, the possibility of recovery within one month of treatment is 2.307 times faster than for non-pregnant patients.

Furthermore, based on the variables that significantly influence the model, namely the variable type of parasite and the variable being pregnant or not pregnant, the government, when conducting socialization on malaria, is more focused on handling the types of malaria parasites and patients who experience pregnancy. Moreover, further research can be carried out on this case by considering comparisons between several models of survival analysis and further examining variables with more than two categories that influence the recovery of malaria sufferers in West Lombok Regency.

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