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

Siti Dwi Khairun Rahmatin Usman a, Mustika Hadijati b, Nurul Fitriyani c

a,b Department of Mathematics, Faculty of Mathematics and Natural Sciences, University of Mataram. Email: atinkhairun@gmail.com, mustika.hadijati@unram.ac.id

Department of Statistics, Faculty of Mathematics and Natural Sciences, University of Mataram. Email: nurul.fitriyani@unram.ac.id

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 (X₁), sex (X₂), type of parasite (X₃), DHP tablets (X₄), primaquine tablets (X₅), treatment (X₆), occupation (X₇), distance from the village to a health centre (X₈), and pregnant or not pregnant (X₉).

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):

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

   (2.1)
and failure function with Equation:

\[ \hat{h}(t) = \frac{m_j}{n_j \tau_j} \] (2.2)

Time interval,

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

for estimating the survival function and time interval,

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

for estimating the failure function, with:

\[ n_j = \text{number of individuals who get sick before the time } t(j) \]
\[ m_j = \text{number of individuals who recovered at the time } t(j) \]
\[ t(j) = j\text{-th time sequence of healing resistance, } j = 1, 2, \ldots, r \]
\[ r = \text{time sequence of healing resistance} \]
\[ \tau_j = t_{(j+1)} - t_{(j)} \]

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:

\[ \text{Log – Rank Statistic} = \frac{(O_i - E_i)^2}{\text{var}(O_i - E_i)} \] (2.3)

for variables with two categories and Equation:

\[ \text{Log – Rank Statistic} = \mathbf{d}'\mathbf{V}^{-1}\mathbf{d} \] (2.4)

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

\[ \chi^2 = \frac{(O_i - E_i)^2}{E_i} \] (2.5)

with:

\[ e_{ij} = \left( \frac{n_{ij}}{n_j} \right) \times m_j \] (2.6)
\[ n_j = \sum_{i=1}^{G} n_{ij} \quad \text{and} \quad m_j = \sum_{i=1}^{G} m_{ij} \] (2.7)

Then, \( v_i = \text{Var}(O_i - E_i) \) and

\[ v_{it} = \text{Var}(O_i - E_i, O_i - E_i) \]

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

Details:

\[ O_i = \text{i-th group individual observation value} \]
\[ E_i = \text{i-th group individual expectation value} \]
\[ m_{ij} = \text{number of recovered subjects in the } i\text{-th group at the time } t_j \]
\[ n_{ij} = \text{number of subjects at risk of recovery in the } i\text{-th group at the time } t_j \]
\[ e_{ij} = \text{i-th group individual expectation value at the time } t_j \]

Decision making is seen if hypothesis \( H_0 \) is rejected if:

\[ \text{Log – Rank Statistic} > \chi^2_{(a, G - 1)} \]

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):

\[ h_i(t) = h_0(t) \cdot \exp(\beta_1 x_1 + \beta_2 x_2 + \cdots + \beta_p x_p) \]
\[ = h_0(t) \cdot \exp(\beta \mathbf{x}) \] (2.14)

with:

\[ h_i(t) : \text{individual failure of the } i\text{-th function} \]
\[ h_0(t) : \text{basic failure function} \]
6. Carrying out parameter tests with the Likelihood Ratio test using the formula in Equation (Pahlevi et al., 2016):

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

(2.15)

where,

- \( L(0) \): likelihood function value without independent variables
- \( L(\beta_j) \): likelihood function value with independent variables
- \( j \): number of parameters \( \beta \)

and the Wald test uses the formula in the Equation:

\[ z^2 = \left( \frac{\beta_j}{SE(\beta_j)} \right)^2 \]  

(2.16)

\[ SE(\beta_j) = \sqrt{\text{var}(\beta_j)} \]  

(2.17)

where,

- \( SE(\beta_j) \): standard deviation of \( \beta_j \)
- \( \text{var}(\beta_j) \): variance of \( \beta_j \)

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.


\[ HR = \frac{\hat{h}_0(t) e^{\sum_{j=1}^{p} \beta_j x_j^*}}{\hat{h}_0(t) e^{\sum_{j=1}^{p} \beta_j x_j}} \]  

(2.18)

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

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>
<thead>
<tr>
<th>Cure time (days) (Y)</th>
<th>Frequency</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>205</td>
<td>49.6</td>
</tr>
<tr>
<td>14</td>
<td>199</td>
<td>48.2</td>
</tr>
<tr>
<td>28</td>
<td>9</td>
<td>2.2</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>413</strong></td>
<td><strong>100.0</strong></td>
</tr>
</tbody>
</table>

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>
<thead>
<tr>
<th>Event Information</th>
<th>Category</th>
<th>Frequency</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Observed</td>
<td>0</td>
<td>410</td>
<td>99.3</td>
</tr>
<tr>
<td>Censored</td>
<td>1</td>
<td>3</td>
<td>0.7</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>413</strong></td>
<td><strong>100.0</strong></td>
<td></td>
</tr>
</tbody>
</table>
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

<table>
<thead>
<tr>
<th>Variable</th>
<th>Category</th>
<th>Amount</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age ($X_1$)</td>
<td>Children (1-10 years) ($X_{10}$)</td>
<td>0</td>
<td>24.9</td>
</tr>
<tr>
<td></td>
<td>Teenagers (11-19 years) ($X_{11}$)</td>
<td>1</td>
<td>16.8</td>
</tr>
<tr>
<td></td>
<td>Adult (20-60 years) ($X_{12}$)</td>
<td>2</td>
<td>55.2</td>
</tr>
<tr>
<td></td>
<td>Elderly (&lt; 60 years) ($X_{13}$)</td>
<td>3</td>
<td>3.1</td>
</tr>
<tr>
<td>Gender ($X_2$)</td>
<td>Man ($X_{20}$)</td>
<td>0</td>
<td>48.18</td>
</tr>
<tr>
<td></td>
<td>Woman ($X_{21}$)</td>
<td>1</td>
<td>51.82</td>
</tr>
<tr>
<td>Type of Parasite ($X_3$)</td>
<td>Plasmodium falciparum ($X_{30}$)</td>
<td>0</td>
<td>45.76</td>
</tr>
<tr>
<td></td>
<td>Plasmodium Vivax ($X_{31}$)</td>
<td>1</td>
<td>13.56</td>
</tr>
<tr>
<td></td>
<td>Plasmodium Mix ($X_{32}$)</td>
<td>2</td>
<td>40.68</td>
</tr>
<tr>
<td>DHP Tablets ($X_4$)</td>
<td>Low Dosage (0.7-4.5 tablets) ($X_{40}$)</td>
<td>0</td>
<td>10.7</td>
</tr>
<tr>
<td></td>
<td>Moderate Dosage (4.6-8.4 tablets) ($X_{41}$)</td>
<td>1</td>
<td>25.4</td>
</tr>
<tr>
<td></td>
<td>High Dosage (8.5-12.3 tablets) ($X_{42}$)</td>
<td>2</td>
<td>63.9</td>
</tr>
<tr>
<td>Primaquine Tablets ($X_5$)</td>
<td>Low Dosage (0-4.7 tablets) ($X_{50}$)</td>
<td>0</td>
<td>51.6</td>
</tr>
<tr>
<td></td>
<td>Moderate Dosage (4.8-9.5 tablets) ($X_{51}$)</td>
<td>1</td>
<td>15.3</td>
</tr>
<tr>
<td></td>
<td>High Dosage (9.6-14.3 tablets) ($X_{52}$)</td>
<td>2</td>
<td>33.1</td>
</tr>
<tr>
<td>Maintenance ($X_6$)</td>
<td>Outpatient ($X_{60}$)</td>
<td>0</td>
<td>95.64</td>
</tr>
<tr>
<td></td>
<td>Inpatient ($X_{61}$)</td>
<td>1</td>
<td>4.36</td>
</tr>
</tbody>
</table>

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.
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>
<thead>
<tr>
<th>Variable</th>
<th>Log Ranks</th>
<th>Degrees of Freedom</th>
<th>Error</th>
<th>Decision</th>
</tr>
</thead>
<tbody>
<tr>
<td>$X_1$</td>
<td>10.920</td>
<td>3</td>
<td>0.012</td>
<td>Reject $H_0$</td>
</tr>
<tr>
<td>$X_2$</td>
<td>3.300</td>
<td>1</td>
<td>0.069</td>
<td>Fail to reject $H_0$</td>
</tr>
<tr>
<td>$X_3$</td>
<td>192.843</td>
<td>2</td>
<td>0.000</td>
<td>Reject $H_0$</td>
</tr>
<tr>
<td>$X_4$</td>
<td>2.678</td>
<td>2</td>
<td>0.262</td>
<td>Fail to reject $H_0$</td>
</tr>
<tr>
<td>$X_5$</td>
<td>135.449</td>
<td>2</td>
<td>0.000</td>
<td>Reject $H_0$</td>
</tr>
<tr>
<td>$X_6$</td>
<td>0.054</td>
<td>1</td>
<td>0.816</td>
<td>Fail to reject $H_0$</td>
</tr>
<tr>
<td>$X_7$</td>
<td>12.773</td>
<td>6</td>
<td>0.047</td>
<td>Reject $H_0$</td>
</tr>
<tr>
<td>$X_8$</td>
<td>9.463</td>
<td>2</td>
<td>0.009</td>
<td>Reject $H_0$</td>
</tr>
<tr>
<td>$X_9$</td>
<td>19.715</td>
<td>1</td>
<td>0.000</td>
<td>Reject $H_0$</td>
</tr>
</tbody>
</table>

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 $\alpha$, then the Log Rank test results in a decision to reject $H_0$ meaning 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 $\alpha$. So this test results in a failed decision to reject $H_0$ meaning 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 $X_1, X_3, X_5, X_7, X_9$, and $X_8$. Meanwhile, the other three variables $X_2, X_6$, and $X_9$ did 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**

<table>
<thead>
<tr>
<th>Variable</th>
<th>$\hat{\beta}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$X_1$</td>
<td></td>
</tr>
<tr>
<td>$X_{11}$</td>
<td>-0.297</td>
</tr>
<tr>
<td>$X_{12}$</td>
<td>-0.120</td>
</tr>
<tr>
<td>$X_{13}$</td>
<td>-0.278</td>
</tr>
<tr>
<td>$X_3$</td>
<td></td>
</tr>
<tr>
<td>$X_{31}$</td>
<td>0.933</td>
</tr>
<tr>
<td>$X_{32}$</td>
<td>0.102</td>
</tr>
<tr>
<td>$X_5$</td>
<td></td>
</tr>
<tr>
<td>$X_{51}$</td>
<td>0.032</td>
</tr>
<tr>
<td>$X_{52}$</td>
<td>-0.042</td>
</tr>
<tr>
<td>$X_7$</td>
<td></td>
</tr>
<tr>
<td>$X_{71}$</td>
<td>-0.080</td>
</tr>
<tr>
<td>$X_{72}$</td>
<td>-0.358</td>
</tr>
<tr>
<td>$X_{73}$</td>
<td>-0.339</td>
</tr>
<tr>
<td>$X_{74}$</td>
<td>-0.262</td>
</tr>
<tr>
<td>$X_{75}$</td>
<td>-0.320</td>
</tr>
<tr>
<td>$X_{76}$</td>
<td>-0.312</td>
</tr>
<tr>
<td>$X_9$</td>
<td></td>
</tr>
<tr>
<td>$X_{91}$</td>
<td>0.828</td>
</tr>
<tr>
<td>$X_{92}$</td>
<td>0.770</td>
</tr>
<tr>
<td>$X_9$</td>
<td>0.836</td>
</tr>
</tbody>
</table>

**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:

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

(the model does not match)

$H_1 : \text{at least } 1, \beta_j \neq 0, \text{ for } j = 1, 2, \ldots, p$

(the model is suitable)

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

$$G = -2[\ln L (0) - \ln L (\beta_j)]$$

$$= 80.656$$

Based on the results of parameter testing simultaneously, $G \geq \chi^2(\alpha; df = p)$ is $80.656 \geq 26.2962$ or $p$-value $< \alpha$, 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:

$H_0 : \beta_j = 0, \text{ for } j, j = 1, 2, \ldots, p$

(the parameter is not significant)

$H_1 : \beta_j \neq 0, \text{ for } j, j = 1, 2, \ldots, p$

(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 $X_{11}$:

$$Z^2 = \left( \frac{\hat{\beta}_{11}}{SE(\hat{\beta}_{11})} \right)^2 = \left( \frac{-0.297}{0.376} \right)^2 = 0.624$$

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

$\hat{\beta}$ denotes the estimated parameter.
Based on simultaneous estimation and parameter testing results, the six independent variables significantly influence the model. Therefore, a model is obtained as follows.

\[ h(t | X) = h_0(t) \exp \left( -0.297X_{11} + (-0.120)X_{12} + (-0.278)X_{13} + 0.933X_{31} + 0.102X_{32} + 0.032X_{51} 
+ (-0.042)X_{52} + (-0.080)X_{71} + (-0.358)X_{72} + (-0.339)X_{73} + (-0.262)X_{74} 
+ (-0.320)X_{75} + (-0.312)X_{76} + 0.828X_{81} + 0.770X_{82} + 0.836X_{91} \right) \]

with,

- \( X_1 \): Age, \( i = 0, 1, 2, 3 \)
  - \( X_{10} \) = children,
  - \( X_{11} \) = teenager,
  - \( X_{12} \) = adult,
  - \( X_{13} \) = elderly

- \( X_3 \): Parasite type \( i = 0, 1, 2 \)
  - \( X_{30} \) = \textit{plasmodium falciparum},
  - \( X_{31} \) = \textit{plasmodium vivax},
  - \( X_{32} \) = \textit{plasmodium mix}

- \( X_5 \): Primaquine tablets, \( i = 0, 1, 2 \)
  - \( X_{50} \) = low dosage,
  - \( X_{51} \) = moderate dosage
  - \( X_{52} \) = high dosage

- \( X_7 \): 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

- \( X_8 \): Distance from village to health center,
  \( i = 0, 1, 2 \)
  - \( X_{80} \) = near
  - \( X_{81} \) = moderate
  - \( X_{82} \) = far

- \( X_9 \): 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

<table>
<thead>
<tr>
<th>Variable Name</th>
<th>$\hat{\beta}$</th>
<th>$\exp(\hat{\beta})$</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Plasmodium Vivax</em> ($X_{31}$)</td>
<td>0.933</td>
<td>2.542</td>
</tr>
<tr>
<td><em>Plasmodium Mix</em> ($X_{32}$)</td>
<td>0.102</td>
<td>1.108</td>
</tr>
<tr>
<td>Pregnant ($X_{91}$)</td>
<td>0.836</td>
<td>2.307</td>
</tr>
</tbody>
</table>

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 to 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.

REFERENCES


