Modelling Status Food Security Households Disease Sufferers
Pulmonary Tuberculosis Uses the Method Regression
Logistics Binary

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Abstract. Food security is the condition where the food fulfilment is managed well for the
country till the individual. Indonesia is one of the country which has the commitment to create
the food security becomes main priority. However, the food necessity becomes common thing
means that it doesn’t care about nutrient standard and the health condition of family member,
so in the fulfilment of food necessity also has to consider the disease suffered by the family
member, one of them is pulmonary tuberculosis. From that reasons, this research is conducted
to know the factors which influence on household food security status which suffered from
pulmonary tuberculosis in the coastal area of Surabaya by using binary logistic regression
method. The analysis result by using binary logistic regression shows that the variables wife
latest education, house density and spacious house ventilation significantly affect on household
food security status which suffered from pulmonary tuberculosis in the coastal area of
Surabaya, where the wife education level is University/equivalent, the house density is eligible
or 8 m2/person and spacious house ventilation 10% of the floor area has the opportunity to
become food secure households amounted to 0.911089. While the chance of becoming food
insecure households amounted to 0.088911. The model household food security status which
suffered from pulmonary tuberculosis in the coastal area of Surabaya has been conformable,
and the overall percentages of those classifications are at 71.8%.

1. Introduction
Compliance toward the need of food is one of the basic components in the development of human
resources. Considering the importance of food fulfillment, so every country will prioritize the
development of food security as a foundation for the development of other sectors (Arumsari, 2007).
Indonesia is one country that is committed to achieve food security as a main priority, as stated in
article 34 of the 1945 Constitution (UUD 1945) which states that the State is responsible to fulfill their
basic needs, including food. Indonesia also supports the initiation of world Food and Agriculture
Organization (FAO) in an effort to eradicate hunger through zero hunger (WFP, 2012).

Adverse effects of hunger and food insecurity is the creation of a country's economic instability.
Therefore, in an effort to prevent hunger and food insecurity, then the government must pay attention
to the problem of food security in Indonesia. The food needs should also be oriented towards
achieving the Millennium Development Goals (MDGs). Agenda to achieve the MDGs consist of eight
points, five of them are in health aspect. One of them is the health sector to achieve the MDGs agenda is the fight against tuberculosis (TB) (Dinkes, 2014).

TB disease is included in a chronic infectious disease. WHO stated that Indonesia is the country with a high burden of TB. Number of patients who suffered from TB in Indonesia ranks fourth after India, China and South Africa are almost 700 thousand cases with a mortality rate 25 per 100 thousand inhabitants. TB is the leading cause of death among infectious diseases and is the third of the 10 highest killer disease in Indonesia that caused 100,000 deaths annually (Sarwani, Nurlaela, & Zahrotul, 2012).

East Java Province is one of the provinces in Indonesia with the incidence of TB has increased from year to year. In East Java, Surabaya is a city that ranks first in the spread of TB. Surabaya citizens vulnerable to the bacteria Mycobacterium tuberculosis. At least 4493 citizens of Surabaya infected with the bacteria Mycobacterium Tuberculosis (Dinkes, 2015).

Research on the factors that affect household food security have been carried out. But no studies that examine the factors that affect food security at the household which suffered from pulmonary tuberculosis in the coastal area of Surabaya. Therefore, this study was conducted to analyze the factors that affect the food security status of households with regard disease pulmonary tuberculosis suffered by members of the household.

2. Literature Review

2.1. Binary Logistic Regression

Binary logistic regression is a method of data analysis used to find the relationship between the response variables are binary or dichotomous with the predictor variables that are polichotomous (Hosmer, Lemeshow, & Sturdivant, 2013). The response variable (y) consists of two categories: "success" and "failure" are denoted by y = 1 for success and y = 0 to fail.

2.1.1. Parameters Significance Test. Parameter significance test conducted to determine whether the predictor variables in the model significantly affect the response variable. Significance parameters test consists of simultaneous test and partial test.

Simultaneous Test. Simultaneous test also called model test Chi-square, made an effort to examine the role of the predictor variables in the model together. Hypothesis significance testing coefficient parameters simultaneously are as follows.

Hypothesis:

\[ H_0: \beta_1 = \beta_2 = ... = \beta_p = 0 \]
\[ H_1: \text{At least one } \beta_j \neq 0; \text{ for } j = 1, 2, ..., p \]

Statistical test:

\[ G = -2 \ln \left( \frac{n_1}{n} \binom{n_1}{n}^t \binom{n_0}{n}^0 \right) \prod_{i=1}^n \hat{\pi}_i^{y_i} (1 - \hat{\pi}_i)^{1-y_i} \]  \( (1) \)

The statistical test G follows the Chi-square distribution with degrees of freedom (df) = p (number of predictor variables), so that it will be obtained a decision reject \( H_0 \) if the value of G greater than the value \( \chi^2(\alpha, p) \) or a p-value less than \( \alpha \) (Hosmer, Lemeshow, & Sturdivant, 2013).

Partial Test. After test parameter coefficient \( \beta \) simultaneously on the response variable, then doing the significance test \( \beta \) partially on the response variable. Partial testing hypothesis are as follows.
Hypothesis:

\[ H_0: \beta_j = 0 \]

\[ H_1: \beta_j \neq 0, \text{ For } j = 1,2, \ldots, p \]

Statistical test:

\[ W = \frac{\hat{\beta}_j}{SE(\hat{\beta}_j)} \]  \(\text{(2)}\)

The statistical test \( W \) follows a normal distribution, so that it will be obtained a decision reject \( H_0 \) if the value of \( |W| \) greater than the value \( Z_{\alpha/2} \) or a p-value less than \( \alpha \) (Hosmer, Lemeshow, & Sturdivant, 2013).

2.1.2 The Odds Ratio Value. The odds ratio is defined as the ratio of the value of logistic regression to \( x = 1 \) toward the value of logistic regression to \( x = 0 \) (Hosmer & Lemeshow, 2000), which can be formulated in the following equation.

\[ OR = \frac{\pi(1)}{\pi(0)} = \frac{\pi(1)[1 - \pi(0)]}{\pi(0)[1 - \pi(1)]} = \frac{e^{\beta_0 + \beta_1}}{e^{\beta_0}} = e^{\beta_1} \]  \(\text{(3)}\)

2.1.3 Conformance Model Test. Conformance model test is used to determine whether there is a significant difference between the results of observations with the possible results of model predictions. Hypothesis testing the conformance of the model are as follows.

Hypothesis:

\[ H_0: \text{Model appropriate} \]

\[ H_1: \text{The model does not appropriate} \]

Statistical test:

\[ \hat{C} = \sum_{k=1}^{g} \frac{(O_k - n'_k \pi_k)^2}{n'_k \pi_k (1 - \pi_k)} \]  \(\text{(4)}\)

The statistical test \( \hat{C} \) follows the Chi-square distribution with degrees of freedom (df) = \( g-2 \), so that it will be obtained a decision reject \( H_0 \) if the value of \( \hat{C} \) greater than the value \( \chi^2_{(a, g-2)} \) or a p-value less than \( \alpha \) (Hosmer & Lemeshow, 2000).

2.2. Classification Accuracy Evaluation

Classification accuracy evaluation is an evaluation to see opportunities for misclassification based on the criteria or measures used. The measure used is Accuracy Total (Johnson & Winchern, 2007). Here is a classification table to get the value Accuracy Total.

| Table 1. Table Classification. |
|--------------------------------|
| **Predicted Membership**       |
|                                |
| Actual Positive Class          |
| Positive Prediction            |
| True Positive (TP)             |
| False Negative (FN)            |
| Negative Class                 |
| False Positive (FP)            |
| True Negative (TN)             |

Apparent Error Rate (APER) = \( \frac{FP+FN}{TP+TN+FP+FN} \times100\% \)  \(\text{(5)}\)

Accuracy Total = 1 - APER  \(\text{(6)}\)
3. Research Methodology

3.1. Data Source
The data used in this research is secondary data and primary data. Secondary data is data on the number and address of pulmonary tuberculosis patients who conduct examination in the clinic coastal region of Surabaya, in January till December 2015. The primary data is the information obtained directly through a survey of pulmonary tuberculosis patients who are in the coastal city of Surabaya.

3.2. Research Variables
The variables used in this study consist of the response variable (Y) and the predictor variables (X). The explanation for each of those variables is described as follows.

3.2.1. Response Variable. The response variable (Y) in this study is the household food security status which suffered from pulmonary tuberculosis in the coastal area of Surabaya.

| Variable | Explanation | Category |
|----------|-------------|----------|
| Y        | Food Security Status | 0 = Insecure Food  
|          |              | 1 = Secure Food |

Determination of household food security status is measured based on the following four indicators.

| Indicators | Explanation | Category |
|------------|-------------|----------|
| Sufficiency of Food Availability | Rice Stock for a Month | 0 = < 20 days  
|          |              | 1 = ≥ 20 days |
| Food Stability | Mealtime Frequency Per Day | 0 = < 3 times  
|          |              | 1 = ≥ 3 times |
| Food Accessibility | Market Location | 0 = > 2 km  
|          |              | 1 = ≤ 2 km |
|          | Number of Household Members | 0 = ≥ 7 people  
|          |              | 1 = < 7 people |
|          | Head of Household Education Level | 0 = No School  
|          |              | 1 = Minimum Elementary School |
|          | How To Obtain Food Staple | 0 = Debt  
|          |              | 1 = Not Debt |
| The Quality or Food Safety | Protein Consumed | 0 = Vegetable only or not at all  
|          |              | 1 = Animal and vegetable or animal only |

3.2.2. Predictor Variables. The predictor variables (X) used in this study is as follows.

| Variables | Explanation | Explanation |
|-----------|-------------|-------------|
| X_1       | Head of Household Age   | X_12        | Home Ownership |
| X_2       | Wife Age          | X_13        | House Density  |
| X_3       | The Head of Household Latest Education | X_14 | The Widest Roof Type |
| X_4       | The Wife Latest Education | X_15 | The Widest Wall Type |
| X_5       | The Head of Household Jobs | X_16 | The Widest Floor Type |
| X_6       | Employment Status of Wife | X_17 | Spacious House Ventilation |
| Variables | Explanation                      | Variables | Explanation          |
|-----------|----------------------------------|-----------|----------------------|
| X_7       | Number of Household Members      | X_18      | Toilet Ownership     |
| X_8       | Number of School Children        | X_19      | Clean Water Source   |
| X_9       | Number of Children Under Five    | X_20      | Trash Place          |
| X_10      | Earning per Month                | X_21      | Waste Water Disposal |
| X_11      | Spending per Month               | X_22      | Electricity Source   |

4. Analysis Result

4.1. Binary Logistic Regression Analysis

Binary logistic regression analysis aims to model and find the variables that significantly influence household food security status which suffered from pulmonary tuberculosis in the coastal area of Surabaya. Here are the steps binary logistic regression analysis in this study.

4.1.1. Parameter Significance of the Suspected Factors Affecting Household Food Security Status.

The significance of the parameters is performed to determine which variables are significant effect through simultaneous test and partial test.

Test Simultaneously against Factors Suspected of Affecting the Status of Food Security Household.

Simultaneous test conducted to determine the effect of predictor variables on household food security status simultaneously by using Backward method of inserting all the variables to be obtained only from the best model variables that effect. The best model that was stopped at the last iteration is step 20. Here are the simultaneous test results obtained.

Hypothesis:

H₀: β₁ = β₂ = ... = β₂₂ = 0
H₁: At least one βⱼ ≠ 0 for j = 1, 2, ..., 22

Significant level: α = 0.1

Statistical test: χ²

Rejection zone: Reject H₀ if χ² > χ²(α, df) or P-value < α

Here are the simultaneous test results to include all predictor variables.

| χ²       | df | χ²(0.1,7) | P-value |
|----------|----|-----------|---------|
| 59.317   | 7  | 12.017    | 0.000   |

Table 5 shows that at least one of the predictor variables is significantly effect on household food security status which suffered from pulmonary tuberculosis in the coastal area of Surabaya.

Partial Test toward Suspected Factors Affecting Household Food Security Status. Simultaneous test has been done to the conclusion that at least one of predictor variables that significantly effect on the food security status of households. Therefore, the partial test performed to determine which variables were significant with hypothesis used are as follows.

Hypothesis:

H₀: βⱼ = 0
H₁: βⱼ ≠ 0, for j = 1, 2, ..., 22

Significant level: α = 0.1
Statistical test: $\chi^2$
Rejection zone: Reject $H_0$ if $\chi^2 > \chi^2_{(\alpha, df)}$ or P-value $< \alpha$

**Table 6. Partial Test Results by Inserting Entire Predictors Variables.**

| Variables                        | $\chi^2$ | df | $\chi^2_{(\alpha, df)}$ | P-value |
|----------------------------------|----------|----|--------------------------|---------|
| Wife Education (X4)              | 9.259    | 4  | 7.779                    | 0.055 * |
| Wife Education (1) (X4)          | 5.984    | 1  | 2.706                    | 0.014 * |
| Wife Education (2) (X4)          | 7.097    | 1  | 2.706                    | 0.008 * |
| Wife Education (3) (X4)          | 4.209    | 1  | 2.706                    | 0.040 * |
| Wife Education (4) (X4)          | 7.278    | 1  | 2.706                    | 0.007 * |
| Number of Household Members (1) (X7) | 0.000    | 1  | 2.706                    | 0.998   |
| House Density (1) (X13)          | 6.783    | 1  | 2.706                    | 0.009 * |
| Spacious House Ventilation (1) (X17) | 4.350    | 1  | 2.706                    | 0.037 * |

*) Significant at $\alpha = 10\%$

Table 6 shows the partial test results on the last iteration (step 20). Based on these results known that the variable wife latest education, house density and spacious house ventilation significantly affect on household food security status which suffered from pulmonary tuberculosis in the coastal area of Surabaya.

4.1.2. Formation of Logistic Regression Binary Model toward Factors Suspected of Affecting the Status of Food Security Household. The method used in this modelling is a method Wald by only including three predictor variables which significantly affect on household food security status in accordance with the results obtained in the partial test. The results obtained are as follows.

Hypothesis:

$H_0: \beta_j = 0$

$H_1: \beta_j \neq 0$, for $j = 1, 2, \text{ and } 3$

Significant level: $\alpha = 0.1$

Statistical test: $\chi^2$

Rejection zone: Reject $H_0$ if $\chi^2 > \chi^2_{(\alpha, df)}$ or P-value $< \alpha$

Partial test results of the variables used in the modelling shown by Table 7.

**Table 7. Partial Test Results toward Variables Used in Model Formation**

| Variables                        | B      | $\chi^2$ | df | $\chi^2_{(\alpha, df)}$ | P-value |
|----------------------------------|--------|----------|----|--------------------------|---------|
| Wife Education (X4)              | 10.656 | 4        | 7.779 | 0.031 *                  |
| Wife Education (1) (X4)          | 3.703  | 1        | 2.706 | 0.008 *                  |
| Wife Education (2) (X4)          | 2.926  | 1        | 2.706 | 0.006 *                  |
| Wife Education (3) (X4)          | 1.453  | 1        | 2.706 | 0.119                    |
| Wife Education (4) (X4)          | 1.924  | 1        | 2.706 | 0.016 *                  |
| House Density (1) (X13)          | 0.833  | 1        | 2.706 | 0.046 *                  |
| Spacious House Ventilation (1) (X17) | 0.761  | 1        | 2.706 | 0.061 *                  |
| Constant                         | -2.970 | 1        | 2.706 | 0.000                    |

*) Significant at $\alpha = 10\%$
Table 7 shows the partial test results to the variables used in the formation of a binary logistic regression model. Based on these results known that the variable wife latest education, house density and spacious house ventilation significantly affect on household food security status which suffered from pulmonary tuberculosis in the coastal area of Surabaya.

4.1.3. Logit Models on Household Food Security Status which Suffered from Pulmonary Tuberculosis in the Coastal Area of Surabaya. Logit model formed based on the partial test results are shown in Table 8. Here is a logit model in binary logistic regression analysis on household food security status which suffered from pulmonary tuberculosis in the coastal area of Surabaya.

\[
\hat{g}(x) = -2.970 + 3.703X_{4(1)} + 2.296X_{4(2)} + 1.453X_{4(3)} + 1.924X_{4(4)} \\
+ 0.833X_{13(1)} + 0.761X_{17(1)}
\]

Based on the logit model, then the calculation of the value opportunity for the two categories of the response variable. Here is the value opportunities that come in specific categories, such as households with wife education level is University/equivalent, the house density is eligible or \( \geq 8 \) \( m^2 \)/person and spacious house ventilation \( \geq 10\% \) of the floor area. Households with these categories has the opportunity to become food secure households amounted to 0.911089. While the chance of becoming food insecure households amounted to 0.088911.

4.1.4. Odds Ratio Value of Variables Affecting Household Food Security Status which Suffered from Pulmonary Tuberculosis in the Coastal Area of Surabaya. Odds ratio values obtained from \( \exp (\beta) \). Here is the interpretation of the odds ratio value of each predictor variable that goes into a binary logistic regression model.

| Variables                        | Odds Ratio | Variables                        | Odds Ratio |
|----------------------------------|------------|----------------------------------|------------|
| Wife Education (1) (X4)          | 40.569     | Wife Education (4) (X4)          | 6.846      |
| Wife Education (2) (X4)          | 9.933      | House Density (1) (X13)          | 2.299      |
| Wife Education (3) (X4)          | 4.275      | Spacious House Ventilation (1) (X17) | 2.141      |

Table 8 shows that a household with the latest wife education is University/equivalent will tend to be food secure household amounted to 40.569 times compared to household with wife's education level is not school. A household with the latest wife education is Senior High School/equivalent will tend to be food secure household amounted to 9.933 times compared to household with wife's education level is not school. A household with the latest wife education is Junior High School/equivalent will tend to be food secure household amounted to 4.275 times compared to household with wife's education level is not school. While a household with the latest wife education is Elementary School/equivalent will tend to be food secure household amounted to 6.846 times compared to household with wife's education level is not school.

A household with a house density is eligible or \( \geq 8 \) \( m^2 \)/person will tend to be food secure household amounted 2.299 times compared to household with house density is not eligible or <8 \( m^2 \)/person. A household that has spacious house ventilation \( \geq 10\% \) of the floor area will tend to be food secure household amounted 2.141 times compared to household with spacious house ventilation <10\% of the floor area.

4.1.5. Model Conformance Test of Household Food Security Status which Suffered from Pulmonary Tuberculosis in the Coastal Area of Surabaya. Here is the result of the model conformance test of
household food security status which suffered from pulmonary tuberculosis in the coastal area of Surabaya.

Hypothesis:

\( H_0 \): Model has been conformable (There is not a significant difference between the results of observations with the possible results of model predictions)

\( H_1 \): The model has not been conformable (There is significant difference between the results of observations with the possible results of model predictions)

Significant level: \( \alpha = 0.1 \)

Statistical test: \( \chi^2 \)

Rejection zone: Reject \( H_0 \) if \( \chi^2 > \chi^2_{(0.1,8)} \) or P-value < \( \alpha \)

The following is a model of conformance test results.

| Table 9. Model Conformance Test Results |
|----------------------------------------|
| \( \chi^2 \) | df | \( \chi^2_{(0.1,8)} \) | P-value |
|----------------|----|-------------------|---------|
| 8.360          | 8  | 13.362            | 0.399   |

Table 9 shows that the model household food security status which suffered from pulmonary tuberculosis in the coastal area of Surabaya has been conformable, or there is not a significant difference between the results of observations with the possible results of model predictions.

4.1.6. Classification Appropriateness of Household Food Security Status which Suffered from Pulmonary Tuberculosis in the Coastal Area of Surabaya. Here is the result of the classification accuracy evaluation of household food security status which suffered from pulmonary tuberculosis in the coastal area of Surabaya.

Table 10. Classification of The Household Food Security Status which Suffered from Pulmonary Tuberculosis in the Coastal Area of Surabaya

| Observation | Prediction |
|-------------|------------|
| Food Security Status | Insecure Food | Secure Food |
| Insecure Food | 67 | 24 | 73.6 |
| Secure Food | 16 | 35 | 68.6 |

Table 10 shows that the percentage of classification of insecure food household is at 73.6%, from 91 households there are 67 insecure food households classified correctly as insecure food households, while 24 other households wrongly classified as secure food households. Then the percentage of classification of secure food households is 68.6%, from 51 households there are 35 secure food household classified correctly as secure food household, while 16 other households wrongly classified as insecure food household. The overall percentage of those classifications are at 71.8%, which means that of the 142 households there are 102 households were classified correctly and there are 40 households that are classified incorrectly.

5. Conclusions and Suggestions

The conclusions and suggestions from the analysis results are as follows.

5.1. Conclusions

Based on the analysis result, it can be concluded that variables wife latest education, house density and spacious house ventilation significantly affect on household food security status which suffered from
pulmonary tuberculosis in the coastal area of Surabaya. The model household food security status which suffered from pulmonary tuberculosis in the coastal area of Surabaya has been conformable, or there is not a significant difference between the results of observations with the possible results of model predictions. The overall percentage of those classifications are at 71.8%, which means that of the 142 households there are 102 households were classified correctly and there are 40 households that are classified incorrectly.

5.2. Suggestions
Suggestions for key government decision makers are to improve household food security in the coastal area of Surabaya, especially in households which suffered from pulmonary tuberculosis. The efforts to improve household food security can be through the renewal of the compulsory education program in Indonesia, as well as to educate the society, especially for women to pursue education levels as high as possible, as the analysis shows that wife’s education level significant effect on household food security status. In addition, households are advised to occupy a dwelling house with a density that qualify are ≥ 8 m²/person and are advised to make the spacious house ventilation ≥ 10% of the floor area, because the two variables are also variables that have a significant impact to household food security.

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