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Analysis of Multinomial Logistics Regression on the Students Faith Data

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ABSTRACT

It is essential for the prospective teacher students of Islamic education to have a high faith level because it will influence their behavior. In addition, it positively impacts their social life. The level of a person's faith will have a different impact; hence, it needs to be measured. The faith concepts and their measurement have been widely developed recently. One of them is a faith concept, which is built by two dimensions or variables, i.e., belief and behavior or feeling. Both variables can fluctuate between very high, high, moderate, low, or very low, each influencing faith. Students who study in an Islamic Religious Education study program and at the same time attend Islamic boarding school are predicted to have high faith. This paper aims to describe the level of student faith and find a suitable multinomial logistic regression model through analysis of its method. Data was collected using questionnaires filled out by 52 students. The results showed that the percentage of students' faith levels with very high level was 5.8%, high was 36.5%, moderate was 38.5%, low was 13.5%, and very low was 5.8%. Meanwhile, the model accuracy was 94.2%.

1. Introduction

The rapid advancement of science and technology today have contributed to the lack of public awareness regarding faith. Every individual has faith to varying degrees, whether high or low, falling into the categories of *tahqiqi*, *istidlali*, or *taqlidi*, which is reflected through charity, namely their works or activities through *ihsan* behavior [1]. In other words, a person's faith can be reflected from their good behavior and deeds [2]. Faith is essential as it will influence individual behavior. It even has positive and significant influences on attitudes and behavioral control [3]. Thus, it is very crucial for prospective Islamic Religious Education (PAI) teachers to possess a high level of faith so that they can be faithful and noble individuals [4], [5]. Therefore, in many prophetic hadiths, one of the most important aspects of study is faith because it can influence individual attitudes or behavior in their daily lives [6]. A high level of faith can positively impact individual's lives. The level of faith, whether high or low, will have different impacts in society. Therefore, it is necessary to measure prospects of PAI teachers who will become models in society. Theories about the concept of faith

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and its measurement have been widely developed. One of them is the concept of faith, which is built by two dimensions or variables, namely *tashdiq al-qalb* (belief) and *amal al-qalb* (behavior or feelings). *Tashdiq* (belief) is internal and absolute, while *amal* (behavior or feelings) is external and active; belief also refers to behavior [7]. It means that the dimensions of belief and behavior have a relationship with the dimensions of faith, either separately or together. In reality, these two variables fluctuate, which also impact the faith variable. In this regard, a concept has divided faith into five levels: very low, low, moderate, high, and very high. Logically, students who study religion in the PAI study program and at the same time attend Islamic boarding schools are predicted to have a high level of faith; therefore, they will demonstrate patience as a practical expression of their faith when they enter the educational community [8]. This problem can be studied using descriptive analysis and a multinomial logistic regression model.

Multinomial logistic regression is a method to find the relationship between continuous or categorical predictors and response variables that are dichotomous (nominal or ordinal scale with two categories) or polychotomous (more than two categories). Meanwhile, the logistic regression model is a regression modeling for data with a predictor and a response variable that are nominally categorical, not binary. The response variable in the logistic regression model is dichotomous or binary, called a binary logistic regression model [9]. If the categories of the response variable are polychotomous with more than two categories, it is called a multinomial regression model (multinomial logistic regression model). In binary logistic regression, the categories of the response variable can be coded 0 and 1 [10], while multinomial logistic regression can be coded according to the number of categories. A multinomial is an extension of a binary. Therefore, as in binary logistic regression, the least squares method and maximum likelihood estimation (MLE) can be utilized to evaluate the chances of category members in multinomial logistic regression. They can also be used to predict the category position of a response based on multiple predictor variables. Multinomial logistic regression requires meticulous consideration of the sample size. The guideline for multinomial is at least 10 for each predictor [11]. However, in multilevel multinomial logistic regression analysis, the use of the MLE method must meet the assumption that the sample used must be quite large (> 50) because a small sample can cause biased parameter estimates [12]. When modeling the multinomial logistic regression from predictor and response data with M categories of response variables (M > 2), 1 category is selected as the basic category (baseline). It is compared with the basic, then a logistics regression model was obtained as much as (M -1). If it is not specified, the baseline is the lowest response variable value [13]. In building the model, it is essential to carry out an independence test to examine the relationship between the predictors and responses, assess the model's goodness of fit against the observed or empirical data, conduct simultaneous (overall) and partial tests, and conduct ab analysis testing on the model's significance (model fitting). Knowledge of whether each predicator significantly affect the model can be done through a partial parameter testing. Meanwhile, the coefficient of determination is used to determine the significance of the predictor variables' impacts, which can be seen from the Nagelkerke value [14].

Research on faith are beginning to gain the attention of researchers in the field of scientific modeling. Research included mathematical modeling to measure a person's level of faith in facing the COVID-19 outbreak as a threat to state security using differential equations [15]. Statistical modeling, especially multinomial logistic regression models, has also been utilized [16]. In addition, another research applied fuzzy logic theory to describe the differences of the faith levels of urban and rural communities seen from the worship aspect [17].

2. Method

2.1. Data Sets

Primary data was taken from the results of filling out a questionnaire about faith, which was built on two dimensions: beliefs and behavior or feelings. The faith questionnaire consisted of 113 statement items divided into 53 belief dimension items and 60 behavior or feelings [7]. The questionnaire was filled out by 52 students from the PAI Study Program of the State Islamic

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University (UIN) Prof. K.H. Saifuddin Zuhri Purwokerto, abbreviated as UIN Saizu Purwokerto, who concurrently enrolled in Islamic Religious studies at the Islamic Boarding School. The respondents consisted of 52 students since there were only 52 students from the PAI Study Program who also attended the Islamic boarding school. In addition, this number meets the requirement for using MLE; that is, the sample must be more than 50. Belief and behavior dimension data was on an interval scale. Faith was also on an interval scale, but the data was converted into five categories using the standard five-scale scoring rule: very low, low, moderate, high, and very high. After that, the categorical data from the conversion results of the five-scale standard scores was transformed into a nominal type: five, four, three, two, and one. The results of the conversion of scores and categories of faith are shown in Table 1.

Table 1. Score (X), Faith Category, and Coding

Score	Category	Coding
X > 560	Very high	1
523 < X ≤ 560	High	2
485 < X ≤ 523	Moderate	3
447 < X ≤ 485	Low	4
X ≤ 447	Very low	5

2.2. Descriptive Statistics

Statistics is knowledge of data processing and interpreting. It also involves model building. The main method consists of descriptive statistics [18]. It is also defined as a tool for summarizing, organizing, and simplifying data [18]. The three main types of descriptive statistics are frequency and percentage, namely counting the number of times each variable appears; measures of central tendency, namely mean, median, and mode, namely the single number that best represents the entire set of scores; and measures of dispersion consisting of range, standard deviation, mean variance, indicating to what extent scores deviate from the mean [19].

2.3. Independence Test

The independence test aims to determine if the predictor has relationship with response variables. Testing was carried out by using chi square using the following hypothesis:

H_0: no effect.
H_1: there was n effect.

The chi square test statistic is shown in (1)

$$\chi^2 = \sum_{i=1}^{n} \frac{(O_i - E_i)^2}{E_i} \quad (1)$$

where *O* denotes the observed frequency and *E* denotes the expected frequency [20]. This test was carried out based on the fulfillment of the requirement that the data was taken randomly and used a minimum sample of 20 to 50. Variables that must have a mutually exclusive relationship will be analyzed later in this paper.

2.4. Parameters Estimation

The estimation of multinomial logistic regression parameters using the MLE method with a likelihood function for a sample with *n* independent observations is shown in (2).

$$l(\beta) = \prod_{i=1}^{n} [\pi_0(x_i)^{y_{0i}} \pi_1(x_i)^{y_{1i}} \pi_2(x_i)^{y_{2i}}]. \quad (2)$$

Using the logarithmic transformation, (3) is obtained.

$$L(\beta) = \sum_{i=1}^{n} y_{1i} g_1(x_i) + y_{1i} g_1(x_i) - ln\left(1 + e^{g_1(x_i)} + e^{g_2(x_i)}\right) \quad (3)$$

Using the first partial derivative of $L(\beta)$ towards each $2(p+1)$ unknown parameters, e.g., $\pi_{ji} = \pi_j(x_i)$, the general form of the equation is obtained.

$$\frac{\partial L(\beta)}{\partial \beta_{jk}} = \sum_{i=1}^{n} x_{ki} \left(y_{ji} - \pi_{ji}\right) \quad (4)$$

where j = 1, 2; k = 0, 1, 2, ... p, with x_{0i} = 1 for each subject.

The maximum likelihood estimator $\hat{\beta}$ is obtained by making (4) equal to zero and the solution for β [9].

2.5. Multinomial Logistics Regression Model

Multinomial logistic regression is logistic regression modeling for predictor-response data with nonbinary nominal categorical responses [13]. The multinomial logistic regression with two continuous predictor variables and five categorical response variables was formed from the model:

$$\pi(x) = \frac{exp(\beta_0 + \beta_1 X_1 + \beta_2 X_2)}{1 + exp(\beta_0 + \beta_1 X_1 + \beta_2 X_2)} \quad (5)$$

Transforming (5) into a linear regression model form (6).

$$Logit(Y) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 \quad (6)$$

with $Logit(Y) = \ln\left(\frac{\pi(x)}{1-\pi(x)}\right)$ as in [9], [21], and [14].

2.6. Model Suitability Test

The test statistic used was the goodness of fit. It was utilized to compare the observed values with the predicted by the model. The hypothesis of this test is shown below.

H_0: Model is suitable
H_1: Model is not suitable

The test statistics goodness of fit Cˆas in [9] is shown in (7).

$$\hat{C} = \sum_{k=1}^{g} \frac{(O_k - n_k \overline{\pi_k})^2}{n_k \overline{\pi_k}(1-\overline{\pi_k})} \quad (7)$$

with n_k denotes the total number of subjects in the group k, c_k denotes the number of covariate patterns in deciles kth, O_k denotes the number of responses among covariate patterns c_k, and $\overline{\pi_k}$ denotes the average of the estimated probabilities.

2.7. Measures of Goodness

The coefficient of determination can be analyzed to measure the goodness of the model. Using the analogy of the coefficient of determination (R^2) in linear regression, the goodness of the model in logistic regression can be determined using R^2 Cox and Snell or R^2 Nagelkerke. R^2 Cox and Snell cannot reach a value of 1 (100%) from real data. Due to this limitation, Nagelkerke proposed an adjustment to R^2 Cox and Snell by modifying it to produce a value of 1 if the model explains 100% of the data uncertainty [14]. It means that R^2 Nagelkerke is the improvement, correction, or extension of the R^2 Cox and Snell.

2.8. Overall Test

The overall test in logistic regression aims to test the role of predictor variables in the model simultaneously using the test statistics G. Presentation of test statistics G, as in [9], is shown in (8).

$$G = 2ln\left[\frac{(Likelihood\ without\ the\ Variable)}{(Likelihood\ with\ the\ Variable)}\right] \quad (8)$$

These statistics will test the hypothesis:

$H_o : \beta_1 = \beta_2 = \cdots = \beta_p = 0$ (predictor variables have no effect in the model)

$H_1 : There's\ at\ least\ one\ \beta_i \neq 0, i = 1, 2, \ldots, p$

Since the test statistic G follows the chi-square distribution, the decision criteria are done by comparing $\chi^2(v)$, with v denoting the number of predictor variables and H_0 being rejected if $G > \chi^2(v)$.

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2.9. Partial Test

Partial test is carried out to see whether a predictor variable can be included in the model. The partial test is conducted using the Wald statistic (W), which is obtained from comparing the maximum likelihood estimates of the slope parameters $\widehat{\beta}_i$ with the estimated standard error [9].

$$W = \frac{\widehat{\beta}_i}{\widehat{SE}\,(\widehat{\beta}_i)}. \tag{9}$$

The test statistic W follows the chi-square distribution, hence, the H_0 is rejected if $W > \chi^2(v)$, where v being the number of predictors.

2.10. Measurement of Classification Accuracy

Calculation of classification accuracy in the model is conducted using the geometric mean (G-mean) and area under receiver operating characteristic (ROC) curve (AUC) using formula of expanding G-mean for cases of grouping with more than two categories [9].

$$G_{mean} = \left(\prod_{i=1}^{a} R_i\right)^{1/a} \tag{10}$$

and

$$AUC = \frac{1}{n}\sum_{i=1}^{a} R_i\,;\; R_i = \frac{n_{ii}}{\sum_{l=1}^{c} n_{il}}\,, i = 1, 2, 3, \ldots, a \tag{11}$$

where n_{ii} denote the number of predictions $\widehat{\pi}_i$ appropriately classified to π_i and n_{il} denotes the number of predictions $\widehat{\pi}_i$, which is incorrectly classified to π_i.

3. Results and Discussion

3.1. Descriptive Statistics

Table 2 shows the percentage of PAI Study Program students' faith in each level category.

Table 2. The Percentage of PAI Study Program Students' Faith

Faith Level	Amount	Percentage (%)
Very high	3	5.8
High	19	36.5
Moderate	20	38.5
Low	7	13.5
Very low	3	5.8

Table 2 shows that 3 students exhibit a very high level of faith at 5.8%, 19 students exhibit a high level at 36.5%, 20 students exhibit a moderate level at 38.5%, 7 students exhibit a low level at 13.5%, and 3 students exhibit a very low level at 5.8%. These results indicate that most students exhibited a moderate level of faith, while the very low and high levels were the least, each accounting for the same percentage.

3.2. Independence Test

The independence test revealed a relationship between the predictor variables of belief and attitudes or feelings, respectively, and the response variable of faith level. These results are based on an analysis of data on beliefs, behavior or feelings, and faith level by using the chi-square test statistic.

Table 3. Chi-Square Tests between Belief and Faith Level

	Value	df	Asymptotic Significance (2-sided)
Pearson chi-square	191.153[a]	156	.003
Likelihood ratio	131.147	156	.401
Linear-by-linear association	25.432	1	.000
N of valid cases	52		

Table 4. Chi-Square Tests between Behavior or Feelings and Faith Level

	Value	df	Asymptotic Significance (2-sided)
Pearson chi-square	191.153[a]	156	.029
Likelihood ratio	131.147	156	.927
Linear-by-linear association	25.432	1	.000
N of valid cases	52		

Based on Table 3 and Table 4, the chi-square value between the belief variable and the level of faith is 0.003 < 5%, hence, the null hypothesis is rejected. These results demonstrate a relationship between the belief variable and the level of faith. An analogy to the analysis result of the relationship between behavior or feeling variables and the level of faith was also yielded a chi-square value of 0.029 < 5%.

3.3. Parameter Estimation and Building of Multinomial Logistics Regression Model

The estimated parameters were used to build a multinomial logistic regression model, with a very low level of faith set as the baseline. Parameter estimation was also utilized to determine the significance of the predictor variables of the formed model. The following are the results of parameter estimation and the four of formed models from the faith dataset of the PAI Study Program students at UIN Saizu Purwokerto.

Table 5. Parameter Estimates

Faith Level		B	Std. Error	Wald	df	Sig.	Exp(B)
Very High	Intercept	-2703.357	10642.745	.065	1	.799	
Belief		7.208	.352	418.414	1	.000	
Behavior or feeling		4.151	45.423	.008	1	.927	1350.839 63.499
High	Intercept				1		
Belief		-3332.522	10645.736	.098	1	.754	4338.298
Behavior		8.375	.593	199.686	1	.000	232.403
or feeling		5.448	45.426	.014		.905	
Moderate	Intercept	-2906.499	10642.553	.075	1	.785	
Belief		7.514	.000	.	1	.	1834.177
Behavior		4.673	45.424	.011	1	.918	107.039
or feeling							
Low	Intercept	-349.022	8606.845	.002	1	.968	
Belief		.546	27.710	.000	1	.984	1.727
Behavior		1.008	37.538	.001	1	.979	2.739
or feeling							

Based on the parameter estimation results in Table 5, the four of the logistic regression models can be formed:

$$Logit\ (Y) = -2703{,}36 + 7{,}21X_1 + 4{,}15X_2 \quad (12)$$

$$Logit\ (Y) = -3332{,}52 + 8{,}38X_1 + 5{,}45X_2 \quad (13)$$

$$Logit\ (Y) = -2906{,}50 + 7{,}51X_1 + 4{,}67X_2 \quad (14)$$

$$Logit\ (Y) = -349{,}02 + 0{,}55X_1 + 1{,}008X_2 \quad (15)$$

The interpretation of the predictor variables' meanings in the four models was based on their significance values. If the p-value is less than 0.05, the associated predictor variable is considered significant. Table 5 also demonstrates that (12) compared the probability of students having a very

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high faith level with a very low one, and the significant predictor variable is only the dimension of belief. Equation (13) is of a high level rather than very low, and a predictor variable, i.e., a meaningful dimension, is belief. Meanwhile, (14) indicates a moderate level rather than a very low level and the significant predictor variable is the dimension of belief. Furthermore, (15) indicates a low level rather than a very low level, and there are no significant predictor variables. Overall, based on the logistic regression model formed and its significance, if the concept of faith is not built from belief and behavior or feeling, the probability of students having very low faith is very low because all intercept values are negative. At the same time, the coefficient of the belief variable in (12) and (13) is positive, then the probability of students having a very high or high level of belief is greater than a very low level.

3.4. Model Suitability Testing (Goodness of Fit)

Goodness of fit test was used to test whether the model was appropriate or matched the observed values or empirical data. The test results were done by examining the significance value, where a value greater than 0.05 indicates a good significance.

Table 6. Goodness of Fit

	Chi-Square	df	Sig.
Pearson	12.302	196	1.000
Deviance	12.144	196	1.000

Table 6 presents results indicating a significance value of 1,000 > 0.05, meaning that the model was appropriate or compatible with observational or empirical data. These results show that the model can explain the data well.

3.5. Measure of Goodness

The results of data analysis to determine the goodness of fit model are presented in Table 7.

Table 7. Determinant Coefficient (R-Square) of Nagelkerke

	Value
Cox and Snell	0.912
Nagelkerke	0.980
McFadden	0.913

Table 7 shows that all predictor variables can explain variations in the response variable. It is also seen in Table 6 where the R^2 Nagelkerke value is greater than the R^2 Cox and Snell value. These results prove that the R^2 Nagelkerke is the correction or improvement of the R^2 Cox and Snell. The R^2 Nagelkerke value in Table 6 is 0.980, meaning that the variability of the response variable can be explained by the variability of the predictor variable by 98%. The analysis of this dataset indicates that the faith level of PAI Study Program students is built by the dimensions of belief, behavior, and feeling, which can be trusted at 98%. This also suggests that these two dimensions account for approximately 98% of the influence on faith level.

The magnitude of the influence of 98% on students of the PAI Study Program at UIN Saizu Purwokerto was smaller than that of the Mathematics Education Study Program, which had 100%, with similarities in more dominant beliefs, and the highest level of faith is moderate [16]. This suggests that the behavior or feelings of students of the PAI Study Program are not only influenced by their beliefs but also by other factors. This is different from students of the Mathematics Education Study Program whose behavior or feelings are only influenced by their beliefs. This condition implies that the study program can predict the students' faith level by observing their behavior as behavior refers to belief [7].

3.6. Overall Test (Model Fitting Information)

The model goodness test (model fitting) was used to test whether the addition of predictor variables improves the model's performance. This test is often referred to as a simultaneous or overall

test. The overall test in this study aims to test whether the use of two dimensions of faith can make the model better in explaining the faith level of PAI Study Program students. The test was carried out using -2 log-likelihood statistic.

Table 8. Model Fitting Information

Model	Model Fitting Criteria	Likelihood Ratio Tests		
	-2 Log-Likelihood	*Chi-Square*	*df*	*Sig.*
Intercept only	138.785			
Final	12.144	126.642	8	.000

The results of the -2 log-likelihood statistical calculation, as presented in Table 8, show that the model performed better when predictor variables were included compared to the model containing only the intercept. The -2 log-likehood statistic with only the intercept achieved a value of 138.785The table shows a decrease in the chi-square value to 126.642 with a significance value of 0.000 < 0.05. This means that the two variables representing dimensions of faith are appropriate for predicting the faith level of PAI Study Program students at UIN Saizu Purwokerto. This also suggests that these two dimensions influence the determination of the faith level of PAI Study Program students and the suitability of the model to be implemented.

3.7. Partial Test

The partial test also was also conducted using the -2 log-likelihood statistic to test the null hypothesis that all influencing parameters were zero. In this test, the significance value of each predictor variable that influenced the response would be seen. If the significance value is less than 0.05 then the null hypothesis is rejected, meaning that each predictor variable partially influences the response variable.

Table 9. Likelihood Ratio Tests

Effect	Model Fitting Criteria	Likelihood Ratio Tests		
	-2 Log-Likelihood of Reduced Model	*Chi-Square*	*df*	*Sig.*
Intercept	109.684	97.540	4	.000
Belief	40.243	28.099	4	.000
Behavior or feeling	74.343	62.199	4	.000

The influence of each of the two dimensions on the faith of PAI Study Program students is presented in Table 9. Based on Table 9, the significance value for each dimension of faith is equal to 0.000, which is smaller than 0.05. This result show that each dimension partially has an influence in explaining the faith of PAI Study Program students.

3.8. Measures of Classification Accuracy

The classification accuracy was used to determine or evaluate the model that had been formed. Table 10 displays the accuracy percentage of the model classification formed in each category.

Table 10. Percentage of Classification Accuracy

Predicted	Classification					
	Predicted					
	Very High	*High*	*Moderate*	*Low*	*Very Low*	*Correct Percentage (%)*
Very high	2	0	1	0	0	66.7
High	0	18	1	0	0	94.7
Moderate	0	1	19	0	0	95.0
Low	0	0	0	7	0	100.0
Very low	0	0	0	0	3	100.0
Overall percentage (%)	3.8	36.5	40.4	13.5	5.8	94.2

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The model's prediction accuracy for the PAI Study Program students at UIN Saizu Purwokerto was 66.7% for very high, 94.7% for high, 95.0% for moderate, and 100% for both low and very low levels of faith. The overall accuracy of the model was 94.2%.

4. Conclusion

Most students' faith level falls within the moderate category, i.e., 38.5%. Conversely, the lowest percentage falls into the category of a low and very high level, with each category possessing a percentage value of 5.8%. Based on the independence test, there is a relationship between the predictor variables of belief and behavior or feelings with the faith level. One of the two predictor variables in the multinomial logistic regression model that significantly influences the level of faith is belief, which will refer to another variable, namely behavior or feeling.

Using predictors of belief and behavior or feeling, the model achieved an accuracy of 94.2% in predicting variations in the faith level of the PAI Study Program students at UIN Saizu Purwokerto who also attend Islamic boarding schools. The highest model accuracy based on variations in the faith level was appropriate for predicting very low and low levels, which was 100%. Meanwhile, the model's accuracy in predicting a very high level of faith was the lowest at 66.7%. This finding implies that the study program can use the model to predict the level of faith of students based on their behavior.

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