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CANONICAL CORRELATION ANALYSIS OF FACTORS AFFECTING NUTRITIONAL STATUS OF UNDER-FIVE CHILDREN IN INDONESIA

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ABSTRACT
The purpose of this study was to analyze the correlation of factors affecting the nutritional status of under-five children in Indonesia in 2015. This study employed a canonical correlation method which aimed to determine the relationship between two variables and identify the dimensions between two groups of variables. The resultsshowed that variables of complete basic immunization, complete neonatal visits, vitamin A, birth weight, and birth height were strongly correlated with malnutrition status and poor nutritional status, but indicated a negative correlation with good nutritional andovernutrition status. The independent variables which gave the highest effects on the decrease of malnutrition and poor nutritional status were complete basic immunization, complete neonatal visits, vitamin A, and birth weight, as they indicated a strong negative and an inversedcorrelation between the two variables.

Keywords : canonical correlation, nutritional status, under-five children.

INTRODUCTION

Good and quality human resourcesplay a significant role in the fulfillment and maintenance of the nation's independence since they become one of the main factors needed for the national development.It is really important that mutually sustainable efforts are made to improve the quality of human resources. One of the factors affecting the quality of human resources is the health and nutrition. Therefore, people will not be able to develop their capacity maximally unless they achieve optimal health and nutritional status (Ministry of Health, 2001).

A good nutritional status is needed to developquality human resources and should essentially begin as early as possible, that is since the human is still in the womb. At this stage, food with sufficient nutrients is badly important. From the food, the humans getsome nutrients which are the basic needs to live and grow. Limited knowledge of how to feed under-five children in terms of the amount, type, and frequency, as well as the health-threateninghabits, will, directly and indirectly,cause malnutrition in children (Husaini et al, 1999).

Having healthy and intelligent children is a dream of every parent. To make it happen, parents should always pay careful attention, watch and care for their children especially during the period of growth and development. Furthermore, childhoodiscrucial for every child and becomes a determining stage of the physical, psychological and cognitive growth and development (Sulistijani, 2001).

The prevalence of poor nutrition in under-five children (weight/U <-2SD) in Indonesia shows a fluctuatingstatistics. In 2007, the prevalence was 18.4% and decreased to17.9% in 2010. Furthermore, the prevalence showed another increaseto 19.6% in 2013. In some provincessuch as Bangka Belitung, East Kalimantan, Central Kalimantan, and Central Sulawesi, the prevalenceexperienced a declining trend. Two provinces were found to have the highest prevalence (>30%) namely East Nusa Tenggara and West Papua. On the other hand, two other provinces (Bali and Jakarta) had the lowest prevalence of <15%. The problem of stunting in under-five children in Indonesia is still quite serious as indicated by the national statistics of 37.2%. This statistics varies from the lowest in Riau Islands, Yogyakarta, Jakarta and East Kalimantan (<30%) to the highest (> 50%) in East Nusa Tenggara. The unchanged prevalence of this nutritional status is likely due to the unevenmonitoring of children's growth and development. Furthermore, it can be seen that the proportion of under-five children that has never been measured for their weight in the past six months had increased from 25.5% in 2007 to 34.3% in 2013(Basic Health Research, 2013).

The prevalence of low birth weight infants reduced from 11.1% in 2010 to 10.2% in 2013. The statistics show a very clear variation across the provinces in Indonesia from the lowest in North Sumatra (7.2%) to the highest in Central Sulawesi (16.9%). For the first time in 2013, data collection regarding the height of newborn was carried out. The results found a national rate of infants with stunting problem (height <48 cm) was 20.2%, and this varied from the highest in East Nusa Tenggara (28.7%) to the lowest in Bali (9.6 %).

There have been some improvementsin the outcomes of child health programs especially the complete basic immunization which increased from 41.6% in 2007 to 59.2% in 2013. However, as many as 32.1% of babies did not receive a complete basic immunization, and 8.7% were found to never receive any immunization due to several reasons. These included the feeling of afraid that the baby might get a fever due to the immunization, ungranted permission from the family, far distance to the immunization center, insufficient information regarding the location of immunization center, and the very crowded activities. The other improved programs of child healthcarewere the complete neonatal visit, which increased from 31.8% in 2007 to 39.3% in 2013, and the administration of vitamin A which increased from 71.5% in 2007 to 75.5% in 2013. Furthermore, exclusive breastfeeding in the last 24 hours of infants of 6-month age also increased from 15.3% in 2010 to 30.2% in 2013. An initiation of early breastfeeding of <1 hour also increased from 29.3% in 2010to 34.5% in 2013 (Research of Basic Health, 2013).

Children who are born with low birth weight have a potential tohave poor nutritionor even malnutrition. This malnutrition will give an impact on the decreased level of intelligence or IQ. Every child suffering from malnutrition is at a risk of losing the IQ of 10 - 13 points. A further impact of malnutrition is the increasing incidence of morbidity and mortality. The growth and development of children require a sufficient intake of energy and protein, and some other micronutrients needed primarily for the production of enzymes, hormones, and regulating biological processes for the growth and development, immune system and reproductive system (Devi, 2010).

This study aimed to analyze the correlation of factors affecting the nutritional status of under-five children in Indonesia by 2015.

MATERIALS AND METHOD

This study described a non-reactive or an unobtrusive study since the researchers used secondary data in the measurement of the utilizedvariables. This study was conducted in April to May 2015and used the resulted data from the Basic Health Research in 2013. In this study, the data included the nutritional status based on the body weight per age, namely malnutritional status (Y_1), poor nutritional status (Y_2), good nutritional status (Y_3), overnutritional status (Y_4), complete basic immunization (X_1), complete neonatal visit (X_2), administration of vitamin A (X_3), birth weight (X_4) and birth height (X_5) in 33 provinces in Indonesia.

The data were analyzed by using the canonical correlation method. According to Siregar (2006), canonical correlation analysis is a multivariate statistical model which identifies and quantifies the relationship between two sets of variables. The general form of canonical function in this study is shown in formula 1.

$$Y_1 + Y_2 + Y_3 + Y_4 = X_1 + X_2 + X_3 + X_4 + X_5 \quad (1)$$

In which:
Y_1:Malnutrition status
Y_2: Poor nutritional status
Y_3: Good nutritional status
Y_4:Overnutrition status
X_1: Complete basic immunization
X_2: Complete neonatal visit
X_3:Provision of vitamin A
X_4: Birth weight
X_5: Birth length

RESULT AND DISCUSSION

A. Testing of Assumption

Before processed by usingthe canonical correlation analysis, the data should meet some assumptions, including multivariate normality, free of multicollinearity, and showed linearity between the variables.

1. *Normality Test*

The purpose of normality test was to ascertainwhether the distribution of data was or close to the normal distribution. The “good” data should show a normal pattern that is like the bell–shaped curve.

The normality test on the multivariate data is actually very complex since it should be performed in all variables together. However, this test can be performed on each variable, with a logical reasoning that if individually each variable meets the assumption of normality, then the multivariate variables can also be considered to meet the assumption of normality.

The hypothesis states:

H_0: dataare normally distributed

H_1: data are abnormally distributed

Normal multivariate assumption testing in this study was conducted by using the Kolmogorov-Smirnov test. If the obtained significance value is <0.05, then H_1 is accepted, which means that the data is abnormally distributed, and if the significance valueis >0.05, H_0 is accepted, which means the data is normally distributed. The results of the Kolmogorov-Smirnov test were presented in table 1.

Table 1. Results of normality test of the data

Variables	Kolmogorov-Smirnov Sig.
Y_1 (malnutrition status)	0.799
Y_2 (poor nutritional status)	0.295
Y_3(good nutritional status)	0.950
Y_4 (overnutritional status)	0.528

Based on the above table, it could be seen that the significance value of the 4 variables was >0.05, therefore, H0 was accepted, meaning that the data were normally distributed. Thus, the normal multivariate assumption on the variables of malnutritional, poor nutritional, good nutritional and overnutrition statuses wasfulfilled.

2. *Multicollinearity Test*

Multicollinearity test aimed to determine a definite linear relationship among the independent variables, which could be identified by investigating the variance inflation factor (VIF). If the VIF was <10, then multicollinearity did not occur. The multicollinearity results for the dependent variables of Y_1, Y_2, Y_3 and Y_4were shown in Table 2, 3, 4 and 5.

Table 2. Multicollinearity Test of Dependent Variable Y_1

Independent variables	VIF	Notes
X_1	3.012	Free of multicollinearity
X_2	3.021	Free of multicollinearity
X_3	2.914	Free of multicollinearity
X_4	1.493	Free of multicollinearity
X_5	1.053	Free of multicollinearity

Table 3. MulticollinearityTest of Dependent Variable Y2

Independent variables	VIF	Notes
X_1	3.012	Free of multicollinearity
X_2	3.021	Free of multicollinearity
X_3	2.914	Free of multicollinearity
X_4	1.493	Free of multicollinearity
X_5	1.053	Free of multicollinearity

Table 4. Multicollinearity Test of Dependent Variable Y3

Independent variables	VIF	
X_1	3.012	Free of multicollinearity
X_2	3.021	Free of multicollinearity
X_3	2.914	Free of multicollinearity
X_4	1.493	Free of multicollinearity
X_5	1.053	Free of multicollinearity

Table 5. MulticollinearityTest of Dependent Variables Y4

Independent variables	VIF	Notes
X_1	3.012	Free of multicollinearity
X_2	3.021	Free of multicollinearity
X_3	2.914	Free of multicollinearity
X_4	1.493	Free of multicollinearity
X_5	1.053	Free of multicollinearity

3. *Linearity Test*

Linearity among the independent and dependent variable was tested by using a curve. The model was said linear if the plot between the standardized residual values and the standardized prediction values did not form a particular pattern.

The results of the linearity test based on figure 1, 2, 3 and 4 found that the plot of data regarding the malnutrition status, poor nutritional status, good nutritional status, and overnutrition statusdid not form a specific pattern. Therefore, the results of linearity assumption among the variables were fulfilled.

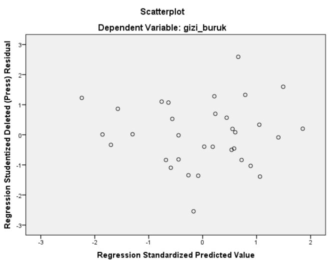

Figure 1. Linearity test on malnutrition status

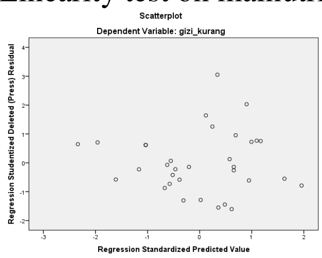

Figure 2. Linearity test on poor nutritional status

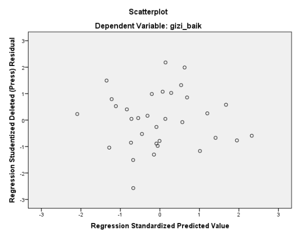

Figure 3. Linearity test on good nutritional status

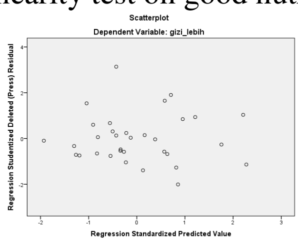

Figure 4. Linearity test on overnutritional status

B. Formationof canonical function

The first step of canonical correlation analysis was to obtain one or more canonical functions. Each canonical function consisted of a pair of variables, one representing the independent variableand another one describing the dependent variable. The formation of the canonical function was used as a determination of a function that could be further analyzed for use in the interpretation of the results of canonical variates. This study involved 4 dependent variables so that there would be 4 canonical functions formed. Of the four functions, two types of tests (individual and joint tests) were performed for determining the functions that could be analyzed further. Individual tests were shown in Table 6 and Table 7.

Table 6 Eigenvalues and canonical relationships

Root No.	Eigenvalue	Pct.	Cum Pct.	Canon Cor.	Sq. Cor
1	1.65328	71.04864	71.04864	.78937	.62311
2	.48682	20.92077	91.96942	.57221	.32742
3	.12379	5.31997	97.28939	.33190	.11016
4	.06308	2.71061	100.00000	.24358	.05933

Table 6 showed that the determination of functions 1, 2, 3 and 4 which could be further analyzed could be seen from the results of the value in the canonical correlation value. The standard value used in the canonical correlation was ≥ 0.5; therefore, if the resulted value exceeded the limit, then the function could be analyzed further. A canonical correlation value >0.5 indicated that the function could be further analyzed for interpretation of canonical variates. Thus, function 1 with a value of 0.78937 and function 2 with a value of 0.57221was chosen for further analyses.

The canonical functionswhich could be further analyzed for the interpretation of canonical variates in individual tests were determined based on the dimensionality reduction analysis by considering their significance values. The significance value should be ≤ 0.05. The result of dimensionalityreduction analysis can be seen in table 7 below.

Table 7. Analysis of dimensionality reduction

Roots	Wilks L.	F	Hypoth. DF	Error DF	Sig. of F
1 TO 4	.21218	2.39995	20.00	80.55	.003
2 TO 4	.56298	1.34269	12.00	66.44	.217
3 TO 4	.83705	.80612	6.00	52.00	.570
4 TO 4	.94067	.85152	2.00	27.00	.438

Based on the results in the Sig of F column, which tested the significance of the canonical function, it could be seen that the significance values for functions 1, 2, 3 and 4 were consecutively 0.003, 0.217, 0.570 and 0.438. Of these results, the significance value of function 1 was far below 0.05, and thus this function was individually significant and could be further analyzed. Meanwhile, function 2, 3 and 4 showed the significance value of >0.05 and thus could not be individually considered for a further analysis.

The formation of further canonical function hereinafter was ajoint test with 3 procedures, including the Pillai's, Hotelling's and Wilks tests to find out whether functions 1, 2, 3 and 4 were jointly significant and could be further analyzed. The significance value used in the joint test was <0.05. The results of the joint test were presented in table 8.

Table 8. Results of the Pillai's, Hotelling's and Wilks Tests

Name	Value	Approx. F	Hypoth.DF	Error DF	Sig.of F
Pillais	1.12002	2.10006	20.00	108.00	.008
Hotellings	2.32697	2.61785	20.00	90.00	.001
Wilks	.21218	2.39995	20.00	80.55	.003
Roys	.62311				

Based on the above table, it could be seen that the overall value of the Pillai's, Hotelling's and Wilks tests in the Sig column of F showed a significance value of <0.05, namely 0.008, 0.001 and 0.003. Thus, if combined together, the canonical functions 1, 2, 3 and 4 were significant and could be further processed.

Based on the results of the individual tests, the selected function for further analysis was the canonical functions 1. According to Santoso (2010), there were indeed differences between the individual and collective testing, and as a guideline, further analyses could be determined from the high canonical correlationvalue.

C. Interpretation of canonical variates

After the canonical function 1 was found significant, the next step was to interpret the results of canonical variates existing in function 1. The interpretation of canonical variates was aimed at determining relationships between the independent variables in the canonical function and the dependent variables being measured. The analytical limit of analysis was ≥ 0.5. If the value generated was above the limit, therefore, a high correlation or a strong positive relationship was existing.

Canonical variate measurements could be done in two ways: canonical weights and canonical loadings.

Table 9 Canonical weight for dependent variates

Variables	Correlational value
Malnutritionstatus (Y_1)	8.84792
Poor nutritional status (Y_2)	10.56620
Good nutritional status (Y_3)	14.94837
Overnutritional status (Y_4)	5.02523

Table 10 Canonical weight for independent variates

Variables	Correlational value
Complete basic immunization (X_1)	.68322
Complete neonatal visit (X_2)	-.72327
Provision of Vitamin A (X_3)	.96887
Birth weight (X_4)	-.65708
Birth height (X_5)	.00200

Based on table 9, it could be seen that the correlational value of the dependent variables (malnutrition status (Y_1), poor nutritional status (Y_2), good nutritional status (Y_3) and overnutrition status (Y_4)) hada strong positive relationship with the independent variables (complete basic immunization (X_1), complete neonatal visits (X_2), administration of vitamin A (X_3), birth weight (X_4), and birth length (X_5)), since the valuewas above the limit of 0.5.

Based on table 10, it was identified that out of 5 independent variables, only birth height (X_5) showed a low correlational value towards the dependent variable. Meanwhile, other independent variables including the complete basic immunization (X_1), complete neonatal visits (X_2), vitamin A (X_3) and birth weight (X_4) showed a correlation or strong positive relationship with the dependent variable sincethey hadthe correlational value of above the limit of 0.5.

In addition to an analysis using the canonical weight, the interpretation was also undertaken by considering the value of canonical loadings. The results of the canonical loading analysis were presented in table11 and table 12.

Table 11. Canonical loadings for dependent variates

Variables	Correlational value
Malnutrition status (Y_1)	.97039
Poor nutritional status (Y_2)	.74632
Good nutritional status (Y_3)	-.93609
Overnutritional status (Y_4)	-.29423

Table 12. Canonical loadings for independent variates

Variables	Correlational value
Complete basic immunization (X_1)	-.81499
Complete neonatal visist (X_2)	-.90034
Provision of Vitamin A (X_3)	-.62503
Birth weight (X_4)	-.77867
Birth height (X_5)	-.22224

Based on table 11 and table 12, a correlational function of canonical loadings could be obtained, namely $0.97039Y_1 + 0.74632Y_2 + (-0.93609Y_3) + (-0.29423Y_4) = (-0.81499X_1) + (-0.90034X_2) + (-0.62503X_3) + (-0.77867X_4) + (-0.22224X_5)$.From this model, the correlational value of malnutrition status (Y_1) and poor nutritional status (Y_2) indicated a high correlation or a strong positive correlation with the independent variables: complete basic immunization (X_1), complete neonatal visits (X_2), vitamin A (X_3), birth weight (X_4) and birth length (X_5) as their values were above the measurement limit of 0.5. Meanwhile, good nutritional status (Y_3) was highly correlated but indicated a strongnegative relationship with the independent variablessince it had a value above the limit of 0.5. Furthermore, overnutritional status (Y_4) showed a low correlational value and a weak negative relationship with the independent variables because it had a value below the measurement limit.

Based on the correlation function of canonical loadings for the independent variables, of the 5 independent variables, there was only one variable (birth weight (X_5)) that indicated a low correlation or a weak negative relationship with the dependent variable, since the correlation value was below the measurement limit of 0.5. Meanwhile, the other independent variables had a high correlational value or a strong negative relationship with the dependent variablesas the value was above the measurement limit of 0.5.

Based on the above calculation, the following results were identified:

a. Four dependent variables and 5 independent variables had a significant relationship. In other words, there was a relationship between the nutritional status and complete basic immunization, complete neonatal visit, provision of vitamin A, birth weight and birth length if they were tested in groups.

b. Of all 5 independent variables, one variable (i.e. birth weight) indicated no relationship. The other four variables: complete basic immunization, complete neonatal visit, provision of vitamin A, and birth weight had a very high but negative relationship. Thus, it could be interpreted that children who did notreceive complete basic immunization, did not attend a complete neonatal visit, were not given vitamin A, and born with abnormal birth weight could experience malnutrition status or poor nutritional status.

CONCLUSION

1. Assumption testing of the data before they were analyzed by using the canonical correlation was performed. The results revealed that the data were of thenormal distribution, free of multicollinearity, and linear between variables or yielded in a curve which did not form a certain pattern.
2. Variables of complete basic immunization, complete neonatal visit, vitamin A, birth weight and birth height had a strong positive correlation with malnutrition status and poor nutritional statusbut showed a negative correlation with good nutritional status and overnutrition status.
3. The independent variables which gave the highest effects on the decrease of malnutrition status and poor nutritional status were complete basic immunization, complete neonatal visit, administration of vitamin A, and birth weight since they had a strong negative and an inversedcorrelationbetween both variables.

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