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Structural Equation Model Data In Case of Double Burden Malnutrition On Brain Development

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Abstract
Malnutrition is the condition of poor health as a result of an imbalance nutrient intake and the body needs at some times. The causes of malnutrition are the social stasus, food consumption, nutritional status and brain development. The variables can not be measured directly but through indicators that reflection of constructs. It is called latent variables, while the measured constructs indicators is called indicator variables (manifest). To know the relationship about the variables we used methods of structural equation modeling. The data used in this study about double burden malnutrition cases in some areas of Bogor. Structural equation models we established is a structural equation model for cases of over nutrition and under nutrition. Structural equation model of over nutrition has greater value of GFI than the structural equation modeling under nutrition. In the model of over nutrition, the indicator variable of memorizing ability give bigger influence to the latent variables of brain development. While, on the model of under nutrition, the IQ indicator variables provide a greater influence on the the brain development of the latent variables.

Keywords: double burden malnutrition, structural equation model, latent variable.

Introduction

Indonesia is currently experiencing nutritional problems which are quite complex, because based on the Global Nutrition Report on 2014, Indonesia include in the 17 countries among the 117 countries that have a third of malnutrition, i.e stunting, wasting and overweight. Malnutrition in early life has a serious impact on the quality of human resources in the future. Nutritional status and society health depends on the level of food consumption. Today Indonesia is facing a double burden of malnutrition, namely the problem of undernutrition and overnutrition. Undernutrition commonly caused by poverty, lack of food supplies, lack of good quality environment (sanitation), the lack of public knowledge about nutrition, balanced diets and health, and the nutrient-poor areas (iodine). Instead overnutrition is caused by economic progress in specific segments of society coupled and the lack of knowledge about nutrition, balanced diets, and health [3].

Based on some causes of malnutrition, it is known that in order to determine the social status, food consumption, nutritional status and brain development, it cannot be measured directly but measured through the indicators as reflection or explanation of constructs or concepts should be measured. Therefore, such a construct is called latent variables, while the measured constructs indicators called indicator variables [5]. Boolen (1989) used structural equation modeling (Structural Equations Modeling) that can simultaneously analyze relative complicated relationship with some or all variable form of latent variables. The relationship between latent variables presumed through structural model built by the measurement model that contains the relationship between indicators with latent variables. Complete structural equation modeling consists of the structural model and the measurement model. Measurement model used to estimate the relationship between latent variables with manifest variables and structural models used to predict the relationship between latent variables. The research will be studied the relationship between the social economy, the volume of milk consumption, nutritional status, and brain development using structural equation modeling. The purpose of this research is to build a prediction model of structural equation and pass analysis model for case data of double burden malnutrition, and to analyze the relationship between latent variables and indicator variables.

Data and Method

Data

The data used in this study comes from research dissertation Eny Palupi [4]. Parameters measured when the research is a latent variable that consists of several indicator variables listed in Table 1.

Table 1: Latent variable and manifest variable

Latent variable	Manifest variable
Socioeconomic status	X1 : Paternal age (year) X2 : Father's education (year) X3 : Maternal age (year) X4 : Mother's education year) X5 : Number of family X6 : Income/month (Rp)
The volume of milk consumption	Y1 : Condensed milk (ml/day) Y2 : Powder milk (ml/day)
Nutritional status	Y3 : *Body mass index* (BMI:kg/m^2)
Brain development	Y4 : IQ (score) Y5 : EQ (score) Y6 : Memory (score) Y7 : Attention (score) Y8 : Learning (score)

Method of Analysis

Broadly speaking, the stages of data analysis on this study consist of:

1. Data Exploration
   On this stage associative analysis will be done using regression analysis between each variable. To see the relationship between the indicators variables and latent variables.
2. Build structural equation model
   Stages in building a structural equation model generally consists of:
   i. Model exploration
   On this model exploration will be built null models and structural equation modifications models, will then be taken the best one by looking at the parsimonious goodness of fit index (PGFI).
   ii. Model specification, there are three steps in the model specification, i.e:
   - Measurement model specifications
     Endogenous variable

$$\begin{bmatrix}Y_1\\Y_2\end{bmatrix}=\begin{bmatrix}\lambda^y_{11}\\\lambda^y_{21}\end{bmatrix}\text{the volume of milk consumption}+\begin{bmatrix}\varepsilon_1\\\varepsilon_2\end{bmatrix}$$

$$[Y_3]=[\lambda^y_{32}]\ \text{nutritional status}\ +[\varepsilon_3]$$

$$\begin{bmatrix}Y_4\\Y_5\\Y_6\\Y_7\\Y_8\end{bmatrix}=\begin{bmatrix}\lambda^y_{43}\\\lambda^y_{53}\\\lambda^y_{63}\\\lambda^y_{73}\\\lambda^y_{87}\end{bmatrix}\text{brain development}+\begin{bmatrix}\varepsilon_4\\\varepsilon_5\\\varepsilon_6\\\varepsilon_7\\\varepsilon_8\end{bmatrix}$$

     Exogenous variable

$$\begin{bmatrix}X_1\\X_2\\X_3\\X_4\\X_5\\X_6\end{bmatrix}=\begin{bmatrix}\lambda^x_{11}\\\lambda^x_{21}\\\lambda^x_{31}\\\lambda^x_{41}\\\lambda^x_{51}\\\lambda^x_{61}\end{bmatrix}\text{socioeconomic status}+\begin{bmatrix}\delta_1\\\delta_2\\\delta_3\\\delta_4\\\delta_5\\\delta_6\end{bmatrix}$$

   - Structural model specifications
     the volume of milk consumption $=\gamma_{11}$ socioeconomic status
     nutritional status $=\gamma_{12}$ the volume of milk consumption
     brain development $=\gamma_{13}$ nutritional status
   - Path diagram, shown in Figure 1.

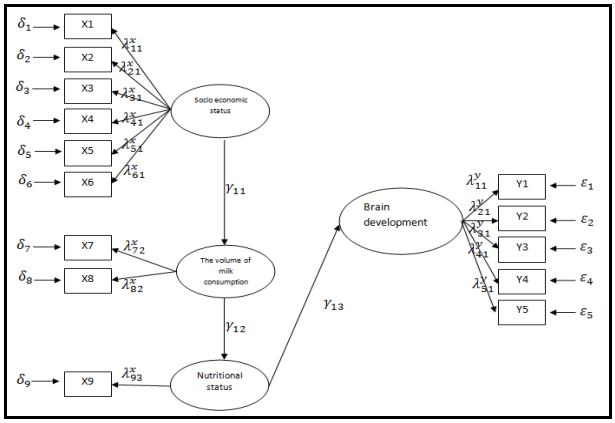

Figure 1: Path diagram of structural equation model

Note : X1 : paternal age (year), X2 : father's education (year), X3 : maternal age (year), X4 : mother's education (year), X5: number of family, X6 : Income/month (Rp), Y2 : powder milk (ml/day), Y1 : condensed milk (ml/day), Y3 : *Body mass index* (BMI:kg/m^2), Y4 : IQ (score), Y5 : EQ (score), Y6 : memory (score), Y7 : Attention (score), Y8 : learning (score).

iii. Estimation model used in structural equation models are unweighted least squares estimation.
iv. Test of model compatibility
The first step in interpreting the resulting model is to assess whether the model is proper or not. There is no single measure to assess the properly of a model. Some researchers suggest to use at least three test of model compatibility. There are several measurement of models compatibility those are Root Mean Square Error of Approximation (RMSEA), Goodness of Fit Index (GFI), and Root Mean Square Residual (RMSR) [1].

Result and Discussion

Data Exploration

To see the relationship about latent variables, then tested by regression analysis. In the regression analysis, the variables used is the social economy, the volume of milk consumption, nutritional status and brain development that has been standardized. Each of these variables produce different level of real influence. The real influence level seen from p-values listed in Table 2.

In Table 2 we can see that the social economy has a real impact on the volume of milk consumption, which is marked with a p-value < α (0.05). The volume of milk consumption also have a real impact on nutritional status. Instead of nutritional status did not significantly affect brain development, which is marked with a p-value> α (0.05). Socio-economic has a real impact on nutritional status. Regression analysis result of all latent variables in Table 2,

illustrates some latent variables do not have a real influence directly. So that based on that results of the regression analysis, it will be further analyzed using structural equation modeling.

Table 2: Simple regression analysis about latent variables

Associative	p-value
The volume of milk consumption with socioeconomic status	0.000
Nutritional status with The volume of milk consumption	0.000
Brain development with Nutritional status	0.118
Nutritional status with socioeconomic status	0.000
Brain development with socioeconomic status	0.682
Brain development with The volume of milk consumption	0.432

Structural Equation Model

Based on the results of data exploration then built several structural equation model on double burden of malnutrition data toward brain development by the method of unweighted least square which listed on Table 3. On this Table 3 can be seen several values of proper test for several structural equation model. Based on the value of parsimonious proper test (PGFI) on the models for overnutrition case, null models and modifications models have the same value, but the modification models have smaller RMSEA and RMR value. In the case of undernutrition, null model has values of parsimonious compatibility test (PGFI) is greater than the modified model. Thus taken further discussion about the modified model for overnutrition cases.

Table 3: Exploration structural equation models

Proper test	Null Model (over+ normal)	Modifications Model (over+ normal)	Null Model (normal+ under)	Modifications Model (normal+ under)
GFI	0.89	0.89	0.87	0.87
PGFI	0.63	0.63	0.63	0.62
RMSEA	0.13	0.12	0.13	0.13
RMR	0.11	0.10	0.12	0.12

Note: GFI (Goodness of Fit Index), PGFI (Parsimonous Goodness of Fit Index), RMSEA (Root Mean Square Error), RMR (Root mean Square Residual)

The allegation results of cross coefficient measurement model on the modified model for overnutrition cases are presented in Figure 2. Based on those results can be established model of measurement and structural i.e:

- Measurement model for endogenous variable

$$\begin{bmatrix} Y_1 \\ Y_2 \end{bmatrix} = \begin{bmatrix} 1.00 \\ 1.47 \end{bmatrix} \text{the volume of milk consumption} + \begin{bmatrix} 1.09 \\ 1.19 \end{bmatrix}$$

$$[Y_3] = [0.69]\ \text{nutritional status} + [0.53]$$

$$\begin{bmatrix} Y_4 \\ Y_5 \\ Y_6 \\ Y_7 \\ Y_8 \end{bmatrix} = \begin{bmatrix} 0.17 \\ 0.07 \\ 0.96 \\ 0.13 \\ -0.54 \end{bmatrix} \text{brain development} + \begin{bmatrix} 0.97 \\ 0.99 \\ 0.10 \\ 0.98 \\ 0.71 \end{bmatrix}$$

- Measurement model for exogenous variable

$$\begin{bmatrix} X_1 \\ X_2 \\ X_3 \\ X_4 \\ X_5 \\ X_6 \end{bmatrix} = \begin{bmatrix} 0.18 \\ 0.84 \\ 0.34 \\ 0.79 \\ 0.21 \\ 0.65 \end{bmatrix} \text{socio-economic status} + \begin{bmatrix} 0.97 \\ 0.29 \\ 0.88 \\ 0.38 \\ 0.96 \\ 0.58 \end{bmatrix}$$

- Structural model

the volume of milk consumption = 0.27 socio economy status

nutritional status = 0.72 socio-economic status – 0.39 the volume of milk consumption

brain development = -0.12 nutritional status

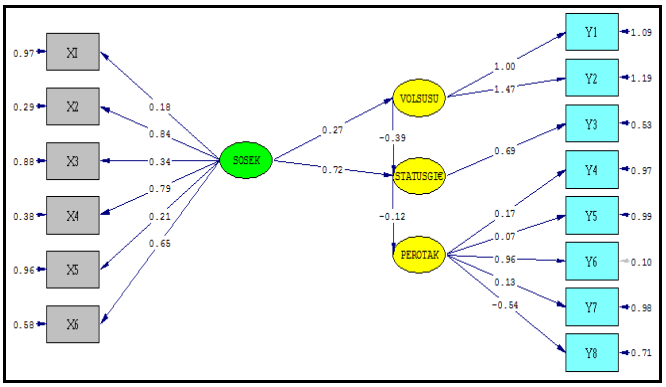

Figure 2: Structural Equation Modeling with ULS method

Note : X1 : paternal age (year), X2 : father's education (year), X3 : maternal age (year), X4 : mother's education (year), X5: number of family, X6 : Income/month (Rp), Y2 : powder milk (ml/day), Y1 : condensed milk (ml/day), Y3 : *Body mass index* (BMI:kg/m^2), Y4 : IQ (score), Y5 : EQ (score), Y6 : memory (score), Y7 : Attention (score), Y8 : learning (score).

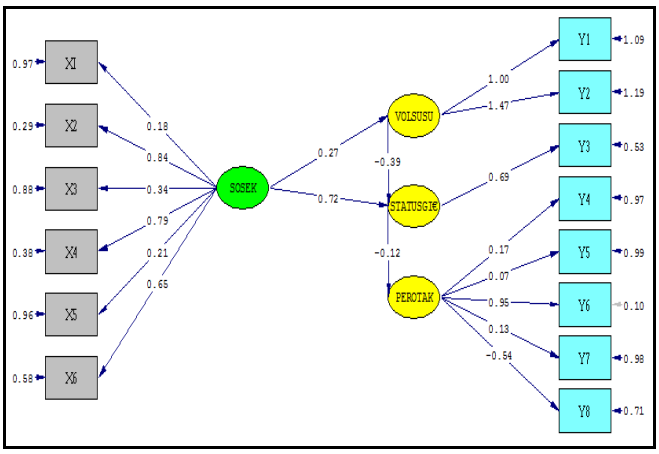

Figure 3: Value loading factor indicator variables

Figure 3 shows the values loading factor indicator variables toward latent variables. Based on Figure 3, there are several indicators that are not influential in describing the latent variables. It is indicated by the value loading factor indicator variable which is < 0.5. However, in this case the indicator variables that do not have a big influence in describing the latent variables will not be discarded, because the indicator

variables in the latent variables have been defined (fixed). Indicator variables that give most influence the latent variable is X2 (the old father's education), X4 (old maternal education), X6 (income / month). As for the volume of milk consumption is variable Y1 (condensed milk), as well as Y6 (ability to memorize) become indicator variables that most influence on brain development.

In Figure 2 and Figure 3 show that not all good indicator variables in describing the latent variables. Based on Figure 2 it is known that a large cross coefficient of socio-economic to the volume of milk consumption by 0.27 with a positive direction, it means increasing socioeconomic then will make volume increased milk consumption. Great socio-economic influence directly on the volume of milk consumption $(0.27)^2 = 0.0729$, so based on survey results revealed that 0.0729 increase occurred in the volume of milk consumption is directly due to an increase in the social economy. Great socio-economic influence directly on the nutritional status of $(0.72)^2 = 0.5184$, so based on survey results revealed that 0.5184 improvement occurred in the nutritional status directly caused by an increase in the social economy.

Based on the existing values in Figure 2 it is known that large cross coefficient of volume of milk consumption on the nutritional status of 0.39 with negative direction, means decreasing the volume of milk consumption will make the nutritional status decreased. Great influence directly the volume of milk consumption to the nutritional status of (-0.39) 2 = 0.1521, so based on the survey results revealed that the 0.1521 decline that occurred in the nutritional status directly caused by the decrease in the volume of milk consumption. Besides being able to calculate the direct effect, it can also be seen total influence and the indirect influence over variables. Total and indirect influence of latent socio-economic variables to other latent variables listed in Table 4.

Table 4: Effect of socio-economic against endogenous latent variables

Latent variable	Socio economy
Total	
The volume of milk consumption	0.28
Nutritional status	0.54
Brain development	-0.06
Direct	
The volume of milk consumption	0.27
Nutritional status	0.72
Brain development	Nothing
Indirect	
The volume of milk consumption	Nothing
Nutritional status	-0.15
Brain development	-0.06

Once the model is established, the next step is measuring the reliability level of variables in reflecting the latent variables. Testing is done by using the value of construct reliability (CR) which results are listed in Table 5. Table 5 shows that the value of CR is quite diverse, and there are several variables which are quite reliable. This is because the number of indicators variables that reflect the latent variables are still lacking. Measurement the feasibility of the formed model using the values listed in Table 6. On table 6 it can be seen that the model established by the structural equation model is not yet fully meet the ideal value. However, if viewed from the goodness of fit, the model shows the empirical state from the data in accordance with the proposed model or models properly claimed. This is still consistent with the theory that used in preparing the path diagram at the beginning of the method.

Table 5: Testing the validity and reliability

Criteria	Value CR	Description
All variables (Total)	0.87	Reliable
Socio-economic	0.75	Reliable
The volume of milk consumption	0.50	Quite reliable
Nutritional status	0.61	Reliable
Brain development	0.53	Quite reliable

Note : CR (construct realibility)

Table 6: Criteria for goodness of estimate model

Criteria	Value	The ideal value
RMSEA	0.12	≤ 0.08
GFI	0.89	≥ 0.90
RMR	0.10	Relatively small

Results alleged cross coefficient measurement model on the modified model to the case of deficiency malnutrition is presented in Figure 4. Based on these results it can be established model of measurement and structural models are:

- Measurement model for endogenous variable

$$\begin{bmatrix} Y_1 \\ Y_2 \end{bmatrix} = \begin{bmatrix} 1.00 \\ 1.60 \end{bmatrix} \text{the volume of milk consumption} + \begin{bmatrix} 1.09 \\ 1.01 \end{bmatrix}$$

$$[Y_3] = [0.96] \text{nutritional status} + [0.10]$$

$$\begin{bmatrix} Y_4 \\ Y_5 \\ Y_6 \\ Y_7 \\ Y_8 \end{bmatrix} = \begin{bmatrix} 0.95 \\ 0.13 \\ 0.13 \\ 0.42 \\ 0.02 \end{bmatrix} \text{brain development} + \begin{bmatrix} 0.10 \\ 0.98 \\ 0.98 \\ 0.82 \\ 1.00 \end{bmatrix}$$

- Measurement model for exogenous variable

$$\begin{bmatrix} X_1 \\ X_2 \\ X_3 \\ X_4 \\ X_5 \\ X_6 \end{bmatrix} = \begin{bmatrix} 0.16 \\ 0.80 \\ 0.30 \\ 0.85 \\ 0.11 \\ 0.68 \end{bmatrix} \text{socio-economic status} + \begin{bmatrix} 0.97 \\ 0.36 \\ 0.91 \\ 0.27 \\ 0.99 \\ 0.54 \end{bmatrix}$$

- Structural model

the volume of milk consumption = 0.33 socio-economic status

nutritional status = 0.48 socio-economic status – 0.13 the volume of milk consumption

brain development = -0.01 nutritional status

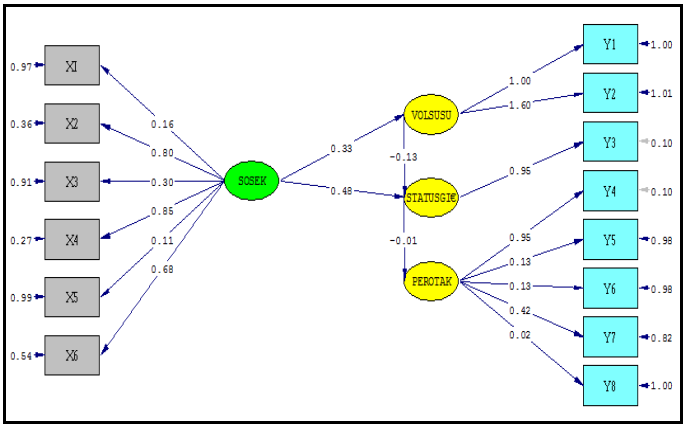

Figure 4: structural equation model with ULS method

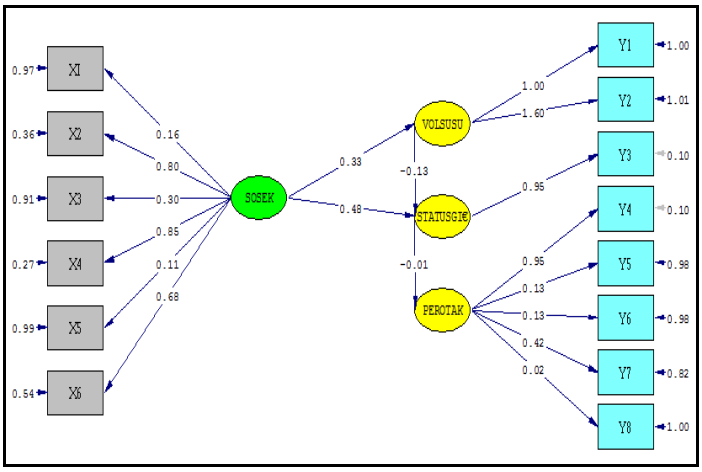

Figure 5: Value loading factor indicator variables

In Figure 5 shows the values of load factor indicator variables for latent variables. Based on Figure 5, there are several indicators that are not influential in describing the latent variables. It is characterized by the value of the indicator variable load factor < 0.5. However, in this case the indicator variables that do not have a big influence in describing the latent variables will not be discarded, because the indicator variables in the latent variables have been defined (fixed). Indicator variables that most give influence for the latent variable is X2 (the old father's education), X4 (the old mother's education), X6 (income / month). As for the volume of milk consumption is variable Y1 (condensed milk), and Y4 (IQ) be the indicator variables that most influence on brain development.

In Figure 4 and 5 shows that not all indicator variables are good in describing the latent variables. Based on Figure 4 it is known that a large cross coefficient of socio-economic to the volume of milk consumption by 0.33 with a positive direction, it means increasing socioeconomic then will make volume increased milk consumption. Great socio-economic influence directly to the volume of milk consumption amounted to $(0.33)^2 = 0.1089$, so based on survey results revealed that 0.1089 increase occurred in the volume of milk consumption is directly due to an increase in the social economy. Socio-economic influence directly on the nutritional status is about $(0.48)^2 = 0.2304$, so based on survey results revealed that 0.2304 improvement occurred in the nutritional status directly caused by an increase in the social economy.

Based on the existing values in Figure 2 it is known that large cross coefficient of volume of milk consumption on the nutritional status of 0.13 with negative direction, means decreasing the volume of milk consumption will make the nutritional status decreased. Great influence of volume of milk consumption directly to the nutritional status of $(-0.13)^2 = 0.0169$, so based on the survey results revealed that the 0.0169 decline that occurred in the nutritional status directly caused by the decrease in the volume of milk consumption. Besides being able to calculate the direct effect, it can be seen also total influence and the indirect influence between variables. Total and indirect influence of latent socio-economic variables to other latent variables listed in Table 7.

Table 7: Socio-economic influence of the endogenous latent variables

Latent variable	Social economy
Total	
The volume of milk consumption	0.33
Nutritional status	0.43
Brain development	0.00
Direct	
The volume of milk consumption	0.33
Nutritional status	0.48
Brain development	Nothing
Indirect	
The volume of milk consumption	Nothing
Nutritional status	-0.04
Brain development	0.00

Once the model is established, the next step is measuring the reliability level of variables to reflect the latent variables. Testing is done by using the value of construct reliability (CR) which results in Table 8. Table 8 shows that the value of CR visible results are quite diverse, and there are several variables that are less reliable. This is because the number of variables indicators that reflect the latent variables are still lacking. Measurement of the formed proper model is using the values listed in Table 9. On Table 9 it can be seen that the model established by the structural equation model is not yet fully meet the ideal value. However, if viewed from the goodness of the model (goodness of fit) it shows the state of empirical from the data in accordance with the proposed model or models are claimed proper. This is still consistent with the theory that used in preparing the path diagram at the beginning of the method.

Table 8: Testing validity and reability

Criteria	CR Value	Description
All variables (Total)	0.87	Reliable
Social economy	0.73	Reliable
The volume of milk consumption	0.50	Fair reliable
Nutritional status	0.94	Reliable
Brain development	0.44	Less reliable

Note : CR (construct realibility)

Table 9: Criteria for goodness of estimate model

Criteria	Value	The ideal value
RMSEA	0.13	≤ 0.08
GFI	0.87	≥ 0.90
RMR	0.12	Quite lilttle

Conclusion

Modifications model on the structural equation model for the overnutrition and undernutrition cases formed based on the results of exploration data. Structural equation model of overnutrition have greater GFI value than the structural equation modeling undernutrition. In the model of overnutrition indicator variable of memorizing gives greater influence towards the latent variables of brain development. While, on the model of undernutrition IQ indicator variables provide a greater influence on the latent variables of brain development.

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