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The Health Status Model in Urban and Rural Society in West Sumatera, Indonesia: An Approach of Structural Equation Modeling

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Abstract

Objective: The main purpose of this study is to apply the Structural Equation Modeling (SEM) approach to model the health status in rural and urban society in West Sumatera, Indonesia. **Methods:** The data set was taken from Primary Health Research that was conducted in the year 2013 in Indonesia. In this study, SEM was applied to 3677 respondents from urban area and 3134 respondents from rural area who lived in West Sumatera, a propince in Indonesia. The survey involved the gathering of information on the respondent's socio-demography, lifestyles, mental health condition, and bio-markers. **Results:** After fitting the data to the hypothesis model, this study highlighted that the health status model for urban area and rural area were different. For urban area's model, socio-demography and mental health condition were found to have a significant direct effect on the health status. However, lifestyle had an indirect effect on the health status, as mediated by the socio-demography. Meanwhile for rural area's model, this study found that socio-demography, lifestyle and mental health had significant direct effect on the health status. **Conclusions:** Both proposed model fitted the data well based on the indicators of goodness-of-fit. Thus, this study proved that SEM was pertinent to be applied for constructing the health status on individual.

Keywords: Health Status, Rural Area, Socio-Demography, Structural Equation Modeling, Urban Area

1. Introduction

There were many studies which have been done in determining the factors of health status[1,2] where they used logistic regression (including cross-tabulation and χ^2 test), path analysis and multilevel logistic technique respectively in their analysis. Those studies found that socio-demography, mental health and lifestyle are significant factors effecting the health. Actually, those factors are latent or not directly observable but are inferred by the relationship or correlation among measured variables in the analysis. Such as socio-demography is measured by socio-economic level, age or gender. Various studies found that structural equation modeling approach is the appropriate method in modeling the interrelationship between observable and unobservable factors simultaneously which describe the health status[3-6]. SEM enables a researcher to test a set of regression equations simultaneously and consider both the direct and indirect effects of variables such as socio-demography, mental health and lifestyle on health status. An overview of structural equation modeling is presented in the next section of this article.

The aim of the current article was to provide an empirical example of the construction for the health status by allowing for the interrelationship among latent variables and their relationship to the health status by applying the structural equation modeling technique. The health status model then implemented to the Primary Health Research data for communities living in rural and urban area in West Sumatera, a province in Indonesia. The health status model described the health condition of particular communities in those areas.

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2. Materials and Methods

2.1 Materials

The analysis is applied on a data set obtained from the Primary Health Research of Indonesia in the year 2007. Primary Health Research is one of the four grand strategy established by Ministry of Health, Republic of Indonesia[7]. This research has been accordance with the ethical standards of the committee responsible for human experimentation as it is written in Helsinki Declaration[8]. The function of research is to support evidence-based health information systems by collecting basic data and health indicators. Some indicators are health status and health determinants which are generated from Henrik Blum's concept that represent the picture of national, province and district area.

Based on the information obtained from the Primary Health Research 2007, West Sumatera was province who had the highest percentages in the habit of eating less fruit and vegetables (97.8%). West Sumatera was a province of total 16 provinces in Indonesia which had Acute Respitory Infection above the national prevalence (25.50%). A total of 14 provinces had prevalence above the national prevalence of pneumonia (2.13%), including West Sumatra. National prevalence of Pulmonary Tuberculosis is 0.99% and West Sumatera was a province that had Pulmonary Tuberculosis prevalence above the national prevalence. Prevalence of Hepatitis of West Sumatera was above 0.60% and as well as its prevalence or diarrhea was above 9.00%[9]. West Sumatera was one of three provinces with lowest IMR (Infant Mortality Rate) (74 per 1,000 live births) based on estimation of 10 years periods of Indonesia Demography and Health Survey (IDHS) from 1998 until 2007[7].

This study modeled the health status in rural and urban area in West Sumatera. The sample of respondents were taken from two cities, i.e. Padang and Bukittinggi, indicated as urban area and two villages, i.e. Padang Pariaman and Agam, denoted as rural area. There were 3677 respondents from urban area and 3134 respondents from rural area who involved in the analysis and provided complete information needed. The research used a questionnaire form to obtain the information from respondents. The information about respondents that used for this study were related to socio-demography status, lifestyle, mental health condition and biomarkers. Information related to individual's biomarkers were measured during a house visit. Respondents were also asked about the number of health problems experienced and their perceptions about their health condition at the time of interview. Complete information regarding the data could be obtained from the Ministry of Health, Republic of Indonesia[8].

In this study, the indicators of interest for assessing the socio-demography factor were gender, age, education level and employment status[1,6,10-12]. Respondents were asked about the gender and the responses were indicated by 1 or 2 as "male" or "female" respectively. The age of respondents were recorded and treated as a continuous variable. Responses to education level were indicated by 1 to 6 as "never attended school", "not graduated elementary school", "elementary school", "junior high school", "senior high school" and "college/university", respectively. With respect to employment status which were treated as nominal variable, the responses obtained were coded from 1 to 13.

The important role of lifestyle as an influence factor on health status of an individual have been proved by many studies[1,2,10-12]. An individual with healthy lifestyle, such as doing physical exercise routinely or not being a smoker, could give positive impact to the health condition of particular individual. Thus, the indicators to measure lifestyle considered in this study were physical exercise, smoking habits and fiber and/or vegetable consumption. With respect to physical exercise, the responses of respondents were coded from 1 to 4 to indicate "rarely", "sometimes", "3 or 4 times in a week", "always" respectively. With respect to smoking habits, respondents were asked about this indicator using the question "did you smoke one month later?". The responses for this question ranged from 1 indicating "yes, every day", 2 referring to "yes, sometimes", 3 for denoting "no, but ever before" and 4 as "never at all". Meanwhile, to know whether or not the respondents consumed fruits and/or vegetables, the respondents were asked the question "how many days in a week do you consume fruits and vegetables in average?". The responses for this question were coded with 1, 2, 3 and 4 referring to "rarely", "sometimes", "almost always" and "everyday".

Another factor that has been proved as determinants of health was mental health[2]. Nakayama et al.[2] showed the significant correlation between physical health and mental health. The indicators of mental health considered in this study were mental health condition and the number of experiences of serious health problems. Respondents were asked about their mental health condition coded by 1 as "bad", 2 as "many problems", 3 referring to "two or three problems" and 4 indicating "no problems". With respect to the number of experiences of serious health problems, the responses of respondents were coded as 1, 2, 3 and 4 referring to "bad", "many problems", "two or three problems" and "no problems" respectively.

Based on many literatures, it was assummed that socio-demography, lifestyle, and mental health were latent factors that were related to the health status of an individual[6,11]. Meanwhile, health status its self was measured by certain indicators. The indicators of health status considered in this study were blood pressure, the subjective judgment of the respondents on their health condition and Body Mass Index (BMI). The classifications that were used for blood pressure level were normal, prehypertension, and high blood pressure, based on the American Heart Association[14] and as used by Yanuar et al[6]. In the Primary Health Research 2007 survey, the respondents were asked about their general health condition by identifying 22 disabilities that which were listed in the questionnaire. In the present study, the respondents who had more than 18 disabilities were considered as "bad" and coded as 1, the respondents who had 11 to 18 disabilities were considered as "unhealthy" and coded as 2, the respondents with 4 to 10 disabilities were coded as 3 indicating "less healthy" and the respondents who had less than 4 disabilities were referred as "healthy" and coded as 4. Meanwhile, the measurement and classifications of BMI as"obese" coded by 1, "underweight or overweight" coded as 2 and "normal" coded as 3 were based on the categories suggested by the Centers for Disease Control and Prevention[13]. BMI of an individual was calculated by dividing the value of body weight and by the square of his/her height.

2.2 Methods

Structural equation modeling was applied to the data obtained from the survey. Before the structural equation modeling was applied, a path model was constructed based on the hypothesized relationships as described above. The hypothesized relationships involved the interrelationships between the latent variables, which included socio-demography, lifestyle, mental health, and the health status, as well as the relationships between the indicators and each individual latent variable. The discussion related to process of modeling in structural equation modeling can also be seen in Yanuar et al.[6]

The process of modeling in structural equation modeling could be thought of as a four-stage process: model specification, model estimation, model evaluation, and model modification[6,14]. To achieve the first process, structural equation modeling involves two major components; namely, the measurement equation and the structural equation. A mathematical expression of the measurement equation model is specified as follows:

$$x = \Lambda_x \xi + \in \quad (1)$$

$$y = \Lambda_y \eta + \delta \quad (2)$$

where $x(m \times 1)$ is random vector of the manifest variable describing the exogenous latent vector $\xi(q1 \times 1)$, and $y(n \times 1)$ is random vector of indicator describing the endogenous latent vector $\eta(q2 \times 1) \cdot \Lambda_x(m \times q1)$ and $\Lambda_y(n \times q2)$ are loading matrices of as obtained from the regressions of x on ξ and y on η respectively, and $\varepsilon(m \times 1)$ and $\delta\,(n \times 1)$ arerandom vectors of error measurements, respectively. It is assumed that ε and δ are independent and uncorrelated with the latent variables ξ and η respectively.

The structural equation, which specifies relationships among the identified latent factors, is defined in mathematical formula as given by:

$$\eta = B\eta + \Gamma\xi + \zeta \quad (3)$$

where $\eta(q2 \times 1)$ is anendogenous random vector of latent variables and $\xi(q1 \times 1)$ is exogenous random vector of latent variable, $B(q2 \times q2)$ is unknown matrix of regression coefficient that represent the causal effects among endogenous latent variables, $\Gamma(q2 \times q1)$ is unknown matrix of coefficients relating ξ and η, and $\zeta\ (q2 \times 1)$ is a random vector of residuals or error measurements in the equations. It is assumed that $(I - B)$ is required to be nonsingular, $\boldsymbol{B}$ has zeros in the diagonal, and, ξ is uncorrelated with ζ.

The next process in structural equation modeling is the estimation of the population parameters. This estimation process is to minimize the difference between the hypothesized matrix and the sample covariance matrix. The hypothesized matrix, denoted as $\Sigma\theta$, is a function of parameter θ, a vector that includes all the unknown parameters, meanwhile the sample covariance matrix, denoted as $\boldsymbol{S}$. Then, a fitting function, denoted by $F(S, \Sigma(\theta))$ is utilized to measure the closenessbetween these two variance covariance matrices $\boldsymbol{S}$ and $\Sigma(\theta)$. In this study, an approach called Robust Weighted Least Square (RWLS) is applied to handle non-normal and/or non-continuous data. This estimation method is not only preferable for data which are non-normal but also for data with small and large sample sizes. The RWLS estimates parameter, standard errors, χ^2, and fit indices based on diagonal elements of the weight matrix derived from the asymptotic variances of the thresholds and latent correlation estimates. One of the software packages available for this estimation is Mplus[15].

After estimation process is done then model evaluation of sample parameters is followed to check how well the specified model fits the data. The criteria for estimation of fit include examination of the solution, measure of overall fit, and detailed assessment of fit. Firstly, parameter estimates with the right sign and size, standard errors within reasonable ranges, correlations of parameter estimates, and squared multiple correlations are commonly used to check for the appropriateness of each variable. Then, the overall model fit is evaluated to see how well the data is fitted by the specified model. The indicators of model fit applied in this study are the Root Mean Square Error of Approximation (RMSEA), comparative fit index (CFI) and Tucker Lewis Index (TLI). RMSEA measures the degree of model adequacy based on population discrepancy in relation to degrees of freedom; a value less than 0.08 is preferred (acceptable). CFI and TLI are examples of an incremental fit index. These types of index compare the improvement of the fit of the proposed model over a more restricted model, called an independence or null model, which specifies no relationships among variables. CFI and TLI ranges from 0 to 1.0, with values closer to 1.0 (or more than 0.80) indicating better fit[16,17]. Mplus, as software that used in this study, also presents the value of χ^2 and Weighted Root Mean Square Residual (WRMR). Butneither of these indicators is considered to determine the model fit in this study because the χ^2 test is sensitive to the sample size, and WRMR is an experimental fit measure and does not always behave well.

The last step in structural equation modeling is model modification. The modification of the model is purposed to test the hypothesis (in theoretical work) and to improve the fit (especially in exploratory work). The method used in modifying a structural equation model in this article is based on the χ^2 difference test[17].

3. Results

3.1 Health Status Model for Urban Area

The results of model fitting obtained based on the SEM approach for urban area are presented in Figure 1 for structure model and Table 1 for measurement model.

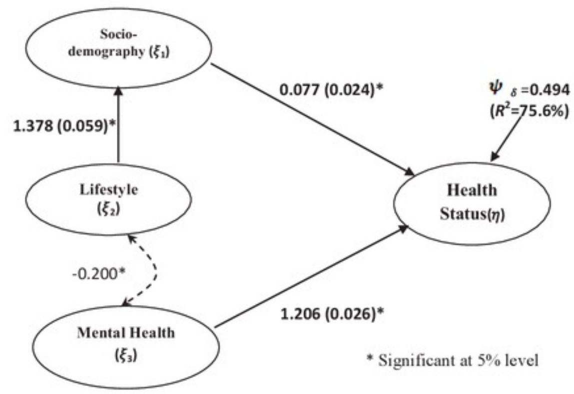

Figure 1. The fitted model of Health Status for the Urban area, including standardized parameter estimates, standard error estimates and measurement error.

Table 1. Parameter estimates, standard error estimates and R^2 for each measurement equation for Urban area

Latent Variable	Indicator Variable	Estimate (Standard error)	R^2
Socio-demography	Gender	0.887 (0.010)*	78.6
(ξ_1)	Age	−1.864 (0.230)*	1.2
	Education	0.059 (0.014)*	0.4
	Employment	−1.893 (0.062)*	25.2
Lifestyle	Smoking	0.757 (0.030)*	57.3
(ξ_2)	Exercise	0.128 (0.014)*	1.6
	Fiber & vegetable	0.099 (0.014)*	1.0
Mental Health	Mental Problem	0.630 (0.010)*	39.7
(ξ_3)	Health Problem	0.548 (0.012)*	30.0
Health Status	Blood Pressure	0.347 (0.013)*	12.1
(η)	GHC	0.759 (0.017)*	57.6
	BMI	0.168 (0.016)*	2.8

*Significant at 5% level

The estimated structural equation model that addressed the relationship of the health status with socio-demography and mental health was:

$$(= 0.077\xi_1 + 1.2065\xi_3 \quad (4)$$

and

$$\xi_1 = 1.378\,\xi_2 \qquad (5)$$

The interpretation of equation (4) is the factors which gave significant effect on health status (0 were socio-demography (ξ_1) and mental health (ξ_3) where the regression coefficientswere 0.077 and 1.206 respectively. Meanwhile, lifestyle (ξ_2) had an indirect effect on the health status, as mediated by the socio-demography. This indicated that people in good condition on her/his socio-demography tended to have positive impact to particular individual's health status. This equation also indicated that individual in good mental health condition correlated positively with health condition, which implied that people of good mental health tended to experience a better health condition as well. The second equation informed us that lifestyle gave positive impact not directly to the health status of an individual but mediated by socio-demography.

Table 1 above informs us that all indicator variables considered in this study were significantly related to their respective latent factors. It shows that male tented to have better health status than female. On the other hand, the elderly people were getting more unhealthy. The highly educated, actively working and not being a smoker is more likely to have good condition of her/his health. These results were similar to the study of Utomo et al.[18] and Muhidin[19]. Utomo et al. indicated that educated mother could improve the health condition for children. Meantime Muhidin wrote in his article that younger generation, educated individual and active workcould promote the health status of particular individual as well.

The value of R^2 in the last column indicated the proportion of variation in the latent factor as explained by each particular indicator.

Another information from Figure 2 is there was only one significant correlation of –0.200 between mental health and lifestyle, asrepresented by theline with the two-headed arrows. It means that people of a better mental health condition tended to practice less healthy lifestyle behaviours. For example, people who were in good condition of his/her mental at the time of interview were found to practice physical exercise less often as opposed to those at a worst condition.

Figure 2 also tells us that the amount of explained variance (R^2) in these relationships are 75.6%. Researchers determine the amount of explained variation (R^2) by squaring the standardized error associated with latent variables and subtracting the value obtained from 1 [21].

Figure 2.

In this relationship, $R^2 = 1 - \zeta^2 = 1 - 0.494^2 = 0.756$ or 75.6%. We could conclude here that altogether,socio-demography, mental health and lifestyle explain 75.6% of the variation of the health status.

The findings show that the proposed model fitted reasonably well to the data (RMSEA = 0.119, CFI = 0.917 and TLI = 0.906). The values of CFI and TLI are well within the acceptable range and the value of RMSEA is out of the range of acceptable value of RMSEA (lower than 0.06)[6]. The calculation of the RMSEA's value is based on the computed χ^2 value of the model. In the case of large sample, the χ^2 value is sensitive. In this study, the sample size is large enough, i.e. 3677. Thus, based on CFI and TLI we could conclude here that the model fits the data well.

3.2 Health Status Model for Rural Area

The proposed health status model for rural area was presented in Figure 3 below. Based on the figure, we could formulate the relationship of health status with socio-demography, lifestyle and mental health as following:

$$(= -0.523\xi_1 + 0.231\xi_2 + 0.396\xi_3 \qquad (6)$$

Figure 3 informs us that all three latent variables had significant effect on health status for rural area. The socio-demography gave negative impact to the health status. To interprete this result we had to look at Table 2 below. Based on Table 2, we knew that the significant indicators forsocio-demographywere age-group and employment level which their regression coefficient were 0.850 and –0.486 respectively. The indicator variables for socio-demography in rural area were age-group and employment level only. The age was recoded into age-group to obtain acceptable proposed model and employment level as well. Respect to

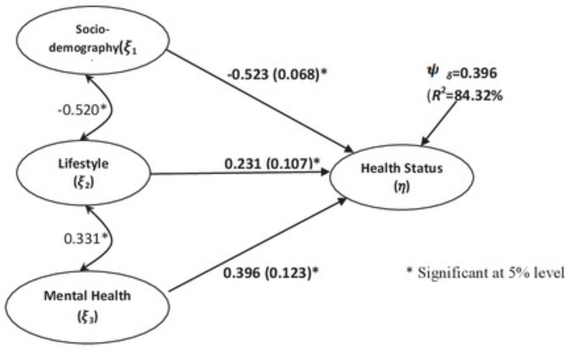

Figure 3. The fitted model of Health Status for Rural area, including standardized parameter estimates, standard error estimates and measurement error.

Table 2. Parameter estimates, standard error estimates and R^2 for each measurement equation for Rural area

Latent Variable	Indicator Variable	Estimate (Standard error)	R^2 (%)
Socio-demography	Age-group	0.850 (0.027)*	72.3
(ξ_1)	Education level	–0.486 (0.024)*	23.6
Lifestyle	Smoking	0.171 (0.032)*	2.9
(ξ_2)	Exercise	0.143 (0.035)*	2.0
	Fiber & vegetable	0.584 (0.065)*	34.1
Mental Health	Mental Problem	0.421 (0.041)*	17.7
(ξ_3)	Health Problem	–0.644 (0.183)*	4.1
Health Status	Blood Pressure	0.797 (0.026)*	63.5
(η)	GHC	0.162 (0.035)*	2.6
	BMI	–0.135 (0.030)*	1.8

*Significant at 5% level

age-group , the responses obtained were coded as 1, 2, 3 and 4 as "less than 31 years old", "between 31 to 40 years old", "between 41 to 60 years old" and "older than 61 years old" respectively. By combining the result of structural and measurement equations, they indicated that older individual tented to have negative health condition while the lower of an individual's education level the worst of his/her health status.

The present study also yielded that individual with healthy lifestyle and had good mental health condition were more likely to have good condition of her/his health status.

In Figure 3 also informed us that socio-demography had negative correlation with lifestyle. It meant that people in older age-group tented to have unhealthy life-style behaviours.There was positive correlation between lifestyle and mental health, as presented in Figure 3. The proposed health status model explained 84.32% of the variation of the Primary Health Research data for rural area.

The indicators of goodness-of-fit model reported that the value of RMSEA is 0.046, CFI is 0.953 and TLI is 0.943. The findings showed that the proposed model fitted reasonably well to the data.

Based on the result of the analysis of this study, it's obtained that the health status model for urban area is different than rural's. The significant factors that affecting health status in urban area are socio-demography and mental health, meanwhile lifestyle had an indirect effect on the health status, as mediated by the socio-demography. For rural model, it was proved that socio-demography, lifestyle and mental health are significant factors which influence the health status directly. Both proposed model could be accepted based on the indicators of goodness of fit. Or, we could also say that both proposed model fitted the data reasonably well. Therefore, this present study proved that SEM approach was appropriate to be implemented in constructing the health status of an individual.

4. Discussion

The main purpose of the present study was to apply structural equation modeling technique in modelingthe health statusfor urban and ruralarea in West Sumatera, Indonesia. The Primary Health Research 2007 in West Sumatera was used in analysis. The data then was analyzed based on hypothesis model by implementing Mplus version 5.2.

The health status model in this study involved two types of variables, i.e. observable, such as age, education level, smoking habits, etc and unobservable variables, such as socio-demographystatus, lifestyle, mental health and health status. The proposed health status model for urban and rural area that were resulted in this present study were different. In urban area, the health status was effected directly by socio-demography and mental health, where lifestyle correlated with health status indirectly as mediated by socio-demography. Meanwhile, in rural area, all three latent varibales were significant in explaining the health status. Another difference between both areawas the indicators for socio-demography. For urban area, socio-demography was measured significantly by gender, age, education level and employment. Meantime, in rural area, the indicators variables for socio-demography were age-group and employment level. In rural area, the age and employment were changed from continuous and nominal respectively in to ordinal types in order to obtain the acceptable proposed model. Based on indicators of goodness of fit model, we could conclude here that both proposed model fitted well to the data. The amount of explained variation (R^2) in the relationship of structural and measurement equation in urban and rural areawere 75.5% and 84.32% respectively.

However, structural equation modeling also has some limitations. The structural equation modelingtechnique is quite complex because structural equation modeling simultaneously tests the relationships between directly observed and unobserved variables, and the relationships among unobserved variables. The user should be careful when constructinga relationship thatis usually built based on the literature. Structural equation modeling also requires a large sample size, generally several hundred observations, as the precision of the estimates is affected by the sample size. The requirement of a large sample size incurs a higher cost. Another limitation of structural equation modelingis that there is no single "gold standard" for goodness-of-fit assessment. The user may refer to any literatures to decide on the cut off criteria for the goodness of fit indexes for their model.

Nevertheless, we understand here that structural equation modeling techniques could model the direct and indirect factors simultaneously and how it's done. The indicators which correlated significantly to these factors could be identified as well. Therfore, in this study, strutural equation modeling proved that it was found to be pertinent to be used for analyzing the health status of a particular individual. This finding is also similar with study many studies, such as by Yanuar et al[6].

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