Global Scientific JOURNALS

GSJ: Volume 9, Issue 10, October 2021, Online: ISSN 2320-9186
www.globalscientificjournal.com

ON THE USE OF STRUCTURAL EQUATION MODEL TO INVESTIGATE RISK FACTORS FOR UNDER-FIVE MORTALITY IN NIGERIA

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ABSTRACT

This study investigates the effect of some risk factors on the under-five mortality rate in Nigeria. Several factors have been identified as cause of Under-5 mortality and a major public health challenge in developing countries like Nigeria. The previous studies considered birth size, birth space and other health related factors as the major cause to death of under-five children. This current study explored other factors like socioeconomic and environmental factors which can also lead to death of children under-five years using structural equation model and identify other risk factors associated with under-five mortality in Nigeria. The data was obtained from Nigeria Demographic and Health Survey 2018. The results yielded an excellent predictive model which revealed that, the likelihood of under-five mortality among the children of mothers that have no either primary, secondary or tertiary education increase by about 252 compared to children of mothers with education which decrease with 74 rate of mortality of under-5 children. Related literatures were reviewed regarding structural equation model. The results has revealed that socioeconomic factor, environmental factors, women education and health seeking knowledge are the major important risk factors that cause U5M rate in six regions of Nigeria more especially north west regions. It was therefore observed from the results that women in the six geopolitical zones need to improve on their educational status. It was also noted that poverty among households contributes to poor health condition in children, hence lead to death of children under-5 years of age. Therefore, Government, Organization and individuals need to join hands in improving the quality of education of women and in the provision of job opportunities to reduce poverty level.

Keywords: Structural Equation Model, Confirmatory Factor Analysis, Akaike Information Criterian, Bayesian Information Criterian and Turkeys Lawmen Shows

1. Introduction

Under-five child mortality rates is the probability dying between birth and fifth birthday and it was widely accepted as a major indicator of country socioeconomic development which reflect country□s health care system and quality of life. To prevent child death, make sure health child survival and reducing under-five mortality to at least as low of 25 per 1,000 live births by 2030 is known as the third Sustainable Development Goals (SDG, 2015).

The risk of a child dying before completing five years of age is still highest in the WHO African Region (76 per 1000 live births), around 8 times higher than that in the WHO European Region (9 per 1000 live births). Many countries still have very high under-five mortality □ particularly those in WHO African Region, home to 5 of the 6 countries with an under-five mortality rate above 100 deaths per 1000 live births. In addition, inequities in child mortality between high-income and low-income countries remain large (WHO, .

In 2018, the under-five mortality rate in low-income countries was 68 deaths per 1000 live births □ almost 14 times the average rate in high-income countries (5 deaths per 1000 live births). Globally, under-five mortality rate has decreased by 59%, from an estimated rate of 93 deaths per 1000 live births in 1990 to 49% with an estimated rate of 39 deaths per 1000 live births in 2018. This is equivalent to 1 in 11 children dying before reaching age 5 in 1990, compared to 1 in 26 in 2018 (NDHS, 2018).

2. Study Risk Factors

In Nigeria, several national policies, strategies and interventions with notable ones among them being the Child Health Policy 2007□2015, Community-based Health Planning and Services (CHPS) and National Health Insurance Scheme (e.g. free maternal delivery services, free treatment of children aged below18years) were launched to improve and promote health of Nigerian children (NHIS and NDHS 2018). Despite all these initiatives, under-five mortality in Nigeria is still a major challenge. The effect of catastrophe may result to reduction in population growth and consequent economic stagnation in the country.

There have been much numbers of studies on the causes of under-five mortality in the developing world especially in Nigeria. For instance, (Tlou et al., 2018) observed that there were regional inequalities in health-seeking attitude especially on immunization, birth size, birth interval in Nigeria. Findings from those above confirm perception that the place where a child is born determines his or her survival using Poisson regression model. Although some studies identified lack of access to electricity, water and sanitation as the factors causing the mortality among children under-five age (Ezeh, 2015; Adewuyi, 2016; Tette et al., 2016 & Aheto et al., 2017).

Thus, there are other very important factors presumed to be responsible for under-five mortality in Nigeria which other studies did not consider these include socioeconomic and environmental factors such as mother age, mother’s education, place of residence, economic status of the household in all six Geopolitical zones of the country. This research will use structural equation model to investigate the causes of under-five child mortality.

3. Materials and Methods

This study was carried out within six regions of Nigeria, using sample surveys or censuses conducted by Nigerian Demographic and Health Survey 2018 data on the investigation of risk factors for under-five mortality in Nigeria using structural equation model (SEM).

The interest in SEM is often on theoretical constructs, which are represented by the latent factors. The relationships between the theoretical constructs are represented by regression or path coefficients between the factors. The structural equation model implies a structure for the covariance between the observed variables, which provides the alternative name covariance structure modeling. However, the model can be extended to include means of observed variables or factors in the model, which makes covariance structure modeling a less accurate name. Many researchers will simply think of these models as “Lisrel -models,” which is also less accurate. LISREL is an abbreviation of LInear Structural Relaations, and the name used by Jöreskog for one of the first and most popular SEM programs. Nowadays structural equation models need not be linear, and the possibilities of SEM extend well beyond the original Lisrel program (Jöreskog, 1987).

Formally, the LISREL models consist of two parts: the Structural Equation model which defines relation among latent variables and the Measurement Model, which defines hypothetical latent variable in terms of observed measured variable.

3.1 Structural Equation Model (SEM)

The matrix equation for the **structural equation** of the model is given as;

$$Y = \beta\eta + \Gamma X + \xi \qquad (1)$$

$$\begin{bmatrix} y_1 \\ \vdots \\ \vdots \\ y_m \end{bmatrix} = \begin{bmatrix} 0 & & & \\ & 0 & & \\ & & 0 & \\ & & & 0 \end{bmatrix} \begin{bmatrix} \eta_1 \\ \vdots \\ \vdots \\ \eta_m \end{bmatrix} + \begin{bmatrix} - & - & - & - \\ - & & & \\ - & & & \\ - & & & \end{bmatrix} \begin{bmatrix} \xi_1 \\ \vdots \\ \vdots \\ \xi_n \end{bmatrix} + \begin{bmatrix} - & 0 & 0 & 0 \\ - & - & 0 & 0 \\ - & - & - & 0 \\ - & - & - & - \end{bmatrix}$$

B is (m x m) matrix of direct effect between endogenous latent variables

Γ (m x n) matrix of regression effect that indicate the influence of exogenous latent variables on endogenous latent variables

ζ is (m x 1) vector of error in prediction for the m endogenous latent variables equation.

Two matrix equations are used to represent the **measurement model** of the LISREL model.

$$X = \lambda_x \xi + \delta \qquad (2)$$

$$\begin{bmatrix} x_1 \\ \vdots \\ x_q \end{bmatrix} = \begin{bmatrix} - & - & - \\ - & & \\ - & & \end{bmatrix} \begin{bmatrix} \xi_1 \\ \vdots \\ \xi_m \end{bmatrix} + \begin{bmatrix} \delta_1 \\ \vdots \\ \delta_q \end{bmatrix}$$

$$Y = \lambda_y \eta + \varepsilon \qquad (3)$$

$$\begin{bmatrix} y_1 \\ \vdots \\ y_p \end{bmatrix} = \begin{bmatrix} - & - & - \\ - & & \\ - & & \end{bmatrix} \begin{bmatrix} \eta_1 \\ \vdots \\ \eta_m \end{bmatrix} + \begin{bmatrix} \varepsilon_1 \\ \vdots \\ \varepsilon_p \end{bmatrix}$$

In equation 1, 2 and 3,

η = the eta is (m × 1) vector of latent endogenous variables,
X = (k × 1) vector of observed exogenous variables,
Y = (p × 1) vector of observed endogenous measured variable
λ_x = (q × n) matrix of coefficient factor loading that indicates the influence of exogenous latent variables
λ_y = is (p x m) matrix of coefficient (factor loading) that indicates the influence of endogenous latent variables
ξ = is a (n x 1) vector of exogenous latent variables
δ = is (q x 1) vector of error in measurement for observed exogenous variables
ε = is (p x1) vector of "error" in the measurement model

3.2 Standard Model Fit Evaluation
The test of exact fit and fit indices (CFI and RMSEA) produced by the□standard□ approach to evaluating model fit in MSEM. The standard refers to the conventional method in which the goodness of fit is examined for the entire multilevel structural equation model simultaneously. Note that the standard approach parallels to the model fit evaluation in single level SEM.

3.3 Test of Exact Fit
The test of exact fit is obtained using likelihood ratio test between the saturated model (i.e., just identified model with degrees of freedom $(df) = 0$) and the hypothesized model with a positive df .

The maximum likelihood (ML) test statistic T_{ML} is obtain by

$$T_{ML} = F_{ML}(\hat{\theta}) - F_{ML}(\hat{\theta}_S) \tag{4}$$

Where $F_{ML}(\hat{\theta})$ is the ML fitting function value for the hypothesize model and $F_{ML}(\hat{\theta}_S)$ is the ML fitting function value for the saturated model.

3.4 Comparative Fit Index (CFI)
The (CFI) is a fit index that measures goodness of fit of the hypothesized model compared to a baseline model. Typically in independence model in which the variance are estimated freely without any constraints and all covariance are fixed to zero is used as baseline model.

$$\Delta = 1 - \frac{\lambda_{Hypothesized}}{\lambda_{Baseline}} \tag{5}$$

Where Δ compares the non-centrality parameter in the hypothesized model to non-centrality of the baseline model. Also, $\lambda = (N-1)F_0$ where F_0 is the ML fitting function value reflecting lack of fit in the population.

$$CFI = 1 - \frac{Max[(\chi_H^2 - df), 0]}{Max[(\chi_S^2 - df), 0]} \tag{6}$$

Where χ_H^2 is the chi-square test statistic for hypothesize model and χ_B^2 is the chi-square test for baseline model.

3.5 Root Mean Square Error of Approximation (RMSEA)
The RMSEA provide measure of lack of fit in the population with an adjustment for the parsimony of the model RMSEA attempts to estimate the error of approximation if the model in the population apart from the error or estimation due to sampling error.

$$\hat{F}_0 = \hat{F}_{ML} - \frac{df}{(N-1)} \tag{7}$$

$\hat{F}_0$ is the biased estimator of the population fitting function value.

$$RMSEA = \sqrt{\frac{\hat{F}_0}{df}} \tag{8}$$

3.6 Goodness of Fit
Likelihood ratio test and Homers-Lemeshow Goodness-of-fit were used to examine the fitness of the model.

$$GFI = 1 - \frac{\chi^2_{Hypothesized}}{\chi^2_{Baseline}} \tag{9}$$

4. RESULTS

Before any statistical analysis, it is better to examine the overall picture of the data. The distribution of the number of under-five mortality per mother and the cross tabulation of region by explanatory variables will be our subsequent task in this section.

Table 4.1

Number of child age that experience different mortality

Variable	Observation	Mean	Std. Dev	Minimum	Maximum
Neonatal	57	35.63158	11.59377	13	74
Post Neonatal	57	27.42105	11.47349	4	59
Infant	57	63.01754	21.31774	19	116
Child	57	53.42105	36.81030	0	157
Under-Five	57	109.4912	53.42088	0	252

Table 4.1 shows the summary statistics of the distribution of selected background characteristics of children aged below five (5) years. Continuous variables were summarized using mean with their associated standard deviation or median with their associated inter-quartile range if the variable violates the normality assumption. Further analyses were conducted to examine mother age, mother□s education, place of residence, economic status of the household that might be significantly associated with under-five mortality and explored unobserved household level effects on under-five mortality. Predictive models for under-five mortality were also developed. To achieve the objectives, structural equation model were employed and model parameters were obtained using maximum likelihood. The goodness of fit for the fitted models were examined using likelihood ratio test (LRT), Aiken Information Criterion (AIC) and Bayesian Information Criterion (BIC). McFadden Pseudo R^2 was also used to further test the fit of the preferred model.

4.1 Structural Equation Model Analysis (SEM)

Table 4.2

Shows Risk Factors consider in the study

Risk Factors	Variables	Est.	Se.	Z	P
Mothers with no Edu	Under-Fivel	0.697	0.411	1.699	0.001
Mothers age	Postneonatal	0.358	0.162	2.179	0.027
Socioeconomic	Under-Five	0.867	0.169	5.130	0.002
Environmental	Neonatal	0.102	0.625	0.163	0.002
Regions	Infant	0.445	0.976	0.456	0.007
Place of Residence	Child	2.162	0.644	3.357	0.906

Table 4.2 shows that all the risk factors are significance at 0.05 levels, with all the p-value is less than the level of significance. Which only place of residence that shows no significance with (p-value=0.906) less that 0.05 level of significance. This result it indicate that Mothers without education has effect on the mortality of under-five children with p-value=0.001, also socioeconomic factor has good effect on the mortality of under-five children in Nigeria and Environmental factor with p-value=0.002.

4.2 Parameters Estimation

Table 4.3

Log likelihood Criteria for Parameter Estimation

Iteration 0: Log likelihood = -910.94356

Iteration 1: Log likelihood = -910.94356

Number of Observation = 57

	Coefficient (Model)	Std. Error	Z-value	P > Z-value	95% CI. Lower	95% CI Upper
Neonatal	0.0054789	0.2069742	0.03	0.979	-0.40018	0.4111408
Post neonatal	0.6900693	0.2358097	2.93	0.03	0.227890	1.152248
Child Mortality	1.257949	0.603136	20.86	0.000	1.139736	1.376161
Infant Mortality	0.506123	0.004563	0.174	0.000	0.345217	1.320467
Under-five	151.1589	28.32465	0.00	0.000	104.7102	218.2118
Constant	23.17264	5.364193	0.003	0.000	12.65901	33.68626

The information criteria were used for model selection and have two components: (mi)fit (-2 log likelihood) and complexity (degrees of freedom). The lower the values better the model. A parsimonious (simple) model with good fit (low deviance) is preferred over a complex model with bad fit.

4.3 Goodness Of Fit Test

Chi-Square Test for SEM Model

Fit Statistic	Value	Description
Likelihood ratio		
Chi-Square (0)	0.000	Model vs. Saturated
P > Chi-Square (0)	-	-
Chi-Square (3)	166.461	Baseline vs. saturated
P > Chi-Square(0)	0.000	-
Information Criteria		
AIC	1831.887	Akaikes information criteria
BIC	1842.102	Bayesian information criteria
Baseline comparison		
CFI	1.000	Comparative fit index
TLI	1.000	Tucker-Lewis index
Size of residual		
SRMR	0.000	Standard root mean squared residual
CD	0.946	Coefficient of determination

From table 4.4 we tested the proposed two-factor model with the obtained data. A test-of-exact-fit revealed a significant result ($\chi^2 = 166.461$, p = 0.000). Therefore, we have to reject the null hypothesis that the obtained variance-covariance aviatrixes are equal. This may be due to high sensitivity of the test for relatively large samples. We also obtain high fit indices (measures) CFI and TLI are greater than critical values or greater than the p-value. Hence, the model developed in this study is statistically accepted. In general, we obtained high fit indices (CFI = 1.00 and TLI = 1.00) indicating a very good fit. Also, Root Mean Square Error of Approximation (RMSEA) is bellow 0.05 (RMSEA = 0.000) this also support our findings of good fit, the closer to 1 for all the additional fit measures the better the model fit. The information criteria AIC and BIC were used to compare two or more models, the smaller (in absolute value) the better fit model, base on our analysis the model gives best fit.

5. CONCLUSION

The results has revealed that socioeconomic factor, environmental factors, women education and health seeking knowledge are the major important risk factors that cause U5M rate in six regions of Nigeria more especially north west regions as shown by the results of the models. It was therefore observed from the results outcome that women in the six geopolitical zones need to improve on their educational status. It was also noted that poverty among households contributes to poor health condition in children, hence lead to death of children under-5 years of age. Therefore, the final output are fit as Structural equation model for study risk factors.

Earlier, the analysis shows that, the risk factors considered here are the highly cause of under-5 mortality in six regions of Nigeria, also looking at the result from the analysis, it that shows good fit for the data.

6. RECOMMENDATION

From the results, it can be seen that still women in the six geopolitical zones are lagging behind in terms of their educational status, also household are poor in terms of socioeconomic status which leads to death for children under age of five.

Government should therefore emphasize on women education/Girls education which can help to take care of their children in very good health condition. Also, more policies should be put in place to reduce poverty among households so that; they can take care of their children.

Also, more policies should be put in place to reduce poverty among household and society should find way of self defendant so that they can take care of their children.

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