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Assessment of Rate and Risk Factors of Child Mortality in Nigeria

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Abstract
Child right to survival is a building block towards the realization of a child's potential and on it hinges the basic rights of children, but many children do not live to enjoy this right. This study examined the rate and risk factors of child Mortality in Nigeria to ascertain the risk factors that significantly affects child mortality. Estimates of mortality rate and some number of indicators on the situation of women and children for the 36 states of the federation and the Federal Capital Territory were used for the analysis. The study shows that from 1960 to the late 1990s there has been a decrease in child mortality by almost 50%, then an increase between 2000 and 2005 followed by a sudden decrease. For the purpose of robustness, factor analysis and a model selection procedure were used. Results from the backward regression procedure using the Akaike Information Criterion (AIC) shows that maternal and environmental risk factors (Immunization, Poor sanitation, Early child bearing and the use of solid fuels) impact significantly on child mortality in Nigeria due to low Immunization, poor health care system, poor environmental sanitation, early child bearing and use of solid fuels etc. The study, therefore calls for urgent action and greater national priority on child survival through interventions that will be integrated at community and family levels, targeting pregnant women, under-five children and accessing the hard to reach in order to improve child survival in Nigeria.

Keywords: Rates, Risk factors, Under-5 mortality, Factor Analysis, Regression

1. Introduction

Child mortality is one of the important indicators of a countries general medical and public health conditions, and consequently its level of socio-economic development. It increase is undesirable and also an indication of a decline in general living standard (Anderson *et al.,* 1998). Reducing mortality has long been a concern of the international community. The international conference on primary health care held in Alma Ata in 1978 was the first to consider how child mortality could be reduced worldwide by systematic development of primary health care system. Since then, the United Nations has been actively involved with efforts aimed at reducing infant and under–five mortality in developing countries. To this end, plan of action was adopted at the world summit for children held in New York September 1990, which incorporates specific targets for reduction of infant and under-five child mortality. Also one of the eight millennium development goals (MDG's) adopted at the millennium summit in year 2000 was to reduce child mortality (MDG4). Donors and development agencies, the united nations and national governments around the world committed themselves to the goal of reducing the under-five mortality rates by two third between 1990 and 2015 (Millennium summit, 2000). The world has made remarkable progress in child

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survival in the past three decades, and millions of children have better survival chances than in 1990. 1 in 27 children died before reaching age five in 2019, compared to 1 in 11 in 1990. Progress in reducing child mortality rates has been accelerated in the 2000-2019 period compared with the 1990's. The global under-five mortality rate declined by 59 percent, from 93 deaths per 1,000 live births in 1990 to 38 in 2019. Despite this considerable progress, improving child survival remains a matter of urgent concern. In 2019 alone, roughly 14,000 under-five deaths occurred every day, an intolerably high number of largely preventable child deaths (UNICEF, 2021). Environmental, maternal and socio-economic factors were acknowledged as additional important determinants of child survival. Child mortality rates still remain unacceptably high in sub-Saharan African countries as approximately half of childhood deaths take place in sub-Saharan Africa despite the region having only one fifth of the world's children population (Smith, 2010). For instance, in sub-Saharan Africa, 1 child in 8 dies before the age of five- nearly 20 times the average of 1 in 2167 in developed parts of the world (Ojikutu, 2008). The region's under-five mortality rates was 173 per 1,000 live births compared to the minimum goal of 70 per 1,000 internationally adopted in the 1990 world summit for children. Of the thirty countries with the world's highest child mortality rates, twenty seven are in sub-Saharan Africa. It is not known why the infant and child mortality rates are staying higher or even increasing in many sub-Saharan countries despite action plans and interventions (Mutunga, 2004). While other areas of the world have experienced declining rates of childhood mortality over the last 30 years, this area, for the most part still maintains relatively high rates. Country estimates of the level and determinants in childhood mortality are needed to help set priorities, Shape policies, design programs and monitor successes recorded at the national level. These estimates are needed at the international level to inform funding decisions for activities directed toward reducing child mortality. As the world enters the 21st century, childhood mortality remains a big issue for developing countries; especially the focus of public health policies to protect the gains in child survival from new threats such as HIV/AIDS, poverty and hunger, as researchers attempt to distinguish what factors contributes to the high levels.

2. Material and Methods

The study uses data from the Nigeria Multiple Indicator Cluster Survey (MICS4). The series of Multiple Indicator Cluster Survey is conducted by the National Bureau Of statistics (NBS) with technical and funding assistance from UNICEF. Estimates of mortality rates and some number of indicators on the situation of women and children for the 36 states of the federation and the Federal Capital Territory were used for the analysis. Factor Analysis is used to represent and explain the covariance relationships among the correlated variables, and multiple regression as a model selection procedure was carried out to ascertain the significant risk factors of child mortality. The choice of Explanatory variables used for the analysis was guided by the Mosley and Chen framework and other literatures.

2.1 Factor Analysis

Factor analysis is a multivariate statistical method used to describe variability among observed variables in terms of a potentially lower number of unobserved variables called factors. The observed variables are modeled as linear combinations of the potential factors, plus "error" term. The information gained about the interdependencies between observed variables can be used later to reduce the set of variables in a dataset.

Explanatory Factor Analysis (EFA) is used to explore the dimensionality of a measuring instrument by finding the smallest number of interpretable factors needed to explain the correlations among a set of variables, exploratory in the sense that it places no structure on the linear relationships between the observed variables and the factors but only specifies the number of latent variables.

2.1.1 Model Definition and Assumptions

We assume a random variable $y_1, y_2 \; . \; . \; . \, y_n$ from a homogeneous population with mean vector μ and covariance matrix $\sum$. The factor analysis model expresses each variable as a linear combination of underlying common factors $f_1, f_2, \; . \; . \; . \; , \; f_m$ with an accompanying error term to account for that part of the variable that is unique (not in common with the other variables). For $y_1, y_2 \; . \; . \; . \, y_n$ in any observation vector$\boldsymbol{y}$, the model is as follows:

$$y_p - \mu_p = \lambda_{p1} f_1 + \lambda_{p2} f_2 + \; . \; . \; . + \lambda_{pm} f_m + \mathcal{E}_p \qquad (1)$$

The coefficients $\lambda_{ij}$are called *loadings* and serve as weights, showing how each y_i individually depends on $f\,'_s$. With appropriate assumptions, λ_{ij} indicates the importance of jth factor f_j to the ith variable y_i and can be used in interpretation of f_j. Thus we assume that $E(\mathcal{E}_i) = 0$, $var(\mathcal{E}_i) = \psi_i$ and $cov(\mathcal{E}_i, \mathcal{E}_k) = 0, i \neq k$. In addition, we assume that $cov\big(\mathcal{E}_i, f_j\big) = 0$ for all i and *j*. We refer to $\psi_i$as the *specific variance*. A simple expression for the variance of y_i is:

$$var(y_i) = \lambda_{i1}^2 + \lambda_{i2}^2 + \, , \; . \; . \; . \; , + \lambda_{im}^2 + \psi_i \qquad (2)$$

Note that the assumption $cov(\mathcal{E}_i, \mathcal{E}_k) = 0$ implies that the factors account for all the correlations among the y'_s that is, all that the y'_s have in common. Thus the emphasis in factor analysis is on modeling the covariance's i.e. (the extent to which the variable vary) or correlations among the y'_s.

2.2 Multiple Regression

Multiple regression is a statistical technique use in exploring the relationships between two or more variables. In the fixed-*x* regression model, we express each *y* in a sample of *n* observations as a linear function of the *x*'s plus a random error *ε*.

$$y_n = \beta_0 + \beta_1 x_{n1} + \beta_2 x_{n2} + \; . \; . \; . + \beta_q x_{nq} + \mathcal{E}_n \qquad (3)$$

The β'_s in the model are called regression coefficients. Additional assumptions that accompany the equations of the model are as follows:

1. $E(\mathcal{E}_i) = \; 0$ for all $i \; = \; 1, 2, \dots, n$.

2. $var(\mathcal{E}_i) = \; \sigma^2$ for all $i \; = \; 1, 2, \dots, n$.

3. $cov(\mathcal{E}_i, \mathcal{E}_j) = 0$ for all $i \neq j$

2.2.1 Backward elimination procedure and stepwise Regression Procedure

The backward elimination procedure begins with all x's (all variables) included in the model testing the deletion of each variable using a chosen model comparison criterion, and deleting any variable that improves the model the most by being deleted, and repeating this process until no further improvement is possible. The stepwise procedure is an extension of forward selection. Each time a variable enters, all the variables that have entered previously are checked using a model selection procedure to see if the least "significant" one is now redundant and can be deleted from the model.

2.3 Akaike Information Criterion

The Akaike Information Criterion (AIC) is a measure of the relative quality of a statistical model for a given set of data; AIC estimates the quality of each model, relative to other models. Hence, AIC provides a means for model selection. Let L be the maximized value of the likelihood function for the model; let k be the number of parameters in the model (i.e. k is the number of degrees of freedom). Then the AIC value is as follows.

$$AIC = 2K - 2Ln(L) \tag{4}$$

We start with a set of candidate models, and then find the models' corresponding AIC values. There will almost always be information lost due to using a candidate model to represent the "true" model (i.e. the process that generates the data). We wish to select, from among the candidate models, the model that minimizes the information loss. We cannot choose with certainty, but we can minimize the estimated information loss.

3. Results and Discussions

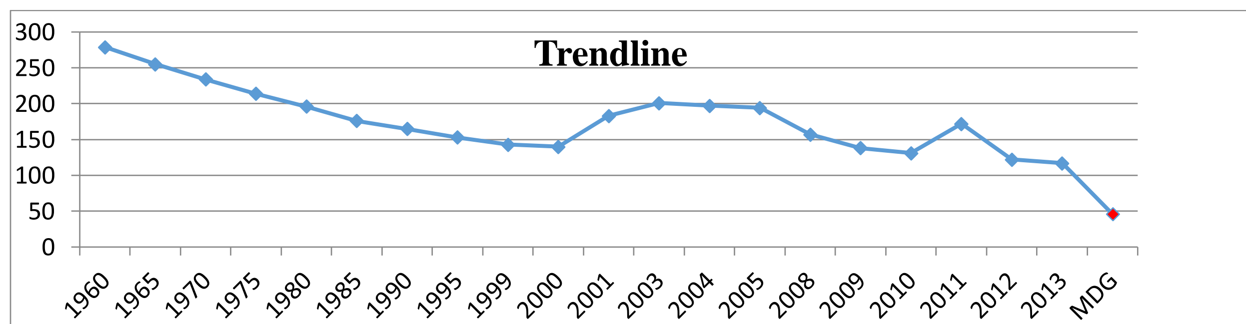

Figure 1: Under five mortality trend line

Between 1960 and 2000, under-five child mortality rate in Nigeria has reduced by almost 50 per cent, from 279 to 140 deaths Per 1,000 live births. A decrease of about 15 percent was also recorded between 1990 and 2000. The country then witnessed a reversal in the achievement made as under-five mortality increase from 140 to 195 per 1,000 live births between 2000 and 2005. Also from 2005 Nigeria witness a decrease in child mortality rate down to year 2013 with only

year 2011 recording a higher mortality rate. Thus, considering the trends in Under-five mortality in Nigeria since 1960, there is no doubt that the trends has been on the decrease, but the decrease is small over the years and still short of achieving the required target. This shows that the child mortality decrease in Nigeria is abysmally low and we therefore conclude that Nigeria is currently off track in achieving the international set target.

3.1 Factor Analysis (Results)

The first thing to do in Explanatory factor analysis is to determine the number of factors, and one way of doing this is by running a principal component analysis (PCA) to determine the number of underlying components. From Table 1 below, looking at the cumulative proportion of variance row, four components account for almost 90% of the variation in the data set. Also the scree plot may be used to determine the number of underlying components. A scree plot is a graphical display of the variances of each component in the data set which is used to determine how many components should be retained in order to explain a high percentage of the variation in the data set. From the scree plot (Fig 2) below the first four components stand out and the rest are very small thus indicating that there is probably four factors in the data and using two of the criteria four components are retained.

Table. 1 Principal Component Analysis Results:

	Comp.1	Comp.2	Comp.3	Comp.4	Comp.5
Standard deviation	71.9109931	26.63952531	21.9910539	16.8301736	14.2199976
Proportion of Variance	0.6982918	0.09582952	0.0653038	0.0382493	0.0273052
Cumulative Proportion	0.6982918	0.79412128	0.8594251	0.8976744	0.9249796

	Comp.6	Comp.7	Comp.8	Comp.9
Standard deviation	12.09232760	10.71015913	8.71894197	7.960722643
Proportion of Variance	0.01974541	0.01548953	0.01026535	0.008557587
Cumulative Proportion	0.94472500	0.96021452	0.97047988	0.979037465

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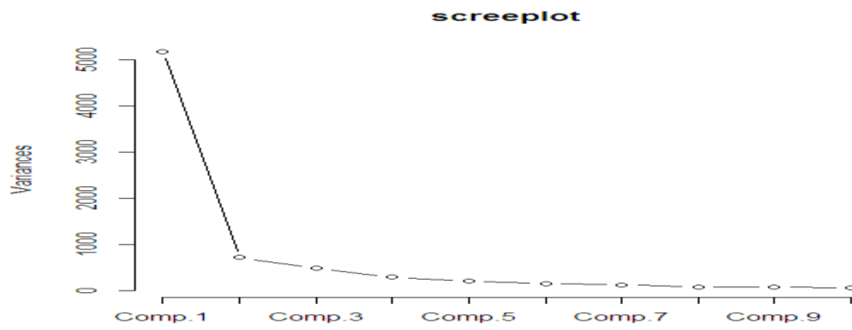

Figure 2

Table. 2: Factor Analysis Results

	Factor1	Factor2	Factor3	Factor4
Mortality	-0.806	0.123		-0.175
Income	0.565	0.114		
F/Educatn	0.860		0.208	
Fertility	-0.827	0.195	-0.237	0.182
Health	0.528	-0.107	0.213	0.765
Immunization	0.833			0.280
Solidfuels	-0.611	-0.174		-0.151
Water	0.494	0.500	-0.227	0.140
Sanitation		0.754	0.104	-0.136
Aids	0.177		0.970	0.134
Breastfdng	-0.601	-0.201	-0.337	
Dskp	0.926	0.157		0.216
Lbwth	-0.713	0.152	-0.203	-0.175
Sdcf		0.729		
Ecbth	-0.907		-0.146	-0.227
Atcc	0.893	0.119		0.323

	Factor1	Factor2	Factor3	Factor4
SS loadings	7.373	1.579	1.354	1.055
Proportion Var	0.461	0.099	0.085	0.066
Cumulative Var	0.461	0.559	0.644	0.710

Test of the hypothesis that 4 factors are sufficient.
The chi square statistic is 84.16 on 62 degrees of freedom.
The p-value is 0.0321

From Table 2 which is the factor analysis results it can be seen how all the variables load on the four factors. Maternal variables tend to load on factor 1 with higher loadings, environmental contamination variables load on factor 2 while HIV/Aids and Healthcare load on factor 3 and factor 4 respectively with higher loadings. The total or Cumulative variance explained is 71 per cent. The result shows that 46 per cent of the variance was accounted for by the first factor while the second, third and fourth factors accounted for 9 per cent, 8 per cent and 6 per cent respectively. It is particularly instructive to note that up to 55 percent of the variance is accounted for by the first two factors which are the proximate determinants (maternal and environmental contamination variables). Also we have the test of hypothesis that four factors are significant with a p-value 0.0321 which is less than 0.05, thus we reject the null hypothesis that 4 factors are not significant. Hence we may decide to name the 4 factors and use the factor scores for further analysis.

3.2 Backward Elimination Method

This involves starting with all candidate variables, testing the deletion of each variable using a chosen model comparison criterion, deleting any variable (with lowest AIC) that improves the model the most by being deleted, and repeating this process until no further improvement is possible.

1. Step: AIC=266.27
Mortality ~ Income + FEducatn + Fertility + Health + Immunizatn + Sanitatn + Solidfuels +Water + Aids + Brstfdng + Dskp + Sdcf + Lbwth + Ecbth + Atcc

	Df	Sum of Sq	RSS	AIC
- Water	1	0.21	20799	264.27
- Atcc	1	8.67	20807	264.29
- Lbwth	1	91.71	20890	264.44
- Brstfdng	1	101.47	20900	264.45

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- FEducatn 1 174.85 20973 264.58
- Aids 1 329.36 21128 264.86
- Health 1 338.25 21137 264.87
- Solidfuels 1 485.62 21284 265.13
- Sdcf 1 626.25 21425 265.37
- Income 1 773.58 21572 265.62
- Dskp 1 1005.08 21803 266.02
<none> 20798 266.27
- Ecbth 1 1206.99 22005 266.36
- Sanitatn 1 1485.12 22284 266.82
- Fertility 1 1889.30 22688 267.49
- Immunizatn 1 2007.20 22806 267.68

2. Step: AIC=264.27
Mortality ~ Income + FEducatn + Fertility + Health + Immunizatn + Sanitatn + Solidfuels + Aids + Brstfdng + Dskp + Sdcf + Lbwth + Ecbth + Atcc

Df Sum of Sq RSS AIC
- Atcc 1 10.96 20810 262.29
- Lbwth 1 91.50 20890 262.44
- Brstfdng 1 110.38 20909 262.47
- FEducatn 1 187.97 20987 262.61
- Health 1 342.95 21142 262.88
- Aids 1 418.93 21218 263.01
- Solidfuels 1 554.92 21354 263.25
- Sdcf 1 681.34 21480 263.47

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- Income 1 940.36 21739 263.91
- Dskp 1 1055.93 21855 264.11
<none> 20799 264.27
- Ecbth 1 1211.87 22010 264.37
- Sanitatn 1 1527.61 22326 264.90
- Fertility 1 1900.14 22699 265.51
- Immunizatn 1 2011.06 22810 265.69

12. Step: AIC=250.76
Mortality ~ Immunizatn + Sanitatn + Solidfuels + Ecbth

Df Sum of Sq RSS AIC
<none> 24785 250.76
- Solidfuels 1 2610.3 27396 252.47
- Sanitatn 1 2815.6 27601 252.74
- Immunizatn 1 2974.3 27760 252.96
- Ecbth 1 6988.1 31773 257.95

Call:
lm(formula = Mort ~ Immunizatn + Sanitatn + Solidfuels + Ecbth)

Coefficients:

(Intercept)	Immunizatn	Sanitatn	Solidfuels	Ecbth
111.1148	-0.8375	0.6719	0.5008	1.4872

Coefficients:

Estimate Std. Error t value Pr(>|t|)
(Intercept) 111.1148 45.7031 2.431 0.02083 *

Immunization -0.8375 0.4274 -1.960 0.05880 .
Sanitation 0.6719 0.3524 1.907 0.06558 .
Solid fuels 0.5008 0.2728 1.836 0.07569 .
Ecbth 1.4872 0.4951 3.004 0.00515 **

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 27.83 on 32 degrees of freedom
Multiple R-squared: 0.7508, Adjusted R-squared: 0.7197
F-statistic: 24.11 on 4 and 32 DF, p-value: 2.875e-09, Significant level α = 5%.

4. Conclusion

For the regression analysis we use a model selection procedures i.e. the backward elimination method. The AIC (Akaike Information Criterion) was used as a criteria for selecting models, the rule is that the lower the AIC the better the model. From the results of the backward elimination procedure in the step 1, the AIC was 266.27 and from the first Table if we remove variable water we will have an AIC of 264.27 which is an improvement from the previous AIC of 266.27, though other variables like Atcc (Antenatal care coverage) and Lbwth (Low birth weight) etc have low AICs but the best we can do here is to remove the variable Water because it has the lowest AIC, the procedure continues until the best model is reached. Looking at step 12, the model has been reduced to four variables Poor Sanitation, Immunization, Early child bearing and solid fuels all having AICs which are greater than 250.76, thus we no longer drop any variable, hence the best model reached is

$$\begin{aligned} \mathit{Mortality\ rate} &= 111.1148 + 0.6719(\mathit{Poor\ Sanitation}) - 0.8375(\mathit{Immunization}) \\ &+ 0.5008(\mathit{Solidfuels}) + 1.4872(\mathit{Early\ child\ bearing}) \end{aligned}$$

From the model above an increase in Immunization will reduce child mortality, while it decrease will increase child mortality but for other variables (Poor sanitation, early child bearing and use of solid fuels) their increase will increase child mortality and their decrease will decrease child mortality. We need to test for the significance of regression model to determine whether a linear relationship exists between the response variable (child mortality) and the regressors (risk factor variables). From the results above we can see that at both α=5% and α=1% our p-value: 2.875e-09 is less than 0.05 and 0.01 which shows that our model is significant and the risk factors (Immunization, Poor sanitation, Early child bearing and the use of solid fuels) perfectly predicts child mortality. The value of R^2 for this model is 0.7197. Thus the model accounts for about 71% of the variability in child mortality, therefore we conclude that our model is adequate.

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