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Tackling High Neonatal Mortality Rates in Liberia Using Empirical Evidence Generated by the Box-Jenkins ARIMA Model

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***Abstract* - Liberia has several challenges such as inadequate infrastructure, lack of skilled medical staff and shortage of medical equipment and supplies. Furthermore, there is low contraceptive prevalence which has resulted in high numbers of teenage pregnancies with 60 percent of neonatal deaths occurring among adolescent women. Tracking future trends of neonatal mortality rate will guide decisions and allocation of resources to maternal and child health program activities across the country. Therefore, this study uses annual time series data on neonatal mortality rate (NMR) for Liberia from 1963 to 2019 to predict future trends of NMR over the period 2020 to 2030. Unit root tests have shown that the series under consideration is an I (1) variable. The optimal model based on AIC is the ARIMA (3,1,3) model. The study findings indicate that neonatal mortality will continue to decline but still remain very high throughout the out of sample period. Hence, the Liberian policy makers should design appropriate and country specific maternal and child health policies with special attention being given to addressing the major drivers of neonatal deaths such as high teenage pregnancy rates, inadequate infrastructure, lack of skilled medical staff and shortage of medical equipment and supplies.**

Keywords: ARIMA, Forecasting, NMR.

I. INTRODUCTION

Remarkable progress has been made in the reduction of under 5 mortality in Sub-Saharan Africa as it decreased from 180 per 1000 live births in 1990 to 83 deaths per 1000 live births in 2015. During the same period Liberia made commendable progress by achieving 73 percent reduction in under five mortality (UNICEF, 2015). This tremendous performance was attributed to the government's commitment in improving maternal and child health (Lori *et al.* 2017; Lori *et al.* 2013; Lori & Stark, 2012). Liberia is a post war country with several challenges such as inadequate infrastructure, lack of skilled medical staff and shortage of medical equipment and supplies. In addition, there is low contraceptive prevalence which has resulted in high numbers of teenage pregnancies with 60 percent of neonatal deaths occurring among adolescent women (Kentoffio *et al*. 2016). The aim of this study is to project neonatal mortality rate (NMR) for Liberia using the widely applied Box-Jenkins ARIMA technique. The model is suitable for modeling linear time series data and easy to understand (Nyoni, 2018; Box & Jenkins, 1970). The findings of this study, which is the first of its kind in the country are expected to pave way for the early detection of abnormal trends ofNMR, facilitate allocation of resources to Maternal and Child health program in the country and track progress towards achieving NMR of at least 12 per 1000 live births by 2030.

II. LITERATURE REVIEW

Yaya *et al*.(2019) investigated the changes in maternal healthcare services utilization between 2007 and 2016 in Post war Liberia. The cross-sectional study utilized 2007 and 2013 Liberia Demographic and Health Survey (LDHS) and the 2016 Malaria Indicator Survey. The outcomes of interest were: place of delivery and antenatal care visits. Univariate analysis was conducted using percentages and means (standard deviations) and multiple binary multivariable logistic models were used to examine the factors associated with the outcome variables. The study findings indicated that key maternal healthcare utilization indicators have improved substantially, especially facility-based delivery. However, a large proportion of women remain deprived of these life-saving health services in the post-war era. In another study, Chang *et al*.(2019) evaluated if the curriculum improved knowledge and comfort in participation. The curriculum included simulations and was based on the Neonatal Resuscitation Protocol (NRP). Students learned newborn airway management, quality chest compression skills, and resuscitation interventions through lectures and manikin-based simulation sessions. Seventy-five participants were trained. The study concluded that a modified NRP and manikin simulation-based curriculum may be an effective way of teaching health care providers in resource-limited settings.

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Brault *et al*.(2018)examined factors contributing to the reductions in under-five mortality in Postwar Liberia by conducting a case study mixed methods approach drawing on data from quantitative indicators, national documents and qualitative interviews were used to describe factors that enabled Liberia to rebuild their maternal, neonatal and child health (MNCH) programmes and reduce under-five mortality following the country's civil war. The findings revealed that three main factors contributed to the reduction in under-five mortality: national prioritization of MNCH after the civil war; implementation of integrated packages of services that expanded access to key interventions and promoted inter-sectoral collaborations; and use of outreach campaigns, community health workers and trained traditional midwives to expand access to care and improve referrals.

III. METHODOLOGY

The Box – Jenkins Approach

The first step towards model selection is to difference the series in order to achieve stationarity. Once this process is over, the researcher will then examine the correlogram in order to decide on the appropriate orders of the AR and MA components. It is important to highlight the fact that this procedure (of choosing the AR and MA components) is biased towards the use of personal judgement because there are no clear – cut rules on how to decide on the appropriate AR and MA components. Therefore, experience plays a pivotal role in this regard. The next step is the estimation of the tentative model, after which diagnostic testing shall follow. Diagnostic checking is usually done by generating the set of residuals and testing whether they satisfy the characteristics of a white noise process. If not, there would be need for model re – specification and repetition of the same process; this time from the second stage. The process may go on and on until an appropriate model is identified (Nyoni, 2018). The Box – Jenkins technique was proposed by Box & Jenkins (1970) and is widely used in many forecasting contexts.

Data Issues

This study is based on annual NMR in Liberia for the period 1963 to 2019. The out-of-sample forecast covers the period 2020 to 2030. All the data employed in this research paper was gathered from the World Bank online database.

Evaluation of ARIMA Models

Criteria Table

Table 1: Criteria Table

Model Selection Criteria Table			
Dependent Variable: DLOG(L)			
Date: 01/23/22 Time: 17:30			
Sample: 1963 2019			
Included observations: 56			
Model	LogL	AIC*	BIC
(3,3)(0,0)	259.958536	-8.998519	-8.709183
(4,2)(0,0)	259.041236	-8.965758	-8.676422
(4,3)(0,0)	260.001627	-8.964344	-8.638841
(3,4)(0,0)	259.982989	-8.963678	-8.638175
(3,5)(0,0)	260.900630	-8.960737	-8.599067
(5,2)(0,0)	259.406035	-8.943073	-8.617570
(5,1)(0,0)	258.389947	-8.942498	-8.653162
(3,1)(0,0)	256.353923	-8.941212	-8.724210
(4,4)(0,0)	260.114707	-8.932668	-8.570998
(4,5)(0,0)	260.900646	-8.925023	-8.527186
(5,4)(0,0)	260.857212	-8.923472	-8.525635
(5,0)(0,0)	256.502630	-8.910808	-8.657639
(5,5)(0,0)	261.452875	-8.909031	-8.475027
(5,3)(0,0)	259.427819	-8.908136	-8.546466
(3,2)(0,0)	256.393907	-8.906925	-8.653756

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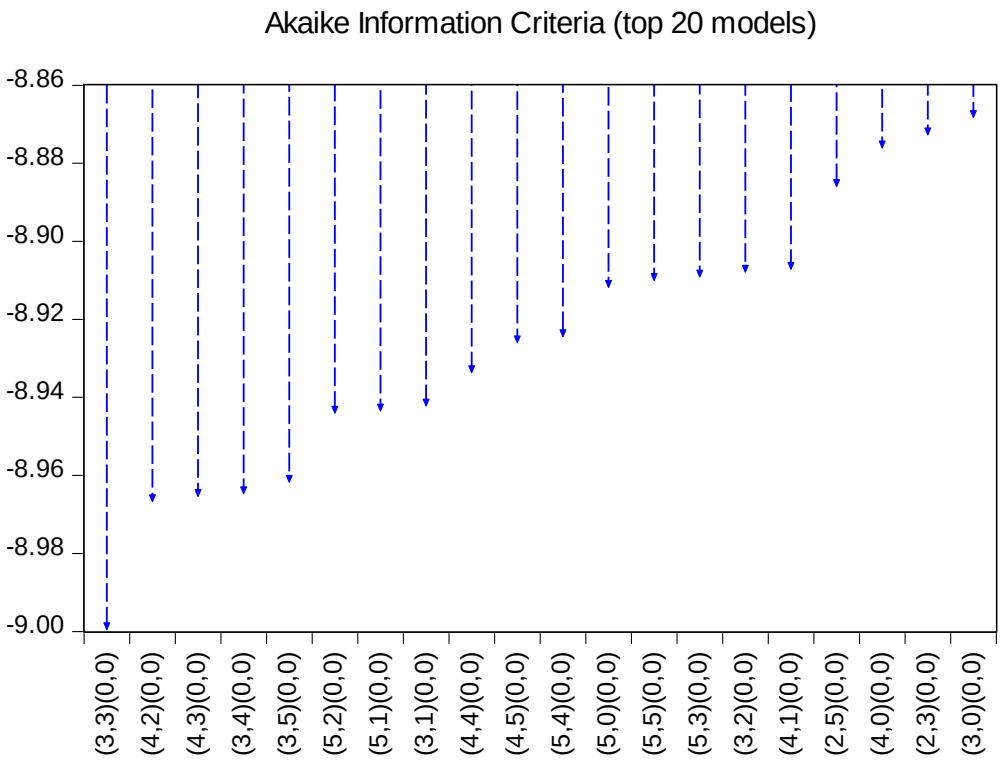
(4,1)(0,0)	256.372501	-8.906161	-8.652992
(2,5)(0,0)	257.779688	-8.884989	-8.559486
(4,0)(0,0)	254.500992	-8.875035	-8.658033
(2,3)(0,0)	255.407318	-8.871690	-8.618521
(3,0)(0,0)	253.284181	-8.867292	-8.686457

Criteria Graph

Figure 1: Criteria Graph



Forecast Comparison Graph

Figure 2: Forecast Comparison Graph

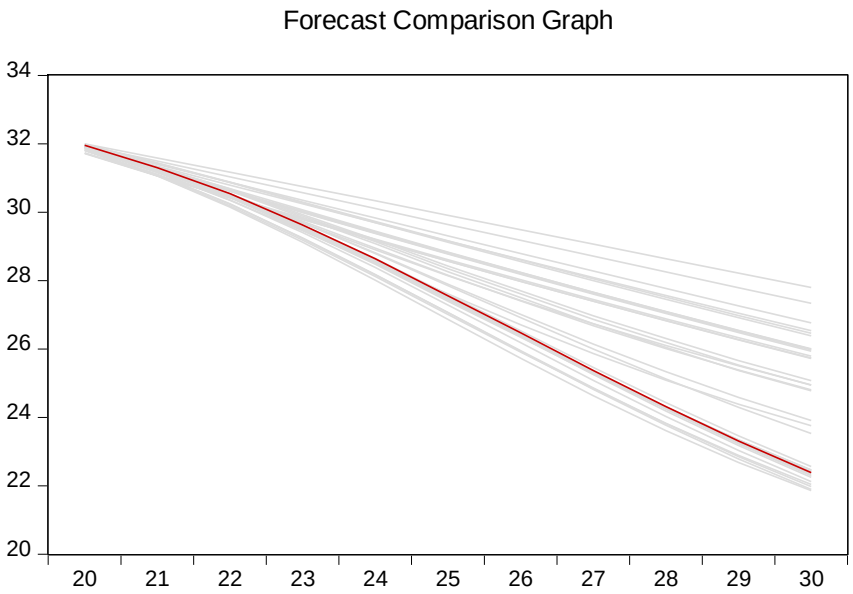


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Table 2 and Figure 1 indicate that the optimal model is the ARIMA (3,1,3) model. Figure 2 is a combined forecast comparison graph showing the out-of-sample forecasts of the top 25 models evaluated based on the AIC criterion. The red line shows the forecast line graph of the optimal model, the ARIMA (3,1,3) model.

IV. RESULTS

ARIMA () Model Forecast

Tabulated Out of Sample Forecasts

Table 2: Tabulated Out of Sample Forecasts

Year	Forecasts
2020	31.95601887455787
2021	31.30082065435191
2022	30.54361782353897
2023	29.62108771102212
2024	28.63540942183107
2025	27.55618746492613
2026	26.47199798850266
2027	25.36898957913467
2028	24.31613813895451
2029	23.30380000051627
2030	22.3796581494171

Table 2 clearly indicates that neonatal mortality will continue to decline but still remain very high throughout the out of sample period.

V. POLICY IMPLICATION & CONCLUSION

Liberia is a post war country with numerous challenges but has managed to make significant progress towards achieving SDG-3 target 3.2.1 of reducing neonatal mortality rate to at least 12 per 1000 live births. The authorities in this country have a huge task of dealing with low contraceptive prevalence and high numbers of teenage pregnancies which contribute to the majority of neonatal deaths. In this paper we proposed the Box-Jenkins ARIMA technique to forecast future trends of neonatal mortality for Liberia. The study results indicated that neonatal mortality will continue to decline but still remain very high throughout the out of sample period. Hence, the Liberian policy makers should design appropriate and country specific maternal and child health policies with special attention being given to addressing the major drivers of neonatal deaths such as high teenage pregnancy rates, inadequate infrastructure, lack of skilled medical staff and shortage of medical equipment and supplies.

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