

Prevention of Adverse Neonatal Health Outcomes in Benin Using Empirical Evidence Generated By the Box-Jenkins ARIMA Model

¹Dr. Smartson. P. NYONI, ²Thabani NYONI

¹ZICHIRE Project, University of Zimbabwe, Harare, Zimbabwe

²Independent Researcher & Health Economist, Harare, Zimbabwe

Abstract - Low-middle income countries continue to report high absolute numbers of under five deaths. The decline in under-five mortality over the previous decades is commendable, however that of neonatal mortality is not impressive. Therefore, it is relevant at this point in time to utilize a forecasting technique to inform decisions and allocation of adequate resources to neonatal healthcare interventions. This article employs annual time series data on neonatal mortality rate (NMR) for Benin from 1960 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 (0,1,4) model. The ARIMA model predictions suggest that NMR will remain very high in Benin. Hence, authorities are encouraged to design and implement appropriate neonatal policies that will address very high deaths among neonates. Special attention should be given to improvement of quality, accessibility and affordability of neonatal healthcare services at all levels of healthcare.

Keywords: ARIMA, Forecasting, NMR.

I. INTRODUCTION

Economic growth is dependent on human capital, therefore it is prudent for developing countries to channel adequate resources towards maternal and child health programs (Bloom *et al.* 2020). There has been significant progress made by low-middle income countries towards achieving sustainable development goals (SDGs) by the end of 2030 including SDG-3 which focuses on ensuring good health for all at every stage of life. Target 3.1 aims to reduce maternal mortality ratio (MMR) to less than 70 maternal deaths per 100 000 live births whereas target 3.2 focuses on the reduction of neonatal mortality rate (NMR) to at least 12 deaths per 1000 live births and under five mortality to levels as low as 25 deaths per 1000 live births by the end of 2030. (UNICEF, 2019; Kayode *et al.* 2017; UN, 2016). It is still unfortunate to mention that under-five and maternal mortality remain a global health challenge especially for poor countries whose health systems are heavily dependent on donor funding and have persistent economic problems that stem from mismanagement of local resources, political conflict, civil unrest, climate change and corruption. Therefore, many Sub-Saharan African countries are likely to miss their SDG targets by the end of 2030. Application of time series forecasting models is very important in order to assess progress towards achieving set SDG targets and provide research evidence for maternal and child health policies which are appropriate for the substantial reduction of neonatal mortality. Hence, in this paper we proposed the widely applied traditional statistical model, the Box-Jenkins ARIMA methodology which is a useful tool in modelling linear data sets (Nyoni, 2018; Box & Jenkins). This statistical technique is underutilized in public health programming especially in developing countries and its use now is going to be an eye-opener for public health specialists by acting as an early surveillance tool to guide planning and allocation of resources.

II. LITERATURE REVIEW

Tiruneh *et al.* 2021 assessed the pooled estimate of infant mortality rate (IMR), time to death, and its associated factors in SSA using the recent demographic and health survey dataset between 2010 and 2018. Parametric survival modelling was used for analysis and the findings revealed that significant number of infants died in SSA with the most common cause of infant death being a preventable bio-demographic factor. A cross-sectional study in Benin by Tanou *et al.* 2021 examined the effect of geographical accessibility to health facilities on antenatal care and delivery services utilization in Benin, with an emphasis on geographical zones by employing multivariate logistic regression. The findings of the study suggested that geographical accessibility to health facilities is critically important for the utilization of antenatal care and delivery services, particularly in the northern part of Benin. A similar study was carried out by Yaya *et al.* 2020 who investigated proximate and socio-economic

factors associated with mortality in under-five children in Benin. The study findings indicated an under-five mortality rate of 96 deaths per 1000 live births and that socioeconomic and proximate factors are important determinants of under-five mortality in Benin. Gayawan *et al.* 2016 pooled data for 10 of the countries in West Africa extracted from Demographic and Health Surveys and used the spatial extension of discrete-time survival model to examine how the variables exert influence on infant and child mortality across space. Inference was Bayesian based on the computationally efficient MCMC technique. The study found different geographical patterns for infant and child mortality. In the case of children under five, demographic factors inherent to the mother and child as well as maternal status variables when accounted to explain a good part of the huge variations observed in the crude rates.

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 Benin for the period 1960 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

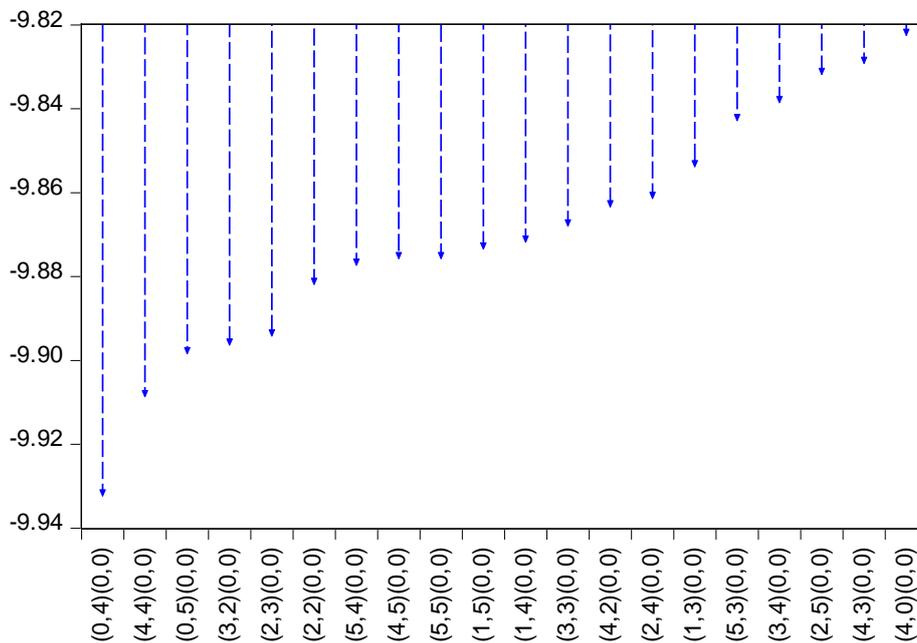
Model Selection Criteria Table			
Dependent Variable: DLOG(B)			
Date: 01/22/22 Time: 12:36			
Sample: 1960 2019			
Included observations: 59			
Model	LogL	AIC*	BIC
(0,4)(0,0)	298.978293	-9.931468	-9.720193
(4,4)(0,0)	302.281395	-9.907844	-9.555719
(0,5)(0,0)	298.978470	-9.897575	-9.651088
(3,2)(0,0)	298.918681	-9.895548	-9.649061
(2,3)(0,0)	298.853163	-9.893328	-9.646840
(2,2)(0,0)	297.491319	-9.881062	-9.669787
(5,4)(0,0)	302.356322	-9.876485	-9.489148
(4,5)(0,0)	302.309409	-9.874895	-9.487558
(5,5)(0,0)	303.308846	-9.874876	-9.452326
(1,5)(0,0)	299.242050	-9.872612	-9.590912
(1,4)(0,0)	298.193840	-9.870978	-9.624490
(3,3)(0,0)	299.080173	-9.867125	-9.585425
(4,2)(0,0)	298.944466	-9.862524	-9.580824
(2,4)(0,0)	298.886329	-9.860554	-9.578854

(1,3)(0,0)	296.663614	-9.853004	-9.641729
(5,3)(0,0)	300.339354	-9.842012	-9.489887
(3,4)(0,0)	299.213318	-9.837740	-9.520827
(2,5)(0,0)	299.013482	-9.830965	-9.514053
(4,3)(0,0)	298.935788	-9.828332	-9.511419
(4,0)(0,0)	295.739284	-9.821671	-9.610396

Criteria Graph

Figure 1: Criteria Graph

Akaike Information Criteria (top 20 models)



Forecast Comparison Graph

Figure 2: Forecast Comparison Graph

Forecast Comparison Graph

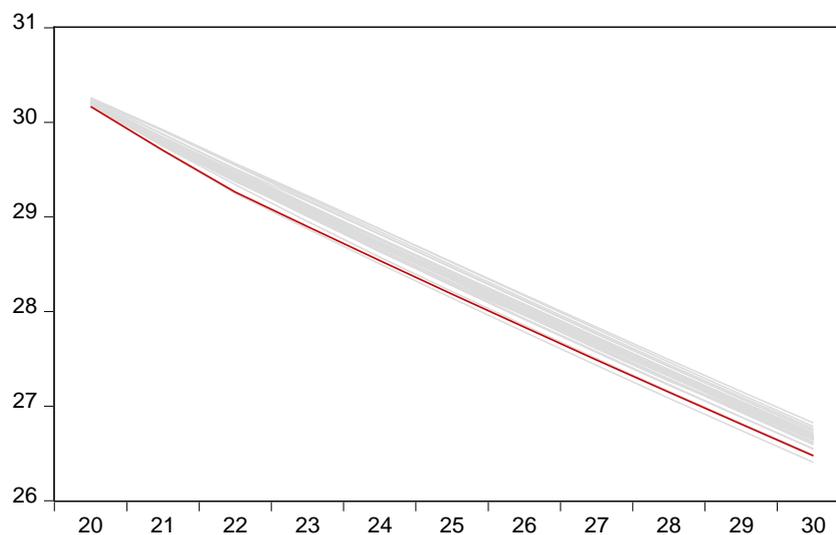


Table 1 and Figure 1 indicate that the optimal model is the ARIMA (0, 1, 4) model. Figure 2 is a combined forecast comparison graph showing the out-of-sample forecasts of the top 25 models evaluated based on the AIC criterion. The red line shows the forecast line graph of the optimal model, the ARIMA (0, 1, 4) model.

IV. RESULTS

ARIMA (0, 1, 4) Model Forecast

Tabulated Out of Sample Forecasts

Table 2: Tabulated Out of Sample Forecast

Year	Forecasts
2020	30.16559646166329
2021	29.70226786494254
2022	29.26189645408643
2023	28.89784005459694
2024	28.53853337224699
2025	28.18369419652512
2026	27.83326697985471
2027	27.48719686532028
2028	27.14542967808003
2029	26.80791191688516
2030	26.47459074570463

Table 5 indicates that there is likely to be a slight decrease in NMR in Benin over the period 2020 to 2030. Clearly, NMR will remain very high in the country for the next decade.

V. POLICY IMPLICATION & CONCLUSION

Maternal and neonatal mortality rates are still high in many countries in Sub-Saharan Africa and South Central Asia. Antenatal care (ANC) visits and institutional delivery with skilled birth attendants are important to prevent adverse pregnancy and neonatal outcomes. However, women’s utilization of antenatal care and delivery services has declined in Benin, a country where the southern and northern parts belong to different geographical zones. Accessibility of healthcare facilities significantly influences maternal and child health outcomes. Benin is an African country which has high maternal and neonatal mortality rates and has made its commitment to the 2015 sustainable development goals which includes goal 3 aimed at reducing neonatal mortality to at least 12 per 1000 live births by 2030. In this paper we modelled and forecasted NMR for Benin using the ARIMA model and the study findings suggest that neonatal mortality will remain very high throughout the forecast period. Therefore, authorities in Benin are encouraged to design appropriate neonatal policies in order to substantially reduce deaths among neonates. Special attention should be given to improvement of quality, accessibility and affordability of neonatal healthcare services at all levels of healthcare.

REFERENCES

- [1] Box, D. E., and Jenkins, G. M. (1970). Time Series Analysis, Forecasting and Control, Holden Day, London.
- [2] Nyoni, T. (2018). Box-Jenkins ARIMA Approach to Predicting net FDI Inflows in Zimbabwe, *University Library of Munich*, MPRA Paper No. 87737.
- [3] Bloom D. E., Kuhn M., and Prettnner K (2020). The contribution of female health to economic development. *Econ J.* 130, 630:1650–77
- [4] United Nation (2016). Transforming our world: The 2030 agenda for sustainable development.
- [5] Kayode GA., Grobbee DE., and Amoakoh-Coleman M (2017). Variation in neonatal mortality and its relation to country characteristics in sub-Saharan Africa: an ecological study. *BMJ Glob Health* 2017;2:e000209. doi:10.1136/ bmjgh-2016-000209

[6] UNICEF (2019). Child Mortality 2019, New York: United Nations Children's Fund.

Citation of this Article:

Dr. Smartson. P. NYONI, Thabani NYONI, "Prevention of Adverse Neonatal Health Outcomes in Benin Using Empirical Evidence Generated By the Box-Jenkins ARIMA Model" Published in *International Research Journal of Innovations in Engineering and Technology - IRJIET*, Volume 7, Issue 8, pp 212-216, August 2023. Article DOI <https://doi.org/10.47001/IRJIET/2023.708028>
