Employment of ARIMA Model Forecasts to Design Effective Neonatal Healthcare Policies in Ghana

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Abstract - **By the end of 2030 all UN member states are expected to achieve a neonatal mortality rate of at least 12 deaths per 1000 live births. However many African countries are likely going to miss their targets as a result of existing challenges such as poverty, hunger, climate change effects and economic hardships. New innovations are required to tackle neonatal deaths especially in the rural areas where patients travel long distances to access healthcare services. In addition, shortage of human resources and inadequate medical supplies contribute to poor quality service provision. This research uses annual time series data on neonatal mortality rate (NMR) for Ghana from 1965 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 (2) variable. The optimal model based on AIC is the ARIMA (5,2,0) model. ARIMA model projections indicate that neonatal mortality will gradually decline from around 22 to approximately 16 deaths per 1000 live births by the end of 2030. Therefore, neonatal policies must address geographic and socio-economic factors that aggravate neonatal mortality.**

Keywords: ARIMA, Forecasting, NMR.

I. INTRODUCTION

The global decrease in neonatal mortality over the past 20years has been slower than that of under 5 mortality and current projections indicate that approximately 69 million under 5 deaths will occur over the period 2016-2030 (UNICEF, 2019; WHO, 2016; UNICEF, 2015). The burden of neonatal deaths is high in Sub-Saharan Africa as the continent contributes 38% of the global neonatal mortalities (WHO, 2019; UNICEF, 2014). The global community set sustainable development goals (SDGs) in 2015 and the targets are expected to be achieved by the end of 2030. The SDG-3 target 3.2 aims to reduce neonatal mortality rate (NMR) to at least 12 per 1000 live births (UNICEF, 2019). Neonatal mortality in Ghana is aggravated by geographic and socio-economic factors hence the government launched the Newborn Health strategy and action plan (2014-2018) and was revised in 2019 to tackle neonatal deaths in the country (World Bank, 2019; GSS, 2019; GSS *et al.* 2015; GMOH, 2014).The aim of this study is to project NMR for Ghana by employing the Box-Jenkins ARIMA technique. The results of this piece of work are expected to indicate likely future trends of NMR and this will facilitate drafting of appropriate neonatal policies and adequate allocation of resources to the maternal and child health program.

II. LITERATURE REVIEW

Neonatal mortality remains a challenge in Ghana. Several previous studies in the country focused on factors associated with mortality in neonates. Adjei *et al*. (2021) investigated the effect of community-, household- and individual-level factors on the risk of neonatal mortality in two districts in Ghana. The longitudinal study used the Kintampo Health and Demographic Surveillance System as a platform to select 30,132 neonatal singletons with 634 deaths. Multilevel cox frailty model was used to examine the effect of community-, household- and individual-level factors on the risk of neonatal mortality. The conclusion from the study was that there is risk of neonatal mortality at the individual- and household-levels in the Kintampo Districts. A cross-sectional study carried out by Edem *et al*. (2020)examined the health practices, care-seeking behavior, and referral of sick out-born neonates to a district and regional hospital in the Upper West Region of Ghana. The study findings suggested that socio-cultural factors strongly influence health seeking behavior and the health outcome of neonates in this setting. A similar cross-sectional study in Ghana was done by Annan & Asiedu (2018) who applied the logit model to assess the maternal, neonatal, and health system related factors that influence neonatal deaths in the Ashanti Region, Ghana. The authors concluded that there was a high number of neonatal deaths which were mainly caused by birth asphyxia, infections, congenital anomalies and respiratory distress syndrome. Owusu *et al*.(2018)also found out that mortality at the neonatal in-patient unit at the Komfo Anokye Teaching Hospital in Ghana is very high. The probit model was applied by a Lambon-Quayefio & Owoo (2018) to investigate the factors that affect neonatal deaths as well as examine the effect of the Ghana Health Insurance on neonatal deaths in Ghana using the most

recent round of the Ghana Demographic and Health Survey. The study findings suggested significant regional differences in neonatal deaths and that the national health insurance may have the potential to substantially improve the health outcomes of neonates and have policy implications for increasing coverage to more mothers and their neonates, as well as coverage in critical neonatal services and drugs.

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 Ghana for the period 1965 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(G, 2)			
Date: 01/22/22 Time: 14:13			
Sample: 1965 2019			
Included observations: 53			
Model	LogL	AIC*	BIC
(5,0)(0,0)	259.606781	-9.532331	-9.272104
(5,1)(0,0)	259.609152	-9.494685	-9.197282
(5,2)(0,0)	259.741345	-9.461938	-9.127360
(5,3)(0,0)	259.741518	-9.424208	-9.052455
(5,4)(0,0)	260.617394	-9.419524	-9.010596
(5,5)(0,0)	261.396779	-9.411199	-8.965095
(4,5)(0,0)	259.803026	-9.388793	-8.979865
(2,4)(0,0)	256.408522	-9.373907	-9.076504
(2,5)(0,0)	257.348103	-9.371627	-9.037049
(4,2)(0,0)	255.956415	-9.356846	-9.059443
(1,4)(0,0)	254.730156	-9.348308	-9.088081
(4,1)(0,0)	254.534113	-9.340910	-9.080683
(1,5)(0,0)	255.448754	-9.337689	-9.040286
(3,5)(0,0)	257.357735	-9.334254	-8.962501
(3,4)(0,0)	256.237641	-9.329722	-8.995144
(0,3)(0,0)	251.991034	-9.320416	-9.134540
(0,5)(0,0)	253.271947	-9.293281	-9.033054
(0,4)(0,0)	252.047929	-9.284828	-9.061776

(1,3)(0,0)	252.034113	-9.284306	-9.061254
(2,2)(0,0)	251.877884	-9.278411	-9.055359

Criteria Graph

Figure 1: Criteria Graph

Akaike Information Criteria (top 20 models)
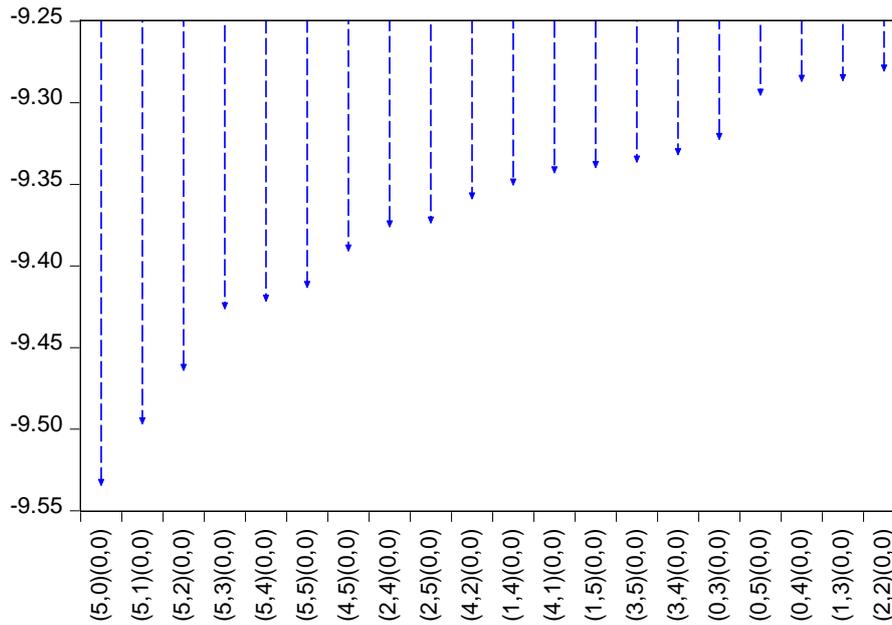
Forecast Comparison Graph

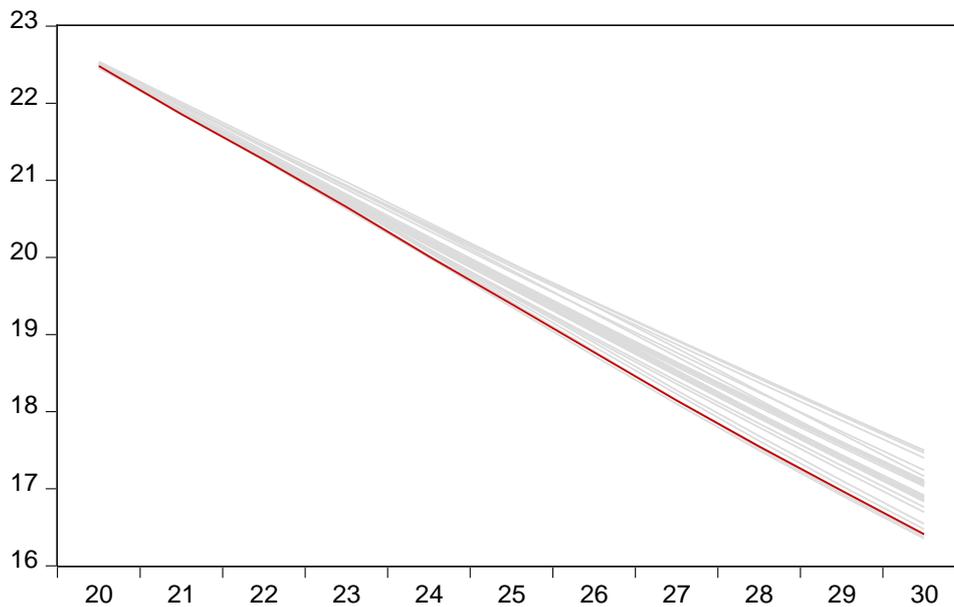Figure 2: Forecast Comparison Graph

Forecast Comparison Graph

Table 1 and Figure 1 indicate that the optimal model is the ARIMA (5,2,0) 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 (5,2,0) model.

IV. RESULTS

ARIMA () Model Forecast

Tabulated Out of Sample Forecasts

Table 2: Tabulated Out of Sample Forecasts

Year	Forecasts
2020	22.48275338269344
2021	21.85832634501921
2022	21.26573085791652
2023	20.65261588962432
2024	20.01076791735629
2025	19.39341948426877
2026	18.76718664256842
2027	18.14142510476194
2028	17.54793651045008
2029	16.97242013115549
2030	16.40898479715329

Table 2 clearly indicates that neonatal mortality will gradually decline from around 22 to approximately 16 deaths per 1000 live births by the end of 2030.

V. POLICY IMPLICATION & CONCLUSION

Primary healthcare is the backbone of any healthcare delivery system, therefore it is important for public health authorities to ensure availability of adequate staff, medical supplies and equipment at this level so that universal access of health services is achieved. This level is the point where the patient gets in contact with the healthcare worker so that appropriate care can be given and it is logical for policy makers to target this level when drafting maternal and child policies. Accessibility and affordability issues should be taken into account as many people in low-middle income countries live in rural areas where there is poor road infrastructure and the majority cannot afford high quality healthcare services. Neonatal mortality continues to be a problem in developing countries hence it is ideal for public health specialists to utilize early surveillance tools or techniques to detect abnormal trends of neonatal mortality to inform policies and decisions. In this study the ARIMA model was proposed to forecast NMR for Ghana. It was projected that neonatal mortality will gradually decline from around 22 to approximately 16 deaths per 1000 live births by the end of 2030. Therefore, country specific neonatal policies must address major drivers of mortality among neonates.

REFERENCES

[1] UNICEF (2019). Levels & Trends in child mortality. UNICEF, WHO, World Bank Group, UN. https://www.unicef.org/media/60561/file/UN-IGME-childmortal

[2] World Health Organization (2016). Fact Sheet. 2016. http://www.who.int/ media Centre/factsheets/fs178/en/.

[3] UNICEF (2015). Levels & Trends in child mortality. UNICEF, WHO, World Bank Group, UN. https://www.unicef.org/media/files/IGME_Report_Final2. pdf.

[4] United Nations Children's Funds (2014). Committing to child survival: a promise renewed. http://www.apromiserenewed.org.

[5] World Health Organization (2019). Newborns: reducing mortality. https:// www.who.int/news-room/fact-sheets/detail/newborns-reducing-mortality. Accessed 20 Nov 2019

[6] Ghana Statistical Service—GSS, Ghana Health Service—GHS, ICF International (2015). Ghana Demographic and Health Survey 2014. Rockville, Maryland, USA: GSS, GHS, and ICF International.

[7] Ghana Statistical Service U (2019). Ghana Multiple Indicator Cluster Survey 2017/18.

[8] National Newborn Health Strategy and Action Plan (2019–2023). Ministry of Health, Ghana.

[9] Ghana Ministry of Health (2014). Ghana National Newborn Health Strategy and Action Plan 2014–2018.

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