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Usage of the ARIMA Model to Forecast Future Trends of Neonatal Mortality Rate for Bangladesh

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

[1]ZICHIRe Project, University of Zimbabwe, Harare, Zimbabwe
[2]Independent Researcher & Health Economist, Harare, Zimbabwe

***Abstract* - The 17 objectives of sustainable development goals are attached to 169 targets which must be achieved by the end of 2030. UN member states recognize the importance of incorporating national statistical offices in every country for tracking SDG progress. Utilization of various statistical approaches to inform sub-national, national, regional and international decisions should form the core of the evaluation and implementation process. This article uses annual time series data on neonatal mortality rate (NMR) for Bangladesh 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 (2,1,5) model. The ARIMA model predictions suggest that neonatal mortality will decline to levels below 12 deaths per 1000 live births in the out-of-sample period. Therefore, authorities should design appropriate neonatal health policies to address causes of mortality among neonates with priority being given to primary healthcare.**

Keywords: ARIMA, Forecasting, NMR.

I. INTRODUCTION

Bangladesh is a South Asian country with a total population estimate of 164 689 383 (Bangladesh, 2020). Its maternal mortality ratio in 2017 was 173 deaths per 100 000 live births. In 2018 neonatal mortality rate (NMR) was 17.1 deaths per 1000 live births together with a 2020 total fertility rate of 2.0 births per woman (Bangladesh, 2020). The country has witnessed a downward trend in child mortality over the past decades (NIPORT *et al*. 2016). Over the period 1993-2014 neonatal mortality declined from 52 per 1000 live births to 28 per 1000 live births with neonatal deaths contributing 61% of all under five mortality (WHO, 2019). This data indicates that the majority of under 5 deaths are neonates and therefore it is critical for the government to focus on formulating and implementing neonatal policies which will substantially reduce neonatal mortality rate to at least 12 per 1000 live births, the set sustainable development (SDG-3) target by the end of 2030. The aim of this study is to model and project future trends of NMR for Bangladesh using the popular statistical and econometric model: Box-Jenkins ARIMA technique. This early surveillance tool is appropriate for analyzing linear data (Nyoni, 2018; Box & Jenkins, 1970). Public health programming requires informed decisions and policy formulation, hence this underutilized model will be essential in generating scientific evidence and stimulate appropriate public health responses to control neonatal mortality. Forecast results will also help track progress towards achieving SDG-3 target by 2030.

II. LITERATURE REVIEW

Das & Chakraborty (2021) investigated the influence of both individual and community level factors on neonatal death in Bangladesh. The study employed data from Bangladesh Demographic and Health Survey 2014. Bivariate analysis was used to examine the differentials in neonatal mortality by selected background variables of both levels. Multilevel logistic model confirmed that there exists clustering impact on neonatal death. A prospective, population-based observational study was conducted by Aziz *et al.* (2020) to compare pregnancy out- comes in Pakistan to other low-resource countries and explore factors that might help explain these differences. The research included all pregnant women and their pregnancy outcomes in defined geographic communities in six low-middle income countries (India, Pakistan, Democratic Republic of Congo, Guatemala, Kenya, and Zambia). Study staff enrolled women in early pregnancy and followed them up soon after delivery and at 42 days to ascertain delivery, neonatal, and maternal outcomes. The Pakistani pregnancy outcomes were found to be much worse than those in the other GN sites. Reasons for these poorer outcomes likely include that the Pakistani sites 'reproductive-aged women are largely poorly educated, under- nourished, anemic, and deliver a high percentage of preterm and low-birth weight babies in settings of often inadequate maternal and newborn care. In another study, Khan *et al.* (2020) assessed the extent to which maternal histories of newborn danger signs independently or combined with birth weight and/or gestational age (GA) can capture and/or predict post second day (age>48 hours) neonatal death. Prognostic multivariable models showed that maternally recalled danger signs,

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coupled to either birth weight or GA, can predict and capture post-second day neonatal death with high discrimination and sensitivity. A comparison of Pakistan's under-five mortality, neonatal mortality, and postnatal newborn care rates with those of other countries was performed by Ahmed *et al.* (2017). Neonatal mortality rates and postnatal newborn care rates from the Demographic and Health Surveys (DHSs) of nine low- and middle-income countries (LMIC) from Asia and Africa were analyzed. Pakistan's maternal, newborn, and child health (MNCH) policies and programs, which have been implemented in the country since 1990, were also analyzed. The results indicated that postnatal newborn care in Pakistan was higher compared with the rest of countries, yet its neonatal mortality remained the worst.

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 Bangladesh 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: D(B)				
Date: 01/22/22 Time: 12:22				
Sample: 1960 2019				
Included observations: 59				
Model	LogL	AIC*	BIC	HQ
(2,5)(0,0)	55.474280	-1.575399	-1.258487	-1.451690
(3,0)(0,0)	51.334206	-1.570651	-1.394589	-1.501923
(2,2)(0,0)	52.286257	-1.569026	-1.357751	-1.486552
(3,5)(0,0)	55.975422	-1.558489	-1.206364	-1.421034
(4,0)(0,0)	51.753275	-1.550958	-1.339683	-1.468485
(3,1)(0,0)	51.619858	-1.546436	-1.335161	-1.463963
(3,2)(0,0)	52.599218	-1.545736	-1.299249	-1.449517
(3,4)(0,0)	54.578066	-1.545019	-1.228107	-1.421309
(4,1)(0,0)	52.530203	-1.543397	-1.296909	-1.447178
(2,3)(0,0)	52.424205	-1.539804	-1.293316	-1.443585
(2,4)(0,0)	53.408826	-1.539282	-1.257582	-1.429318
(1,5)(0,0)	53.221622	-1.532936	-1.251236	-1.422972
(5,0)(0,0)	52.132546	-1.529917	-1.283429	-1.433698
(4,5)(0,0)	55.980788	-1.524772	-1.137435	-1.373572
(5,1)(0,0)	52.537066	-1.509731	-1.228031	-1.399767

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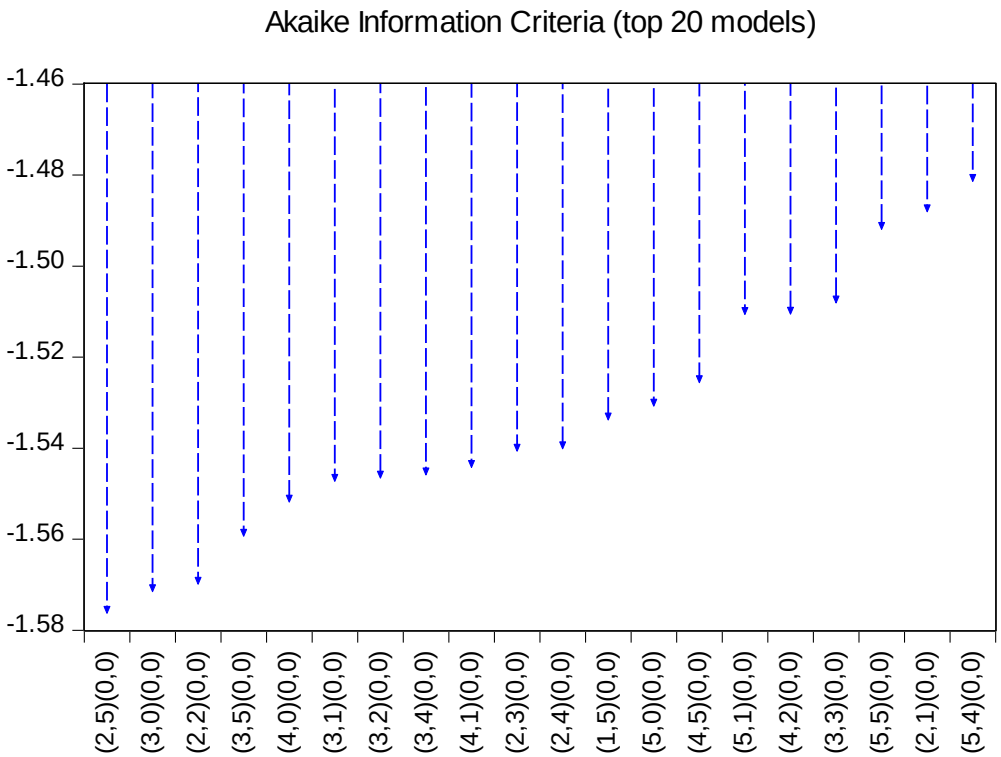
(4,2)(0,0)	52.536628	-1.509716	-1.228016	-1.399752
(3,3)(0,0)	52.463286	-1.507230	-1.225530	-1.397266
(5,5)(0,0)	55.987258	-1.491093	-1.068544	-1.326147
(2,1)(0,0)	48.873257	-1.487229	-1.311167	-1.418501
(5,4)(0,0)	54.675547	-1.480527	-1.093190	-1.329326

Criteria Graph

Figure 1: Criteria Graph



Forecast Comparison Graph

Figure 2: Forecast Comparison Graph

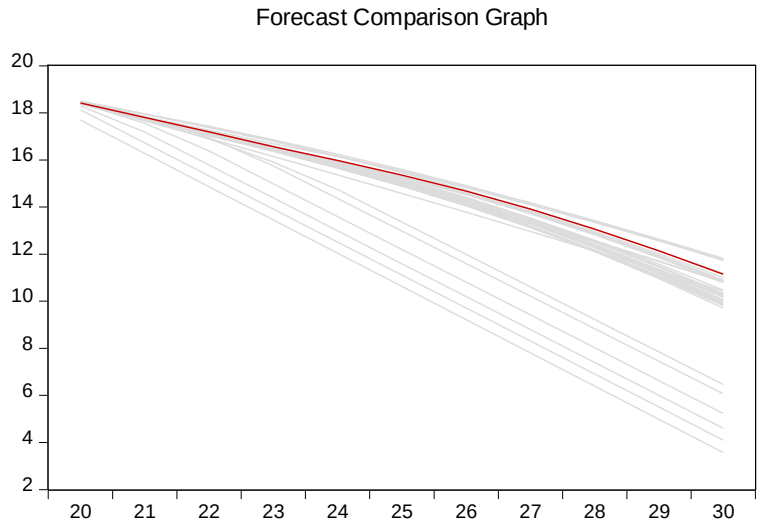


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Table 1 and Figure 1 indicate that the optimal model is the ARIMA (2, 1, 5) model. Figure 2 is a combined forecast comparison graph showing the out-of-sample forecasts of the top 25 models evaluated based on the AIC criterion. The red line shows the forecast line graph of the optimal model, the ARIMA (2, 1, 5) model.

IV. RESULTS

ARIMA (2,1,5) Model Forecast

Tabulated Out of Sample Forecasts

Table 2: Tabulated Out of Sample Forecasts

Year	Forecasts
2020	18.41566362217016
2021	17.80899022398224
2022	17.18970888500458
2023	16.56617500857078
2024	15.97917310902959
2025	15.36043448388162
2026	14.67525607410577
2027	13.90963416628427
2028	13.06179520728857
2029	12.13672185671021
2030	11.14269800872524

In line with WHO (2019) and UNICEF (2019), Table 2 clearly indicates that there is likely to be a decrease in NMR over the out-of-sample forecast. With regards to NMR in Bangladesh, SDG 3 target 3.2.1 is likely to be achieved by 2030.

V. POLICY IMPLICATION & CONCLUSION

Numerous challenges continue to exist in Bangladesh with the country reporting high absolute numbers of maternal and under five mortality. The occurrence of natural disasters such as floods have added a thorn on the flesh as thousands of people are affected by hunger and malnutrition. The country has witnessed a downward trend in under-five and neonatal mortality rates over the past 2 decades but the decline in NMR has not been impressive as thousands of newborns continue to die during the first month of life. This study applies the Box-Jenkins ARIMA model to predict future trends of neonatal mortality rate for Bangladesh and the findings indicate that neonatal mortality is expected to decline to levels below 12 deaths per 1000 live births in the out-of-sample period. Therefore, policy-makers in the country should design appropriate neonatal health policies to address causes of mortality in neonates with priority being given to primary healthcare.

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