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Assessing the Feasibility of Ending All Preventable Neonatal Deaths by the End of 2030 in India Using Empirical Evidence Obtained from the ARIMA Model

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***Abstract* - Dying of newborns between the time of birth and 28 days of life is still a huge public health problem in South Asia including India. Over the period 2000-2017 neonatal mortality dropped from 38 deaths per 1000 live births to 23.5 deaths per 1000 live births. The main causes of this mortality are prematurity, asphyxia, sepsis and congenital anomalies. Prediction of future trends of neonatal mortality will inform neonatal policies, decisions, planning and resource mobilization for the improvement of the quality of healthcare services during antenatal, delivery and postnatal periods. This research utilizes annual time series data on neonatal mortality rate (NMR) for India from 1969 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 (0,2,5) model. The findings of the study revealed that neonatal mortality will gradually decline from around 21 in 2020 to approximately 13 deaths per 1000 live births by the end of 2030.Therefore, Indian authorities are encouraged to design appropriate neonatal policies to address the problem of neonatal deaths with particular attention being given to promotion of institutional deliveries, improving health infrastructure in marginalized regions, ensuring availability of qualified medical staff and strengthening the referral system.**

Keywords: ARIMA, Forecasting, NMR.

I. INTRODUCTION

A newborn death that occurs within the first 28 days of life is called a neonatal death. Several factors have been identified as causes of neonatal mortality in health facility settings namely birth asphyxia, prematurity, sepsis, and congenital anomalies. Previous studies indicate that there is higher neonatal and infant mortality in females compared to males in South Asia (Chowdhury *et al*. 2017; Rosenstock *et al*. 2013). In India under 5 mortality rate declined from 83.1 deaths per 1000 live births in 2000 to 42.4 deaths per 1000 live births in 2017 whereas neonatal mortality rate (NMR) dropped from 38 deaths per 1000 live births to 23.5 deaths per 1000 live births (Thomson & Tevar, 2020).The 3rdSustainable Development Goal target 3.2 aims to reduce neonatal mortality to as low as 12 per 1000 live births by 2030 (United Nations, 2018). The National Health Policy (NHP) of India targets to reduce neonatal mortality to 16 per 1000 live births by 2025 (Government of India, 2017). However, the targets of SDGs and NHP for reduction of neonatal mortality are likely to be missed (Salve*et al.* 2021). For example, the fourth round of National Family Health Survey (NFHS-4) revealed that 30 newborn died per 1000 live births in India (IIPS and ICF, 2017). The Indian government has implemented several strategies to tackle neonatal mortality however efforts are lacking resulting in high neonatal deaths across the country (Salve*et al.* 2021). In this study we propose the ARIMA (p, d, q) model to model and project future trends of NMR for India. The model is appropriate for modelling linear time series data (Nyoni, 2018; Box & Jenkins, 1970). The findings of the study will guide neonatal policy formation and implementation of effective strategies to achieve the sustainable development goal 3 target 3.2 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. Aghai *et al*.(2020) determined the gender differences in neonatal mortality, stillbirths, and perinatal mortality in south Asia using the Global Network data from the Maternal Newborn Health Registry. It was noted that the risks of stillbirths, and early neonatal mortality were higher among male infants than their female

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counterparts. However, there was no gender difference in mortality after 7 days of age. A prospective, population-based research study was conducted by Dhaded *et al*. (2020) to investigate neonatal deaths in rural Karnataka, India for the period 2014–2018. Study staff collected demographic and health care characteristics on eligible women enrolled with neonatal outcomes obtained at delivery and day 28. Cause of neonatal mortality at day 28 was assigned by algorithm using prospectively defend variables. Study found that infants who were preterm and low-birth weight remained at highest risk for 28-day neonatal mortality in India. 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, 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 highlighted 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 India for the period 1969 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(V, 2)			
Date: 01/22/22 Time: 14:32			
Sample: 1969 2019			
Included observations: 49			
Model	LogL	AIC*	BIC
(0,5)(0,0)	241.091930	-9.554773	-9.284513
(0,4)(0,0)	239.438584	-9.528105	-9.296454
(5,5)(0,0)	245.254102	-9.520576	-9.057273
(5,4)(0,0)	244.242715	-9.520111	-9.095416
(1,4)(0,0)	240.021282	-9.511073	-9.240813
(5,3)(0,0)	242.219367	-9.478342	-9.092256
(0,2)(0,0)	236.186598	-9.477004	-9.322570

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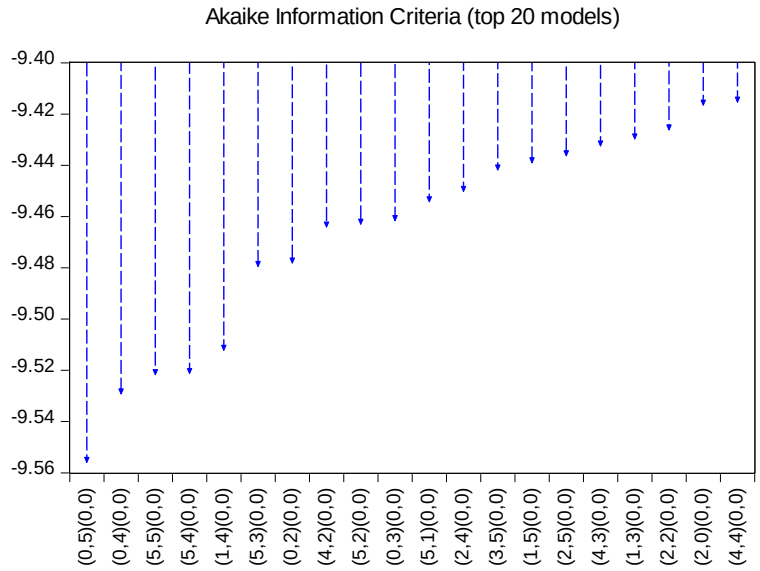
(4,2)(0,0)	239.842643	-9.462965	-9.154096
(5,2)(0,0)	240.816697	-9.461906	-9.114429
(0,3)(0,0)	236.781311	-9.460462	-9.267419
(5,1)(0,0)	239.601018	-9.453103	-9.144234
(2,4)(0,0)	239.502857	-9.449096	-9.140228
(3,5)(0,0)	241.298456	-9.440753	-9.054668
(1,5)(0,0)	239.228376	-9.437893	-9.129024
(2,5)(0,0)	240.162797	-9.435216	-9.087739
(4,3)(0,0)	240.068265	-9.431358	-9.083881
(1,3)(0,0)	237.000518	-9.428593	-9.196941
(2,2)(0,0)	236.914343	-9.425075	-9.193424
(2,0)(0,0)	234.678223	-9.415438	-9.261003
(4,4)(0,0)	240.648738	-9.414234	-9.028148

Criteria Graph

Figure 1: Criteria Graph



Forecast Comparison Graph

Figure 2: Forecast Comparison Graph

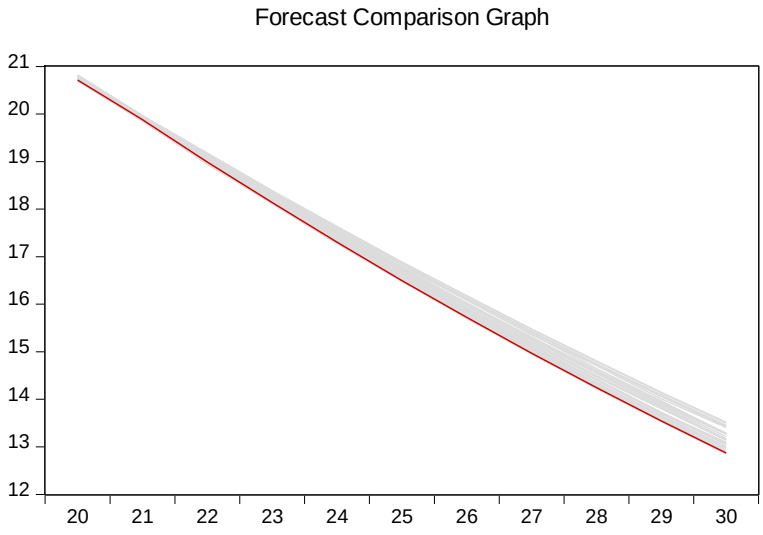


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Table 1 and Figure 1 indicate that the optimal model is the ARIMA (0,2,5) model. Figure 2 is a combined forecast comparison graph showing the out-of-sample forecasts of the top 25 models evaluated based on the AIC criterion. The red line shows the forecast line graph of the optimal model, the ARIMA (0,2,5) model.

IV. RESULTS

ARIMA () Model Forecast

Tabulated Out of Sample Forecasts

Table 2: Tabulated Out of Sample Forecasts

Year	Forecasts
2020	20.71475913544672
2021	19.87846109228958
2022	18.98761296820381
2023	18.13743661030702
2024	17.30475769347311
2025	16.49927309102664
2026	15.72076850915563
2027	14.96898688530541
2028	14.24363107645432
2029	13.54436655040635
2030	12.87082406942948

Table 2 clearly indicates that neonatal mortality will gradually decline from around 21 in 2020 to approximately 13 deaths per 1000 live births by the end of 2030.

V. POLICY IMPLICATION & CONCLUSION

Global estimates indicate that Asian and African countries are lagging behind in the reduction of under-five and neonatal mortality. Although India has made significant progress in reducing mortality of under-fives and neonates, the absolute numbers of neonatal deaths is a cause for concern particularly in the remote rural areas where socio-cultural, demographic, geographic and economic issues have serious influence on mortality among neonates. This piece of work applies the ARIMA model to project future trends of NMR for India and forecast results indicate that neonatal mortality will gradually decline from around 21 in 2020 to approximately 13 deaths per 1000 live births by the end of 2030s. Therefore, Indian authorities are encouraged to design country specific neonatal policies to address the problem of neonatal deaths with particular attention being given to promotion of institutional deliveries, improving health infrastructure in marginalized areas, ensuring availability of qualified medical staff at all levels of healthcare and strengthening the referral system.

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