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Relying on ARIMA Model Forecasts to Address Adverse Neonatal Health Outcomes in Ecuador

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***Abstract* - This study uses annual time series data on neonatal mortality rate (NMR) for Ecuador 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 (2) variable. The optimal model based on AIC is the ARIMA (0,2,0) model. The ARIMA model predictions revealed that neonatal mortality will hover around 7 deaths per 1000 live births throughout the out of sample period. Therefore, we encourage authorities in Ecuador to formulate local neonatal policies to address the problem of deaths of newborns with more attention being given to addressing various challenges in the rural areas.**

Keywords: ARIMA, Forecasting, NMR.

I. INTRODUCTION

Under 5 mortality is still a global public health problem requiring serious commitment from all countries and International bodies. Channeling adequate resources towards maternal and child health interventions will definitely improve maternal and neonatal health outcomes. Mortality in children is influenced by social, proximate, and intermediate factors (Adeyinka *et al.* 2019; Ansari*et al.* 2015; Mckinnon *et al.* 2014). Neonatal deaths constitute 44% of under 5 mortality worldwide (Carlo & Travers, 2016; Liu *et al.* 2016). The occurrence of newborn deaths within the first 28 days of life reflects the standard of care during antenatal, delivery and postnatal periods (Gatt *et al.* 2015). The aim of this study is to model and project future trends of neonatal mortality rate for Ecuador using the popular ARIMA (p, d, q) model. The traditional statistical technique has been shown to be useful in modelling and forecasting linear time series data (Nyoni, 2018; Box & Jenkins, 1970). The findings of this piece of work are expected to facilitate planning and allocation of adequate resources to maternal and newborn care so as to effectively control neonatal mortality in Ecuador.

II. LITERATURE REVIEW

Reis *et al.* (2021) evaluated the fetal and infant mortality rates due to congenital anomalies (CA) in Maranhão from 2001 to 2016 in Brazil. Data were obtained from the SINASC, and SIM databases. The study used simple linear regression, Poisson distribution, and ANOVA (Bonferroni's post hoc test) and analyzed the public data (2001–2016) of 1934858 births and determined the fetal, neonatal, perinatal, and post-neonatal mortality rates associated with CA by mesoregions. The results indicated mortality rates due to CA in Maranhão increased over the period 2001–2016 possibly as a result of improved maternal-infant health conditions eliminating other causes of death. Baroni *et al.* (2021) outlined an integrated dataset containing monthly data in a historical series from 1996 to 2017 with information on all births, neonatal deaths, and NMR (total, early and late components) enriched with information related to the municipality. It is a dataset of historical data with information on the number of births, the number of neonatal deaths, the neonatal mortality rate (including early and late), and geographic information for each month (between January 1996 and December 2017) and Brazilian municipality. In a 2019 study, Souza et al investigated the determinants of neonatal mortality in Foz do Iguassu in Brazil. The authors analyzedall neonatal deaths that occurred in Foz do Iguassu from 2012 to 2016. Birth and mortality data were extracted from two national governmental databases (SINASC and SIM). It was found that high rate of neonatal death in Foz do Iguassu is strongly associated with newborn characteristics and not associated with maternal socio-demographic characteristics. Boulos *et al.* (2017) investigated the etiology of severe bacterial infections in neonates. Researchers conducted a secondary retrospective analysis of a de-identified database from the Neonatal Intensive Care Unit (NICU) at Nos Petit Fre`res et Soeurs-St. Damien Hospital (NPFS-SDH). Records from 1292 neonates admitted to the NICU at NPFS-SDH in Port-au-Prince Haiti from 2013 to 2015 were reviewed. Sepsis accounted for 708 of 1292 (54.8%) of all admissions to the NICU. The most common organism cultured was Streptococcus agalactiae, followed by Klebsiella pneumoniae, Pseudomonas aeroginusa, Enterobacter aerogenes, Staphylococcus aureus and Proteus mirabillis.

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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 Ecuador 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(E, 2)			
Date: 01/22/22 Time: 13:36			
Sample: 1960 2019			
Included observations: 58			
Model	LogL	AIC*	BIC
(0,0)(0,0)	47.679128	-1.575142	-1.504093
(1,0)(0,0)	47.740967	-1.542792	-1.436217
(0,1)(0,0)	47.726301	-1.542286	-1.435712
(0,2)(0,0)	48.717984	-1.541999	-1.399900
(2,2)(0,0)	50.456035	-1.532967	-1.319817
(2,0)(0,0)	48.433903	-1.532204	-1.390104
(1,1)(0,0)	48.008805	-1.517545	-1.375445
(3,2)(0,0)	50.852689	-1.512162	-1.263488
(2,3)(0,0)	50.827883	-1.511306	-1.262632
(0,3)(0,0)	48.738872	-1.508237	-1.330613
(1,2)(0,0)	48.726208	-1.507800	-1.330176
(3,0)(0,0)	48.437727	-1.497853	-1.320228
(2,1)(0,0)	48.435223	-1.497766	-1.320142
(1,3)(0,0)	49.384690	-1.496024	-1.282875
(0,4)(0,0)	49.342669	-1.494575	-1.281426
(0,5)(0,0)	50.264585	-1.491882	-1.243208
(4,0)(0,0)	49.205209	-1.489835	-1.276686
(5,0)(0,0)	50.141917	-1.487652	-1.238978
(3,1)(0,0)	48.922822	-1.480097	-1.266948
(4,2)(0,0)	50.885660	-1.478816	-1.194617

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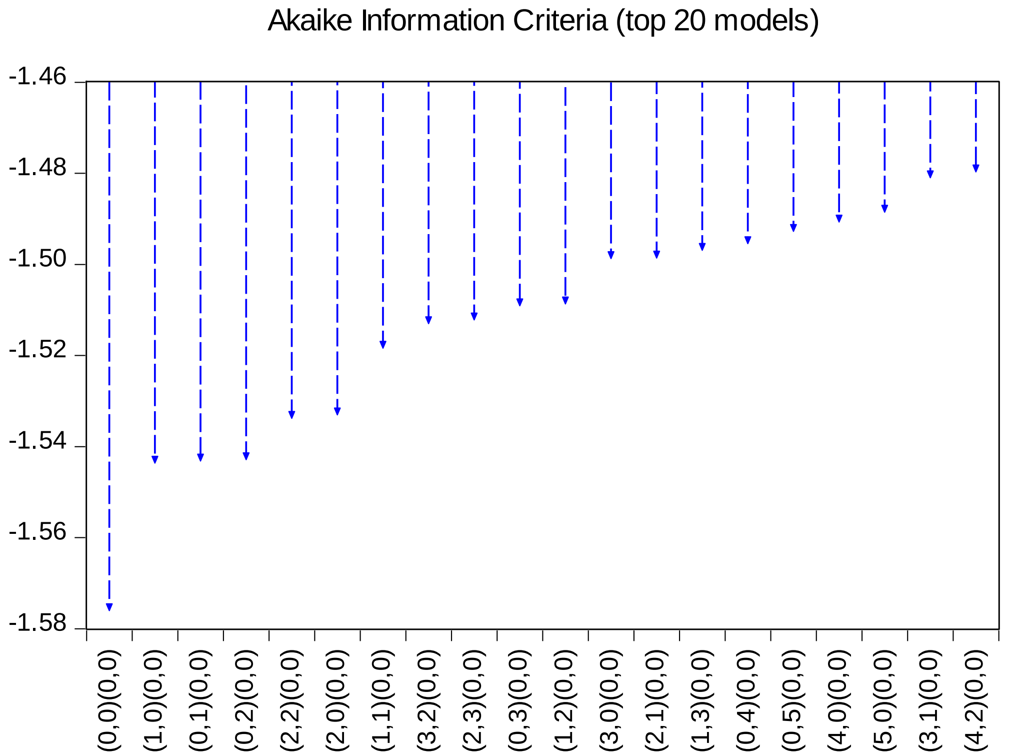
Criteria Graph

Figure 1: Criteria Graph



Forecast Comparison Graph

Figure 2: Forecast Comparison Graph

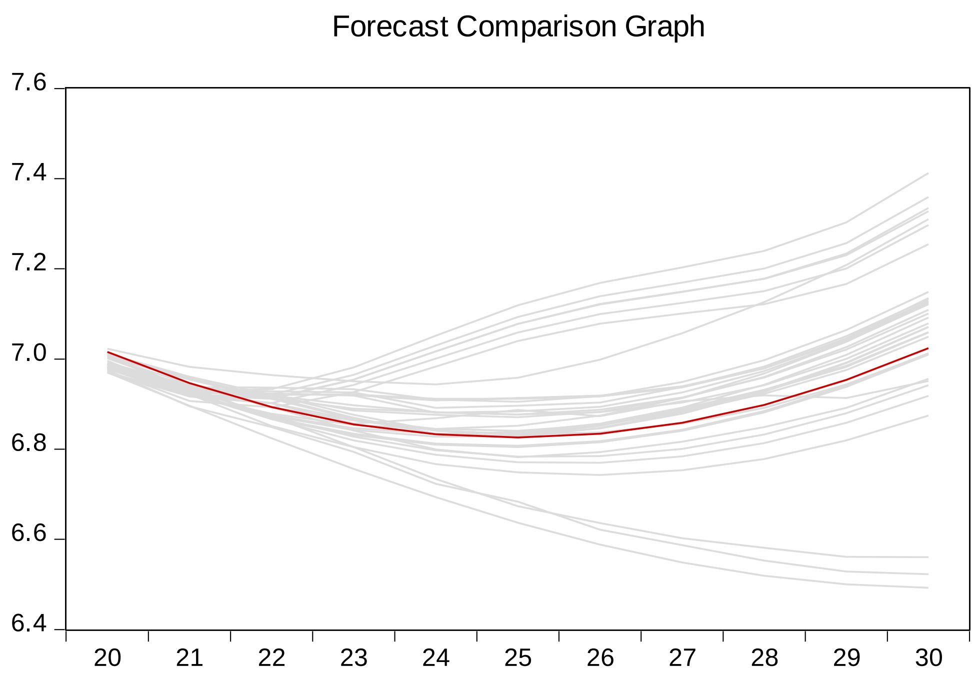


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Table 1 and Figure 1 indicate that the optimal model is the ARIMA (0,2,0) model. Figure 2 is a combined forecast comparison graph showing the out-of-sample forecasts of the top 25 models evaluated based on the AIC criterion. The red line shows the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

IV. RESULTS

ARIMA () Model Forecast

Tabulated Out of Sample Forecasts

Table 2: Tabulated Out of Sample Forecasts

Year	Forecasts
2020	7.01551724137931
2021	6.94655172413793
2022	6.89310344827586
2023	6.855172413793101
2024	6.832758620689651
2025	6.825862068965514
2026	6.834482758620685
2027	6.858620689655168
2028	6.898275862068959
2029	6.953448275862063
2030	7.024137931034475

Table 5 and Figure 3 clearly indicate that neonatal mortality will hover around 7 deaths per 1000 live births throughout the out of sample period.

V. POLICY IMPLICATION & CONCLUSION

The government of Ecuador has made significant milestones in addressing maternal and child health challenges, however neonatal mortality remains an important public health problem. Several factors have been found to influence neonatal mortality and they include maternal, new-born and health system related factors. Intervention strategies implemented by the government contributed significantly to the decline in neonatal mortality over the past decades. In this study we proposed the Box-Jenkins ARIMA model to forecast future trends of neonatal mortality rate and the findings revealed that neonatal mortality will hover around 7 deaths per 1000 live births throughout the out of sample period. Therefore, we encourage authorities in Ecuador to formulate local neonatal policies to address the problem of deaths of newborns during the first 28 days of life with more attention being given to addressing challenges in the rural areas.

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