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Using the ARIMA Model as a Surveillance Tool for the Early Detection of Future Trends of Neonatal Mortality in Burundi

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***Abstract* - Tracking future trends of neonatal mortality will help in the assessment of progress towards achieving set SDG-3 target 3.2 by the end of 2030. This will inform policy-making, decisions and allocation of resources to maternal and child health programs. This research uses annual time series data on neonatal mortality rate (NMR) for Burundi from 1964 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 (3,1,5) model. The ARIMA model predictions indicate that neonatal mortality will gradually decline from around 20.6 in 2020 to about 16.2 deaths per 1000 live births by the end of 2030. Therefore, authorities in Burundi are encouraged to draft and implement neonatal policies that will effectively tackle the problem of mortality among newborns. This must include regular refresher courses on essential obstetric and newborn care at all levels of healthcare and continuous health education among communities to address contributing factors.**

Keywords: ARIMA, Forecasting, NMR.

I. INTRODUCTION

It has been observed that many Sub-Saharan African countries are not on track in terms of achieving sustainable development goal-3 target 3.2 which focuses on the reduction of maternal and neonatal mortality rate to less than 70 per 100 000 live births and 12 per 1000 live births respectively (WHO, 2019; Gulmezoglu *et al*. 2016). It is very critical that all countries around the world should use available resources to draft and implement effective maternal & Child health (MNCH) policies to substantially reduce maternal and neonatal deaths (Gergen *et al*. 2017; Kandpal, 2016; Basinga *et al*. 2011). Performance based financing (RBF) has been implemented in many African countries and has been proven to improve the quality and quantity of healthcare services (Gage & Bauhoff, 2020). Modelling techniques have been underutilized in public health programs especially in developing countries. These surveillance tools are useful in the early detection of outbreaks, abnormal trends of diseases and other health related problems, and facilitate timeous implementation of effective evidence based intervention strategies (Zhao *et al*. 2020; Panch *et al.* 2018; Song *et al.* 2017; Song *et al*. 2016). Therefore in this study we proposed the popular Box-Jenkins ARIMA technique (Nyoni & Nyoni, 2020; Nyoni & Nyoni, 2019; Zhou *et al*. 2018; Nyoni, 2018; Box & Jenkins, 1970) to model and project future trends of neonatal mortality rate for Burundi. Forecast results are envisioned to guide formulation and implementation of effective neonatal policies in order to substantially reduce NMR by 2030.

II. LITERATURE REVIEW

The problem of neonatal mortality is common in Burundi and many studies in the country and region have examined factors associated with mortality in neonates using various methods. A multisite retrospective Kenyan cohort study was conducted by Irimu *et al*. 2021 to find out the proportion of all admissions and deaths in the neonatal age group and examine morbidity and mortality patterns, stratified by birth weight, and their variation across hospitals. The results indicated that Intrapartum related complications was the single most common diagnosis among the neonates with birth weight of 2000 g or more who died. A threefold variation in mortality across hospitals was observed for birth weight categories 1000– 1499 g and 1500–1999g. Gage & Bauhoff (2020)assessed the impact of PBF on early neonatal health outcomes and associated health care utilization and quality in Burundi, Lesotho, Senegal, Zambia and Zimbabwe. Authors utilized data from Demographic and Health Surveys and Multiple Indicator Cluster Surveys and applied difference-in-differences analysis to estimate the effect of PBF projects supported by the World Bank on early neonatal mortality and low birth weight and concluded that PBF had no impact on early neonatal health

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outcomes in the five African countries studied and had limited and variable effects on the utilization and quality of neonatal health care. Sougou & Diouf (2020) conducted a secondary analysis of the 2017 DHS for Senegal to analyze the factors associated with neonatal deaths in Senegal in 2017. The study found out that significant predictors of neonatal mortality were newborns with a low birth weight < 2500 g with an OR= 2.3 [1.01-5.28], newborns who are considered "very small" by their mother at birth OR 2.5 [1.04-6.04] and birth by caesarean section (OR=3.97 [1.68-9.39]).In another study in Burundi by Yaya *et al.* 2020 who investigated inequalities in NMR in Burundi with the intent to help the country attain SDG 3.2 which aims to reduce neonatal mortality to at least as low as 12 per 1000 live births by 2030. The researchers used data from Burundi Demographic and Health Survey (BDHS) for the periods of 2010 and 2016 and analyzed it using the WHO's HEAT version 3.1 software. The findings of the study revealed large survival advantage remains to neonates of women who are rich, educated, residents of urban areas and some regions. Females had higher chance of surviving their 28th birthday than male neonates. A cross-sectional study was conducted Burundi by Moise (2018) to describe the main causes of hospitalization and mortality in children during the neonatal period and at ages 1 to 59 months, for boys and girls, and to assess the total annual (2010) burden of under-five morbidity and mortality in hospitals using hospitalization records from 21 district hospitals. The study findings indicated that human malarial infections continue to be the main cause of hospitalization and mortality among under-five children in Burundi.

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 Burundi for the period 1964 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: 13:10			
Sample: 1964 2019			
Included observations: 55			
Model	LogL	AIC*	BIC
(3,5)(0,0)	48.177636	-1.388278	-1.023308
(2,4)(0,0)	46.066135	-1.384223	-1.092247
(3,4)(0,0)	46.790126	-1.374186	-1.045714
(2,5)(0,0)	46.656552	-1.369329	-1.040856
(4,5)(0,0)	48.322642	-1.357187	-0.955720
(4,3)(0,0)	46.201345	-1.352776	-1.024303
(4,0)(0,0)	42.890427	-1.341470	-1.122488
(5,3)(0,0)	46.833470	-1.339399	-0.974429

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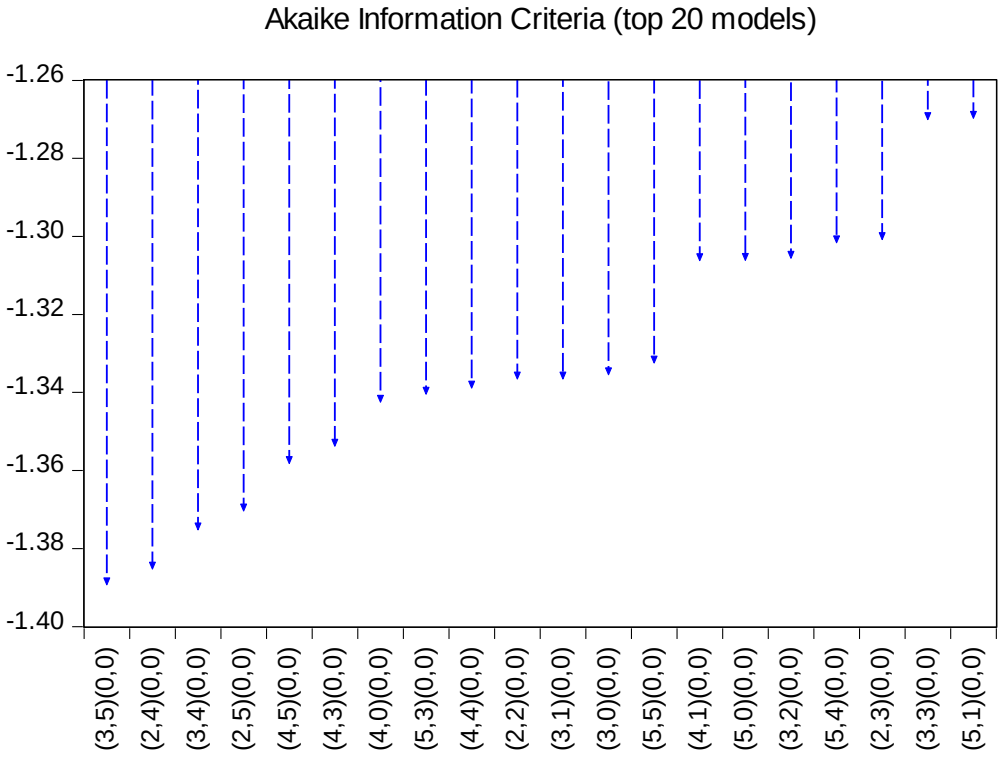
(4,4)(0,0)	46.791635	-1.337878	-0.972908
(2,2)(0,0)	42.728040	-1.335565	-1.116583
(3,1)(0,0)	42.726572	-1.335512	-1.116530
(3,0)(0,0)	41.697918	-1.334470	-1.151985
(5,5)(0,0)	48.613838	-1.331412	-0.893449
(4,1)(0,0)	42.893333	-1.305212	-1.049733
(5,0)(0,0)	42.891463	-1.305144	-1.049665
(3,2)(0,0)	42.875576	-1.304566	-1.049088
(5,4)(0,0)	46.766479	-1.300599	-0.899133
(2,3)(0,0)	42.744356	-1.299795	-1.044316
(3,3)(0,0)	42.899390	-1.269069	-0.977093
(5,1)(0,0)	42.890437	-1.268743	-0.976767

Criteria Graph

Figure 1: Criteria Graph



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Forecast Comparison Graph

Figure 2: Forecast Comparison Graph

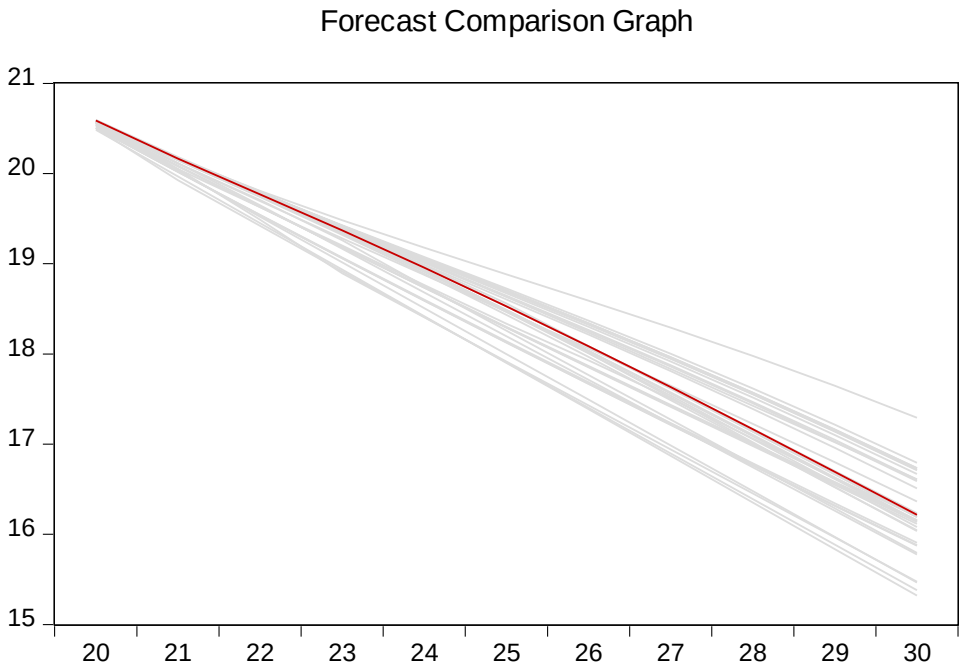

Table 1 and Figure 1 indicate that the optimal model is the ARIMA (3,1,5) model. Figure 2 is a combined forecast comparison graph showing the out-of-sample forecasts of the top 25 models evaluated based on the AIC criterion. The red line shows the forecast line graph of the optimal model, the ARIMA (3,1,5) model.

IV. RESULTS

ARIMA () Model Forecast

Tabulated Out of Sample Forecasts

Table 5: Tabulated Out of Sample Forecasts

Year	Forecasts
2020	20.58657726062183
2021	20.16565197462982
2022	19.76968509532075
2023	19.37050434213224
2024	18.95481503685766
2025	18.52809708553046
2026	18.08504062503361
2027	17.63109862775144
2028	17.16550824294476
2029	16.69329025451286
2030	16.21553422537704

Table 5 and figure 3 indicates that neonatal mortality will gradually decline from around 20.6 in 2020 to about 16.2 deaths per 1000 live births by the end of 2030.

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V. POLICY IMPLICATION & CONCLUSION

Many low and middle income countries will not meet their sustainable development goal targets by the end of 2030 as a result of numerous challenges that include poverty, hunger, political conflict and underutilization of available resources. It is essential to use surveillance tools to track progress towards achieving SDG targets including target 3.2 which aims to significantly reduce maternal and child mortality by 2030. In this study we employ the ARIMA approach as an early surveillance tool to predict future trends of NMR for Burundi and the findings indicate that neonatal mortality will gradually decline from around 20.6 in 2020 to about 16.2 deaths per 1000 live births by the end of 2030. Therefore, health authorities in Burundi are encouraged to draft and implement neonatal policies that will effectively tackle the problem of mortality in newborns. This should include regular refresher courses on neonatal resuscitation at all levels of healthcare and continuous health education among communities to address contributing factors in order to improve neonatal survival rates.

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