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Forecasting Infant Mortality Rate in Angola Using Artificial Neural Networks

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***Abstract* - In this paper, the ANN approach was applied to analyze infant mortality rate in Angola. The employed annual data covers the period 1980-2020 and the out-of-sample period ranges over the period 2021-2030. The residuals and forecast evaluation criteria (Error, MSE and MAE) of the applied model indicate that the model is stable in forecasting infant mortality rate in Angola. The ANN (12, 12, 1) model predictions suggest that over the next decade infant mortality will be around 46 infant deaths/1000 live births per year. Therefore the government should intensify maternal and child health surveillance and control programs in order to reduce infant mortality and to achieve the sustainable development goals by 2030. This should be done in line with the suggested policy prescriptions.**

Keywords: ANN, Forecasting, infant mortality rate.

I. INTRODUCTION

Infant mortality rate (IMR) is a measure of the number of infant deaths per 1000 live births born to a group of women in a specified time period (CDC, 2020). The leading causes of IMR include birth defects, prematurity, low birth weight, infections and sudden infant syndrome (CDC, 2020). IMR is an indicator of the health status of a population implying that problems affecting the entire population can have marked influence on infant mortality (CDC, 2020; Reidpath & Allotey, 2003). Infant mortality continues to be a challenge in many developing nations with the highest burden in Sub-Saharan Africa (World Mortality, 2017). Several studies have reported that IMR varies from country to country or from region to region (Hannah & Roser, 2020; Child trends, 2020; Nyoni & Nyoni, 2020; Bhatia et al, 208; Zhao et al, 2017; Adedin et al, 2014; Hajizadeh et al, 2014; Mujica et al, 2014; Wang et al, 2012; Sohler et al, 2003; Knobel et al, 1994). Afghanistan reported the highest IMR of 110.6 deaths per 1000 live births and Angola 67.6 deaths per 1000 live births (Shibre, 2020). In this paper we aim to apply the artificial neural network model, ANN (12, 12, 1) approach to predict infant mortality in Angola. The findings of this study are expected to serve as a surveillance tool to detect abnormal trends of IMR and facilitate the evaluation of maternal and child health intervention programs in order to reduce maternal and child mortality.

II. LITERATURE REVIEW

Nyoni & Nyoni (2020) modelled and forecasted infant deaths in Zimbabwe using ARIMA model. The study utilized annual time series data on total infant deaths in Zimbabwe from 1960 to 2018. The best model based on AIC was the ARIMA (1, 2, 5) model. The study findings indicated that the number of infant deaths per year, over the out-of-sample period, would follow a downward trend In a similar study, Nyoni & Nyoni (2020) used monthly time series data on neonatal deaths cases at Chitungwiza Central Hospital (CCH) from January 2013 to December 2018; to forecast neonatal deaths over the period January 2019 to December 2020 using the Box-Jenkins SARIMA approach. The parsimonious model was found to be the SARIMA (0, 0, 3) (2, 0, 0)12 model and its predictions indicate slow but steady decrease in neonatal deaths at CCH. Mejı ´a-Guevara et al (2019) examined age distribution, trends, and forecasts of under-5 mortality in 31 sub-Saharan African countries. Data came from 106 nationally representative Demographic and Health Surveys (DHSs) with full birth histories from 31 SSA countries from 1990 to 2017 (a total of 524 country years of data). They assessed the distribution of age at death through the following new demographic analyses. First, they used a direct method and full birth histories to estimate under-5 mortality rates (U5MRs) on a monthly basis and then smoothed raw estimates of death rates by age and time by using a two-dimensional P-Spline approach. A variant of the Lee–Carter (LC) model, designed for populations with limited data, was used to fit and forecast age profiles of mortality. The authors used mortality estimates from the United Nations Inter-agency Group for Child Mortality Estimation (UN IGME) to adjust, validate, and minimize the risk of bias in survival, truncation, and recall in mortality estimation. Our mortality model revealed substantive declines of death rates at every age in most countries but with notable differences in the age patterns over time. U5MRs declined from 3.3% (annual rate of reduction [ARR] 0.1%) in Lesotho to 76.4% (ARR 5.2%) in Malawi, and the pace of decline was faster on average (ARR 3.2%) than that observed for infant (IMRs) (ARR 2.7%) and neonatal (NMRs) (ARR

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2.0%) mortality rates. They predicted that 5 countries (Kenya, Rwanda, Senegal, Tanzania, and Uganda) are on track to achieve the under-5 sustainable development target by 2030 (25 deaths per 1,000 live births), but only Rwanda and Tanzania would meet both the neonatal (12 deaths per 1,000 live births) and under-5 targets simultaneously. Garcı ´a-Basteiro et al (2017) evaluated the morbidity and mortality associated with preterm and SGA births during the first year of life in a rural area of Southern Mozambique. This was a retrospective cohort study using previously collected data from children born at the Manhic ¸a District Hospital in two different periods (2003–2005 and 2010–2012). Newborns were classified as being preterm and/or SGA or as babies not fulfilling any of the previous conditions (term non-SGA). All children were followed up for a year for morbidity and mortality outcomes. The study findings revealed that Neonatal and infant mortality rates are remarkably high among preterm and SGA babies in southern Mozambique. These increased rates are concentrated within the neonatal period.

III. METHODOLOGY

The Artificial Neural Network (ANN), which we intend to apply in this study; is a data processing system consisting of a huge number of simple and highly interconnected processing elements resembling a biological neural system. It has the capability of learning from any data-set to describe the nonlinear and interaction effects with great accuracy. No strict rules exist for the determination of the ANN structure hence the study applies the popular ANN (12, 12, 1) model based on the hyperbolic tangent activation function. This paper applies the Artificial Neural Network (ANN) approach in predicting infant mortality rates in Angola.

Data Issues

This study is based on annual infant mortality rates in Angola for the period 1980 – 2020. The out-of-sample forecast covers the period 2021 to 2030. Infact mortality rate, which is simply a proxy for infant deaths; for the purposes of this study, is defined as the number of infants dying before reaching one year of age, per 1000 live births in a given year. All the data employed in this paper was gathered from the World Bank.

IV. FINDINGS OF THE STUDY

ANN Model Summary

Table 1: ANN model summary

Variable	Z
Observations	29 (After Adjusting Endpoints)
Neural Network Architecture:	
Input Layer Neurons	12
Hidden Layer Neurons	12
Output Layer Neurons	1
Activation Function	Hyperbolic Tangent Function
Back Propagation Learning:	
Learning Rate	0.005
Momentum	0.05
Criteria:	
Error	0.014895
MSE	0.554660
MAE	0.597052

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Residual Analysis for the Applied Model

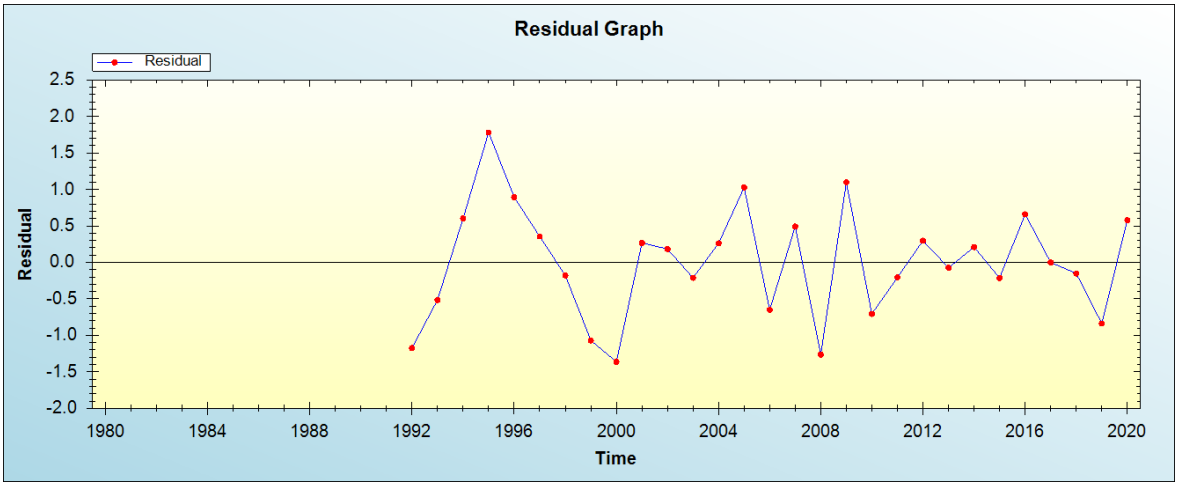

Figure 1: Residual analysis

In-sample Forecast for Z

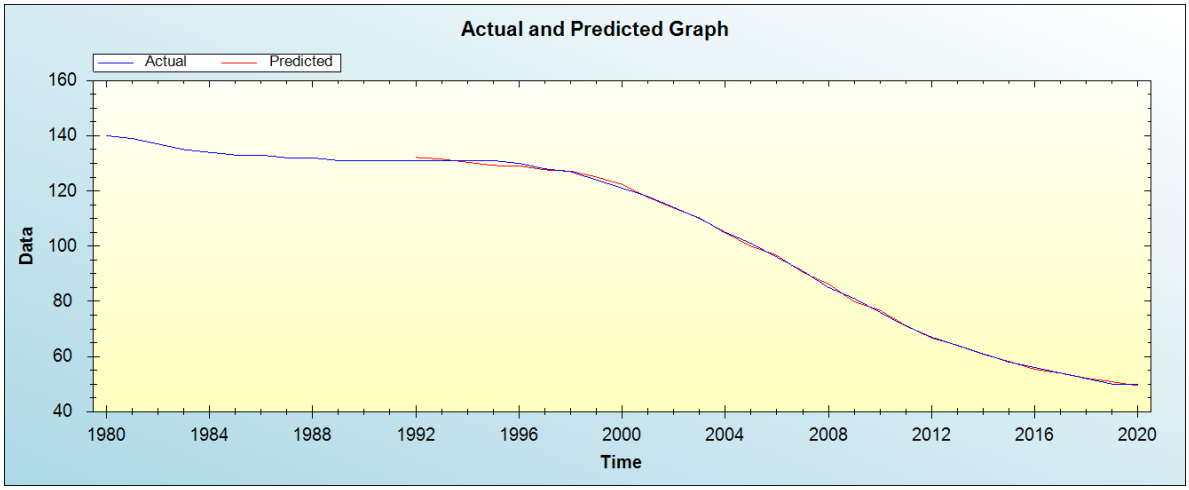

Figure 2: In-sample forecast for the Z series

Out-of-Sample Forecast for Z: Actual and Forecasted Graph

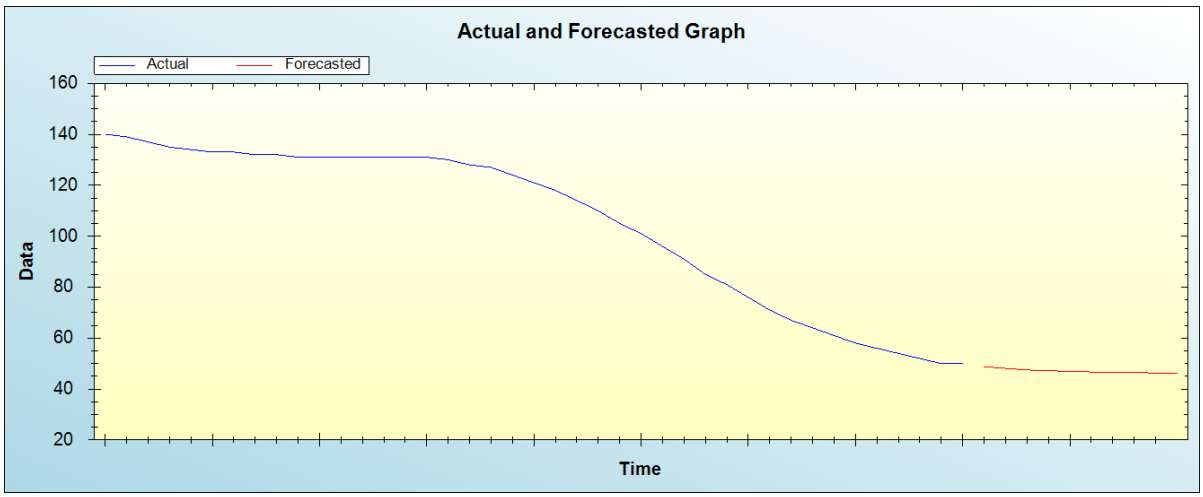

Figure 3: Out-of-sample forecast for Z: actual and forecasted graph

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Out-of-Sample Forecast for Z: Forecasts only

Table 3: Tabulated out-of-sample forecasts

Year	Forecasts
2021	48.7235
2022	48.1097
2023	47.4723
2024	47.1692
2025	46.9563
2026	46.7107
2027	46.4945
2028	46.4370
2029	46.3312
2030	46.2696

The main results of the study are shown in table 1. It is clear that the model is stable as confirmed by evaluation criterion as well as the residual plot of the model shown in figure 1. It is projected that infant mortality in Angola is likely to remain around 46/1000 live births per year over the next decade.

V. CONCLUSION AND POLICY RECOMMENDATIONS

Preventing infant mortality remains one of the main objectives of the health ministry in Angola. The Angolan government remains committed to ending preventable deaths infants in the country. The study used annual data to analyze the trends of infant mortality in Angola. The applied model is the ANN model. In order to make sure that infant mortality in the country significantly declines, the government of Angola ought to consider the following policy suggestions:

i. The Angolan government should continue to encourage mothers to breast-feed their babies adequately.
ii. There is need for all Angolan child-bearing women to be vaccinated against common illnesses.
iii. There is need to prevent birth defects in Angola.
iv. The government of Angola should address preterm birth, low birth-weight and their outcomes.
v. The government of Angola should also ensure adequate access to pre-pregnancy and prenatal care.
vi. There is need to educate, especially, mothers on the importance of creating a safe infant sleep environment in the country.
vii. Healthcare providers in Angola need to use newborn screening activities in order to detect hidden conditions.

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