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Forecasting Infant Mortality Rate in Madagascar Using Artificial Neural Networks

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***Abstract* - In this research work, the ANN approach was applied to analyze infant mortality rate in Madagascar. The employed annual data covers the period 1960-2020 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 Madagascar. The ANN (12, 12, 1) model predictions suggest that IMR will be around 35/1000 live births per year in the out-of-sample period. Therefore, in line with our recommendations; the government is encouraged to intensify Maternal and Child care surveillance and control programs in the country amongst other measures.**

Keywords: ANN, Forecasting, infant mortality rate.

I. INTRODUCTION

The objective of public health surveillance systems is to monitor trends in disease incidence, health behaviors and other health related issues in order to allocate resources to maintain healthy populations (Teutsch & Churchill, 2000). Machine learning (ML), a sub discipline of artificial intelligence (AI) has been noted to be a very useful tool in public health surveillance where it is used in screening, diagnosis and time series forecasting. ML techniques do not rely on assumptions such as normally distributed residuals with a constant variance and known probability distribution of the time series variable (Zhao et al, 2020; Panch et al, 2018). They are classified into one of the following 1) supervised learning 2) unsupervised learning and 3) semi-supervised learning (Panch et al, 2018; Mooney & Pejavar, 2017; Weng et al, 2017). In supervised learning the algorithm learns a predictor function when the inputs and outputs are provided for the training process. When the computer program identifies hidden structures in the input data it is called unsupervised learning. Semi-supervised learning is a mixture of both (Zhu, 2005).The main advantage of ML algorithms is that they are capable of handling large amounts of complex data in public health (Zhao et al, 2020, Nyoni et al, 2020).Artificial neural networks, ensembles, K-nearest neighbors, support vector machine and Bayesian networks are the most widely used ML algorithms in medicine (Nyoni et al, 2020; Zhao et al, 2020). In this paper we aim to model and predict infant mortality in Madagascar using the artificial neural network (ANN) approach. The Multilayer perceptron will be the chosen ANN framework. The model is based on the structure and function of the human brain consisting of 3 layers of neurons which are connected by connection weights (Zhao et al, 2020; Nyoni et al, 2020; Kaushik & Sahi, 2018; Yan et al, 2018; Fojnica et al, 2016; Zhang, 2003). The results of the study are envisioned to help in the evaluation of measures that have been put by the government to reduce infant mortality and achieve the sustainable development goals by 2030.

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 projections from the applied model indicated that the number of infant deaths per year, over the out-of-sample period, would follow a downward trend. In similar research, 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. Akinwande et al (2016) Analyzed Infant and Child (Under-five) Mortality in Zaria using a regression Analysis Approach. The study was carried out using secondary data from Ahmadu Bello University Teaching Hospital, Zaria, on infant and child (under-five) mortality and delivery rates. Findings from the study showed that both infant and child mortality rates have a direct relationship with delivery rates. The correlation analysis result showed that there is a very strong and positive relationship between mortality and delivery rates. The study revealed that infant and child mortality rates will continue to decrease if there can be improvement in the factors under study.

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Bashir et al (2013) analyzed data from the Sudan Household Health Survey 2nd round, which was carried out in 2010. Total of 6,198 live-born infants delivered within the two years preceding the survey were included as the study population. Multivariate logistic regression was used to model neonatal mortality as a function of maternal health parameters, socioeconomic indicators and the sex of the child. The authors concluded that Public health interventions which target neonatal mortality reduction should adopt a risk-factor-based approach to detect pregnancy complications early and once identified, the health system should be strengthened so that these complications can be dealt with adequately.

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 Madagascar.

Data Issues

This study is based on annual infant mortality rates in Madagascar for the period 1960 – 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	K
Observations	41 (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	0.016864
MSE	0.455025
MAE	0.542928

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Residual Analysis for the Applied Model

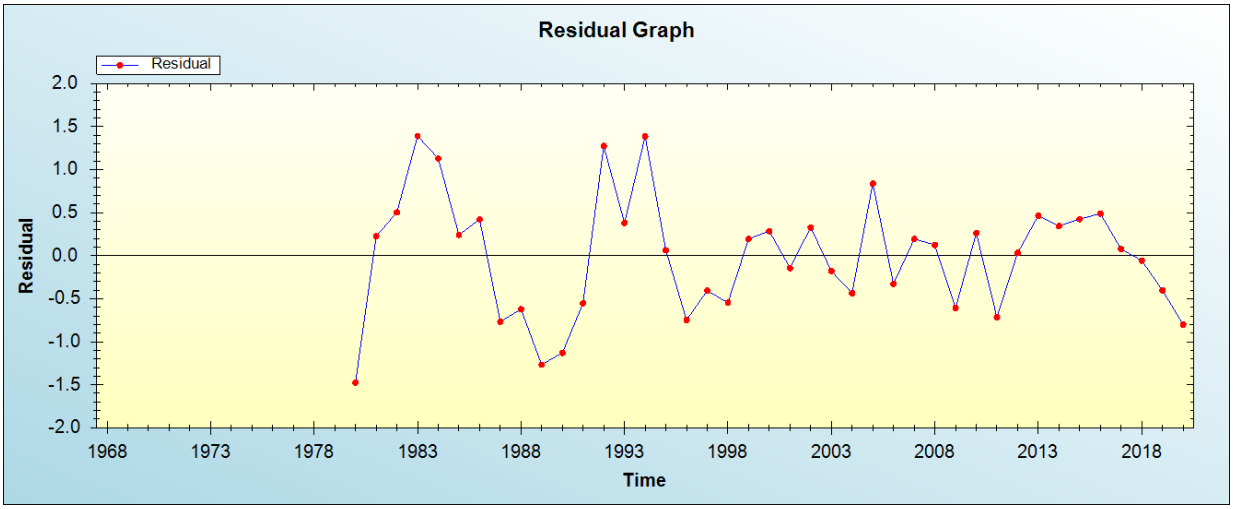

Figure 1: Residual analysis

In-sample Forecast for K

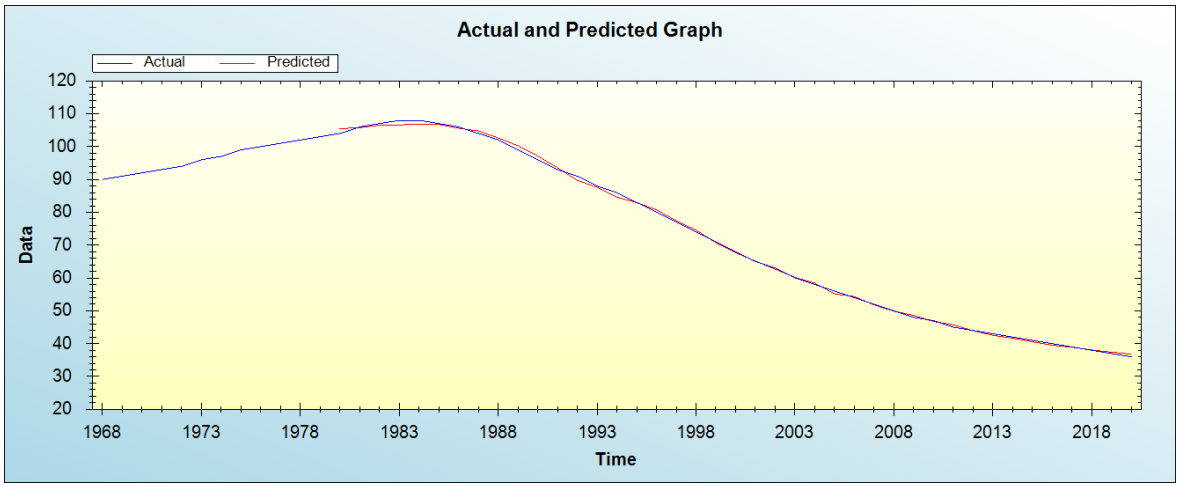

Figure 2: In-sample forecast for the K series

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

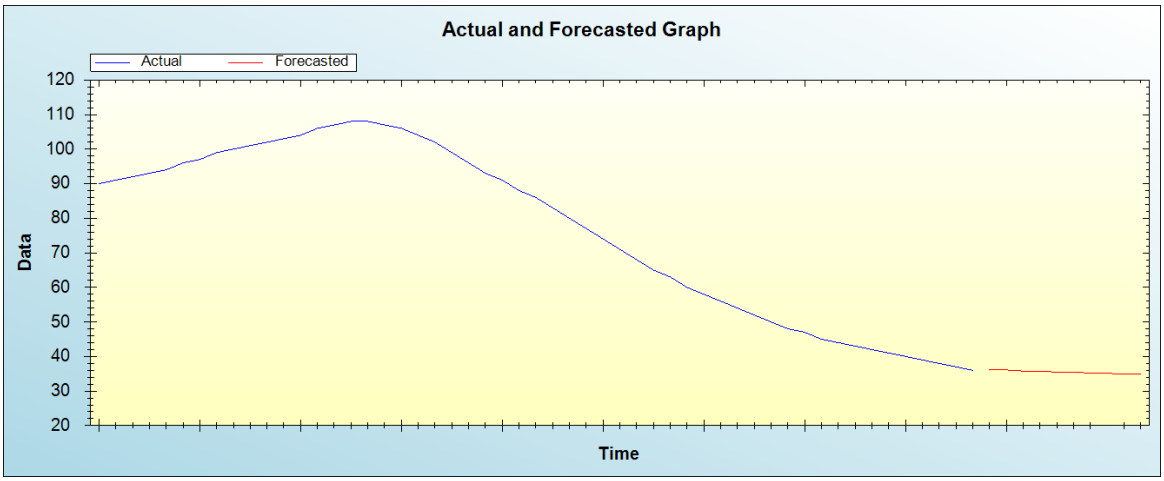

Figure 3: Out-of-sample forecast for K: actual and forecasted graph

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Out-of-Sample Forecast for K: Forecasts only

Table 3: Tabulated out-of-sample forecasts

Year	Forecasts
2021	36.2176
2022	36.1022
2023	35.7758
2024	35.6660
2025	35.5086
2026	35.4148
2027	35.2651
2028	35.1107
2029	34.9571
2030	34.8370

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 Madagascar is likely to remain around 35/1000 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 Madagascar. The government remains committed to ending preventable deaths infants in the country. The study used annual data to analyze the trends of infant mortality in Madagascar. The applied model is the ANN model. In order to make sure that infant mortality in the country significantly declines, the government of Madagascar ought to consider the following policy suggestions:

i. The government should continue to encourage mothers to breast-feed their babies adequately.
ii. There is need for all child-bearing women to be vaccinated against common illnesses.
iii. There is need to prevent birth defects in Madagascar.
iv. The government of Madagascar should address preterm birth, low birth-weight and their outcomes.
v. The government of Madagascar 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 Madagascar need to use newborn screening activities in order to detect hidden conditions.

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