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Forecasting Infant Mortality Rate in Yemen Using a Machine Learning Method

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***Abstract* - In this research paper, the ANN approach was applied to analyze infant mortality rate (IMR) in Yemen. 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 IMR in Yemen. The applied ANN (12, 12, 1) model predictions suggest that IMR will be around 43/1000 live births per year over the next 10 years. Therefore the government is encouraged to prioritize primary health care in order to improve access to health services especially safe institutional deliveries and quality early neonatal care.**

Keywords: ANN, Forecasting, infant mortality rate.

I. INTRODUCTION

Yemen has been ravaged by war and civil conflict and is seriously needs humanitarian aid with approximately 7.3 million people food insecure and over 8 million have no access to quality health care as a result of the ongoing conflict (OCHA, 2019; Al-Mekhlafi,2018; Burki, 2015). The continuous fighting in Yemen is worsening the existing challenges such as poverty, poor health services and shortage of water, fuel and medical supplies (Qirbi & Ismail, 2017; Elshaq et al, 2017). During the period 2009-2013 neonatal mortality was 26 deaths per 1000 live births representing 49 % of all deaths in children below 5 years (MOH, 2015). It is difficult to implement health programs in war zones such as child immunizations, Vitamin A supplementation and ensuring the availability of skilled birth attendants in health institutions. Many pregnant women tend to deliver at home because of un-availability of safe health centers (MOH, 2015) as a result countries like Yemen will continue to record high infant and neonatal deaths.

In this paper we aim to model and forecast infant mortality rate in Yemen using artificial neural network approach. This machine learning algorithm is based on the structure of the human brain. The multilayer perceptron (MLP), recurrent neural network (RNN), radial basis function (RBF) and generalized regression neural network (GRNN) are the artificial neural frameworks applied in machine learning. In this paper the MLP is applied because of its popularity in time series forecasting problems. The model is composed of three layers of neurons connected by connection weights (Nyoni et al, 2020; Zhao et al, 2020; Kaushik & Sahi, 2018; Yan et al, 2018; Scavuzzo et al, 2018; Gambhir et al, 2018; Laurean-Rosario et al, 2018; Weng et al, 2017; Guo et al, 2017; Althouse et al, 2011; Fojnica et al, 2016; Zhang, 2003; Kishan, 1997; Patterson, 1995). The results of the study are expected to provide an insight of the likely future trends of infant mortality rate in Yemen and facilitate planning and decision making in order to reduce infant mortality in the country.

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 selected optimal model, based on AIC was the ARIMA (1, 2, 5) model. The ARIMA model projected that the number of infant deaths per year, over the out-of-sample period, would follow a downward trend. In a related 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. Taha et al (2020) investigated the prevalence of and factors associated with preterm birth and LBW among mothers of children under two years in Abu Dhabi, United Arab Emirates. Data were collected in clinical and non-clinical settings across various geographical areas in Abu Dhabi. The data were analyzed using both descriptive and inferential statistics. A total of 1610 mother–child pairs were included in the study. The study found that factors that were positively associated with preterm birth were Arab mothers, maternal education level below secondary, caesarean section, and LBW. LBW was associated with female children, caesarean section (CS),

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first child order, and preterm birth. Kadir et al (2018) did a systematic review and summarized the current and past knowledge on the effects of armed conflict on child health and development. A systematic review was performed with searches in major and regional databases for papers published 1 January 1945 to 25 April 2017. Included studies provided data on physical and/or developmental outcomes associated with armed conflict in children under 18 years. Data were extracted on health outcomes, displacement, and social isolation, experience of violence, orphan status, and access to basic needs. The authors found out that the reviewed papers described mortality, injuries, illnesses, environmental exposures, limitations in access to health care and education, and the experience of violence, including torture and sexual violence. Romanello (2018) calculated the rate of infant mortality and child mortality in Yemen and put into evidence some characteristics of households that could influence the rate of child mortality. Data was obtained from the Yemen National Social Protection and Monitoring Survey (NSPMS). The Brass indirect method was used for calculating infant and child mortality rates, while Poisson regression was utilized for putting into evidence covariates that could affect mortality. According to the results of Brass indirect analysis, infant and child mortality rates were elevated in Yemen. Poisson regression revealed that mother education, quantity of water available, household economic situation and electricity in household were major factors in reducing child mortality. Authors concluded that Yemen needs to increase the access to schools to the population, particularly girls, and improve the infrastructure of the country, mainly water and electricity supply, with the objective of further reduction of child mortality.

III. METHODOLOGY

The Artificial Neural Network (ANN), which we intend to employ 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 Yemen.

Data Issues

This study is based on annual infant mortality rates in Yemen 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	Y
Observations	47 (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	0.008405
MSE	1.224572
MAE	0.85564

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Residual Analysis for the Applied Model

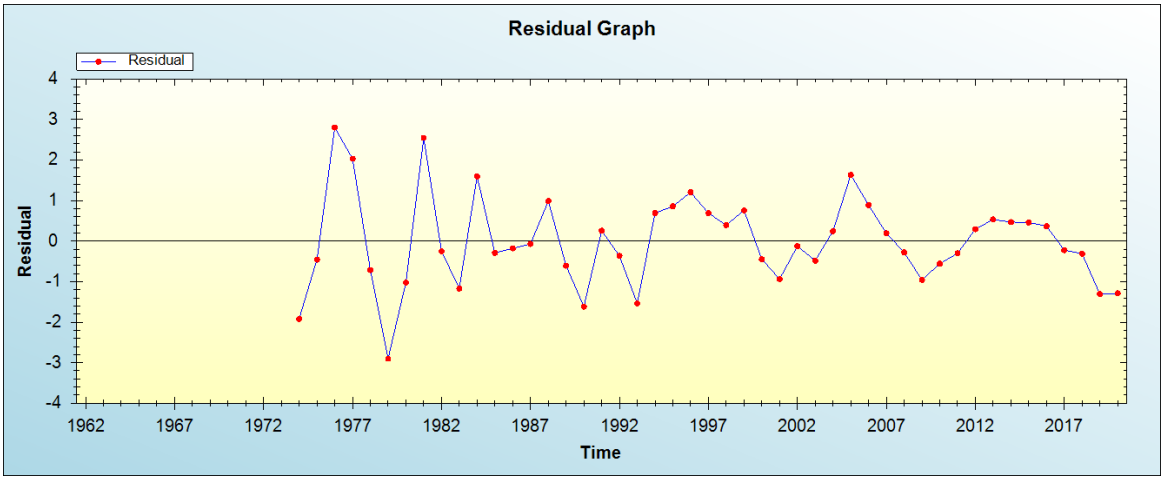

Figure 1: Residual analysis

In-sample Forecast for Y

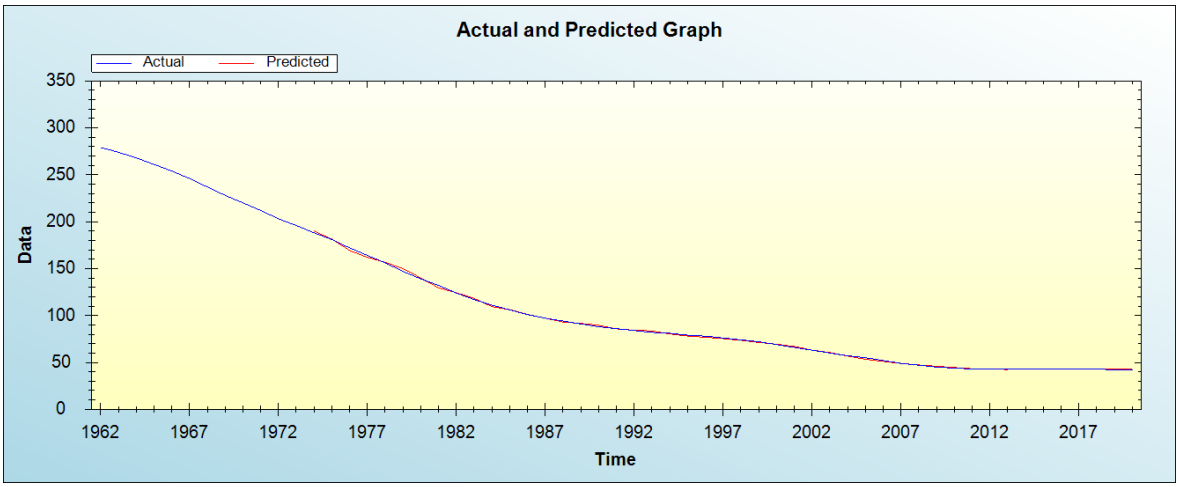

Figure 2: In-sample forecast for the Y series

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

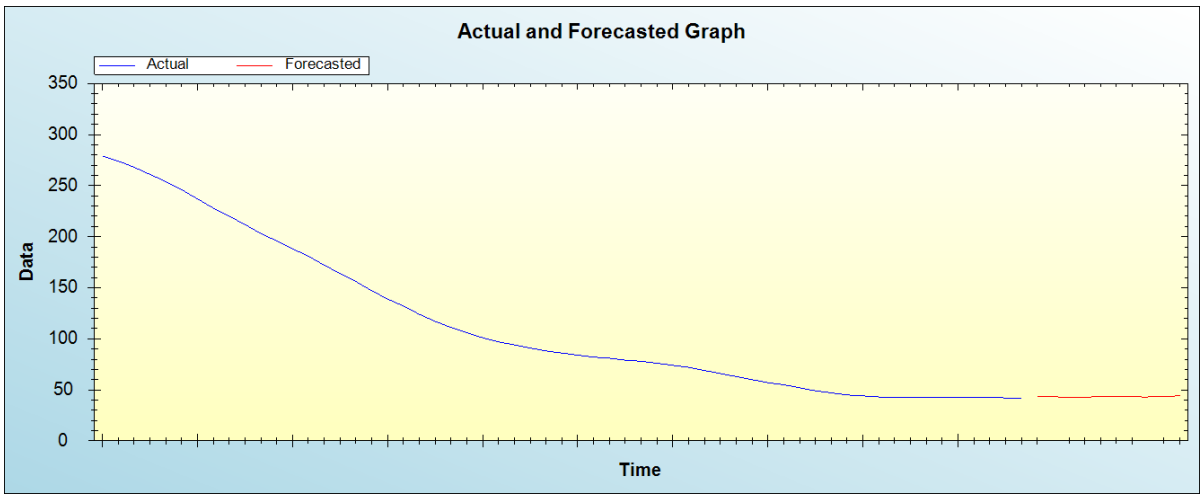

Figure 3: Out-of-sample forecast for Y: actual and forecasted graph

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Out-of-Sample Forecast for Y: Forecasts only

Table 3: Tabulated out-of-sample forecasts

Year	Predictions
2021	43.2355
2022	43.2023
2023	42.7048
2024	42.7465
2025	43.4952
2026	43.6299
2027	43.1106
2028	43.0036
2029	43.5874
2030	44.0279

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 Yemen is likely to remain around 43/1000 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 Yemen. 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 Yemen. The applied model is the ANN model. In order to make sure that infant mortality in the country significantly declines, the government of Yemen 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 Yemen.

iv. The government of Yemen should address preterm birth, low birth-weight and their outcomes.

v. The government of Yemen 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 Yemen need to use newborn screening activities in order to detect hidden conditions.

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