Forecasting Infant Mortality in Oman Using Artificial Neural Networks

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Abstract - **In this research paper, the ANN approach was applied to analyze infant mortality rate (IMR) in Oman. The employed data annual covers the period 1963-2020 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 Oman. The applied ANN (12,12,1) model predictions indicated that IMR will be around 9/1000 live births per year in the out-of-sample period. Therefore the government is encouraged to allocate more resources towards primary health care in order to improve the quality of maternal and child healthcare services in the underprivileged communities.**

Keywords: ANN, Forecasting, infant mortality rate.

I. INTRODUCTION

Oman has witnessed economic growth which was characterized by a significant improvement in several health indicators including infant mortality rate (Abdellatif et al, 2013). High quality preventive and curative care services in maternal and child health are the major contributors to the reduction in child mortality (Bhutta et al, 2010). It has been noted that low birth weight was the leading cause of early neonatal mortality and the 3rd leading cause of mortality among infants. The rate of neonatal and child mortality dropped from 22 per 1000 live births in 1990 to 6 per 1000 live births in 2010 (UNICEF, 2011). The causes of infant mortality include congenital deformities, birth asphyxia, infections and severe prematurity. In this paper we aim to model and forecast infant mortality rate (IMR) in Oman using artificial neural networks (ANNs). The multilayer perceptron (MLP) is applied to predict IMR. The model is composed of three layers of neurons namely input, hidden and output layer connected by weights (Nyoni et al, 2020; Zhao et al, 2020; Kaushik & Sahi, 2018; Yan et al, 2018, 2017;Althouse et al, 2011; Fojnica et al, 2016; Zhang, 2003; Kishan, 1997; Patterson, 1995; Scavuzzo et al,2018; Gambhir et al, 2018; Laurean-Rosario et al, 2018; Weng et al, 2017; Guo et al e results of the study are expected to reveal the future trends of infant mortality rate and help in the assessment of maternal and child health programs in the country which aim to reduce maternal and infant 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 showed that the number of infant deaths per year, over the out-of-sample period, would follow a downward trajectory. 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. Gonzalez & Gilleskie (2017) developed a novel method to adjust country-specific reported infant mortality figures that may misrepresent development within a country. The authors concluded that an "augmented" measure of mortality that includes both infant and late fetal deaths should be considered when assessing levels of social welfare in a country. Also, mortality statistics that exhibit a substantially high ratio of late fetal to early neonatal deaths should be more closely scrutinized. Mazharul Islam (2015) investigated the levels, trends and some possible explanations for the increasing rate of low birth weight (LBW) infants in Oman. LBW data from national health surveys in Oman, and published reports from Oman's Ministry of Health and the World Health Organization were collected and assessed between January and August 2014. Oman's LBW rate has been increasing since the 1980s. It was approximately 4% in 1980 and had nearly doubled (8.1%) by 2000. Since then, it has shown a slow but steady rise, reaching 10% in recent times. High rates of consanguinity, premature births, number of increased pregnancies at an older maternal age and changing lifestyles are some important factors related to the increasing rate of LBW in Oman. Abdellatif et al (2013) reported the patterns and causes of neonatal death from a tertiary care neonatal intensive care unit over a period of four years. This was a retrospective cohort study

where four years data (January 2006 - December 2009) of all inborn neonatal admissions and deaths were collected from the neonatal intensive care unit at Sultan Qaboos University hospital on predesigned forms. All out born admissions and deaths were excluded. The causes of neonatal death were classified using Wigglesworth's classification. The study revealed that there was an increasing trend of neonatal admissions and deaths among inborn babies. Prematurity, sepsis and congenital malformations were the leading causes of neonatal mortality.

III. METHODOLOGY

The Artificial Neural Network (ANN), which we intend to apply in this research paper; 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 Oman.

Data Issues

This study is based on annual infant mortality rates in Oman for the period 1963 – 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

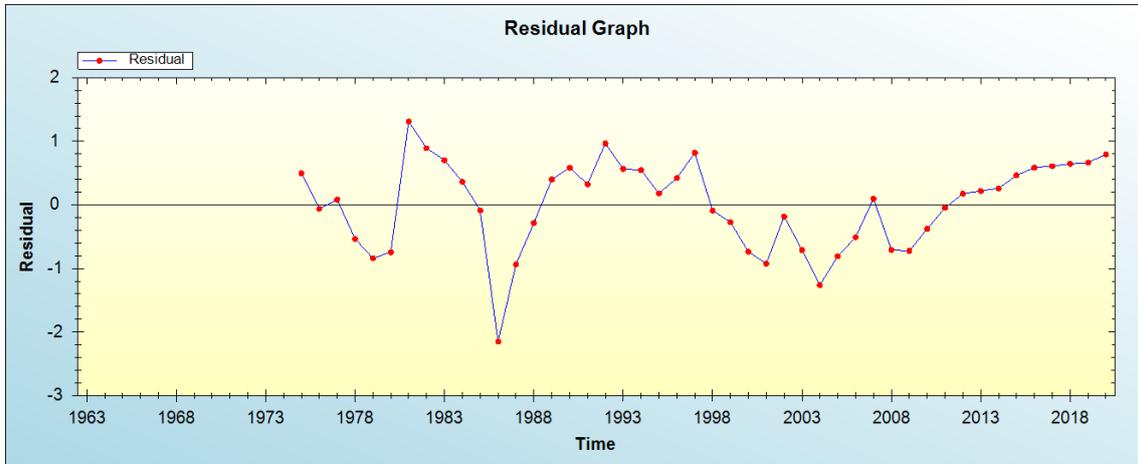| Variable	J
Observations	46 (After Adjusting Endpoints)
Neural Network Architecture:	
Input Layer Neurons	12
Hidden Layer Neurons	12
Output Layer Neurons	1
Activation Function	Hyperbolic Tangent Function
Back Propagation Learning:	
Learning Rate	0.005
Momentum	0.05
Criteria:	
Error	0.006020
MSE	0.474657
MAE	0.568688

Residual Analysis for the Applied Model

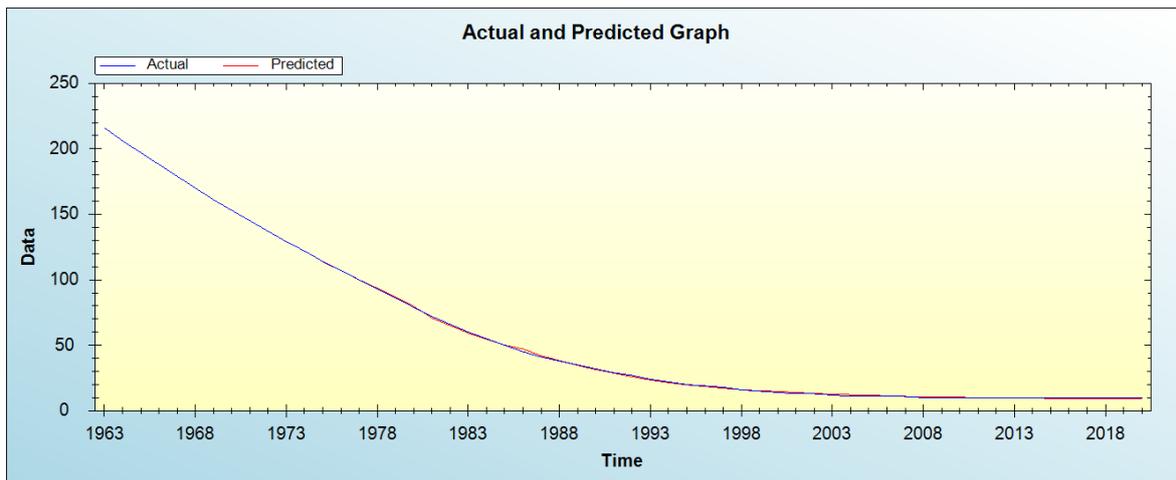**Figure 1: Residual analysis**

In-sample Forecast for J

Figure 2: In-sample forecast for the J series

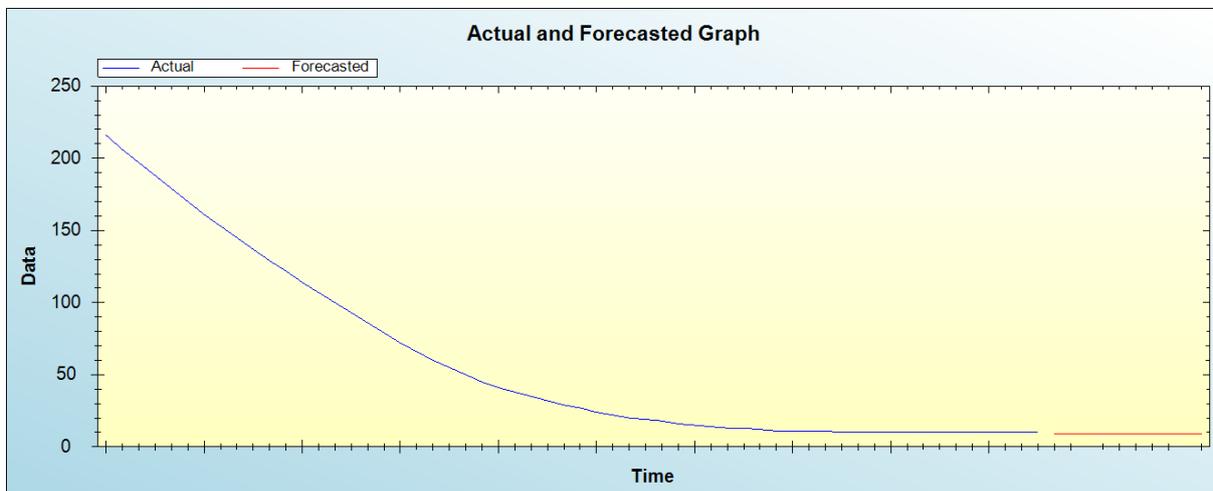*Out-of-Sample Forecast for J: Actual and Forecasted Graph*

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

Out-of-Sample Forecast for J: Forecasts only

Table 3: Tabulated out-of-sample forecasts

Year	Predictions
2021	9.2037
2022	9.2613
2023	9.3040
2024	9.2284
2025	9.1977
2026	9.3307
2027	9.3227
2028	9.2639
2029	9.3029
2030	9.2978

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 Oman is likely to remain around 9/1000 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 Oman. 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 Oman. The applied model is the ANN model. In order to make sure that infant mortality in the country significantly declines, the government of Oman ought to consider the following policy suggestions:

i. The government should continue to encourage mothers to breast-feed their babies adequately.

ii. The government of Oman should address preterm birth, low birth-weight and their outcomes.

iii. The government of Oman should also ensure adequate access to pre-pregnancy and prenatal care.

iv. There is need to educate, especially, mothers on the importance of creating a safe infant sleep environment in the country.

v. Healthcare providers in Oman need to use newborn screening activities in order to detect hidden conditions.

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