Forecasting Future Trends of Under Five Mortality Rate for Jordan Using a Machine Learning Algorithm

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Abstract - **This study uses annual time series data on under five mortality rate (U5MR) for Jordan from 1960 to 2020 to predict future trends of U5MR over the period 2021 to 2030. Residuals and forecast evaluation criteria indicate that the applied model is stable in forecasting U5MR. ANN (12, 12, 1) model projections indicate that U5MR will continue to decline throughout the out of sample period. Therefore, we encourage the government of Jordan to design local policies that will help to address all the existing health challenges that contribute significantly to under five mortality.**

Keywords: ANN, Forecasting, U5MR.

I. INTRODUCTION

The genesis of the period of sustainable development goals (SDGs) provided an opportunity for all 193 UN member countries to reflect on their past performance during the era of millennium development goals (MDGs). It was realized that most countries had outstanding issues at the end of the MDG era and it was high time for the Heads of states and governments, and global partners to reconfigure their strategies so as to effectively solve the existing challenges affecting different populations in the entire world (UN, 2016; UN, 2015). Top on the global agenda was the urgent need to accelerate efforts to eliminate poverty and hunger, end inequalities, ensure global peace and security, address educational and health needs of various populations across all the regions of the world and end all forms of human rights violations (UN, 2020; UNICEF, 2019; WHO, 2019; UNICEF, 2018; UN, 2016; UN, 2015).Ensuring good health and promotion of well-being for all at all ages is stimulated in the 3rd sustainable development goal (SDG-3). Addressing neonatal and under five mortality is the focus of SDG3 target 3.2 which aims at substantially reducing newborn and under five mortality to as low as 12 neonatal deaths per 1000 live births and 25 under five deaths per 1000 live births by 2030 (UNICEF, 2019).Jordan's neonatal mortality rate significantly dropped during the period 1990- 2013 but still remains high (UNICEF, 2014). Neonatal mortality in Jordan contributes 50% of all under 5 deaths with prematurity accounting for half of neonatal deaths and neonatal mortality rate is around 14 per 1000 live births (Khasawneh & Khriesat, 2020). In line with the Agenda 2030 for sustainable development and the Cape Town global action plan (2017), this study applies the artificial neural network technique to forecast future trends of under-five mortality rate in Jordan. The findings will assist in tracking progress towards achieving the set sustainable development goal 3 target 3.2 which aims to reduce under five mortality to 25 deaths per 1000 live births and neonatal deaths to least 12 per 1000 live births by 2030 (UNICEF, 2019).

II. LITERATURE REVIEW

A retrospective cohort study was conducted by Mangu *et al.* (2021) to investigatetrends, patterns and causes of neonatal mortality in hospitals in Tanzania during 2006–2015. This retrospective study was conducted in 35 hospitals. Mortality data were obtained from inpatient registers, death registers and International Classification of Diseases-10 report forms. Annual specific hospital-based neonatal mortality rates were calculated and discussed. Two periods of 2006–2010 and 2011–2015 were assessed separately to account for data availability and interventions. It was found that neonatal mortality rate was 3.7/1000 during 2006–2010 and 10.4/1000 during 2011–2015, both periods indicating a stagnant trend in the years between. The leading causes of early neonatal death were birth asphyxia (22.3%) and respiratory distress (20.8%), while those of late neonatal death were sepsis (29.1%) and respiratory distress (20.0%). Nyoni & Nyoni, 2020 applied the Box-Jenkins ARIMA methodology to forecast neonatal deaths in Zimbabwe using annual time series data on neonatal deaths in Zimbabwe from 1966 to 2018.The ARIMA (8, 2, 0) was found to be the optimal model. The study findings revealed that the numbers of neonatal deaths per year would decline sharply over the next 25 years. A cross sectional study was conducted by Nadin *et al.* (2017) to investigate the incidence of preterm delivery, maternal risk factors for having a preterm neonate, and preterm neonates' mortality in Jordan. Socio-demographic, perinatal, delivery risk factors, and survival information were gathered in pre- and post-hospital discharge interviews with 21075 women who gave birth to live neonates at ≥20 weeks of gestation in 18 hospitals in Jordan. Women were

interviewed between 2012 and 2013. The study revealed that mortality rate was considerably higher among preterm neonates than among term neonates; discrepancies between Jordan and other countries existed.

III. METHODOLOGY

The Artificial Neural Network (ANN) approach, which is flexible and capable of nonlinear modeling; will be applied in this study. The ANN is a data processing system consisting of a large number of highly interconnected processing elements in architecture inspired by the way biological nervous systems of the brain appear like. Since no explicit guidelines exist for the determination of the ANN structure, 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 annual under five mortality rate for Jordan.

Data Issues

This study is based on annual under five mortality rate in Jordan for the period 1960– 2020. The out-of-sample forecast covers the period 2021– 2030. All the data employed in this research paper was gathered from the World Bank online database.

IV. FINDINGS OF THE STUDY

ANN Model Summary

Table 1: ANN model summary

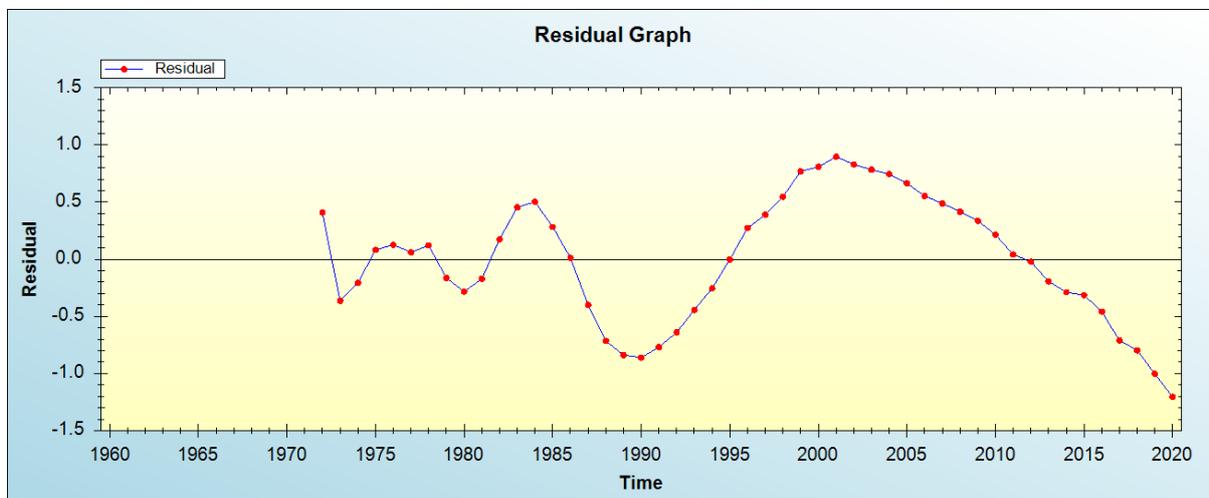| Variable	X
Observations	49 (After Adjusting Endpoints)
Neural Network Architecture:	
Input Layer Neurons	12
Hidden Layer Neurons	12
Output Layer Neurons	1
Activation Function	Hyperbolic Tangent Function
Back Propagation Learning	
Learning Rate	0.005
Momentum	0.05
Criteria:	
Error	0.001148
MSE	0.290562
MAE	0.450576

Residual Analysis for the Applied Model

Figure 1: Residual analysis
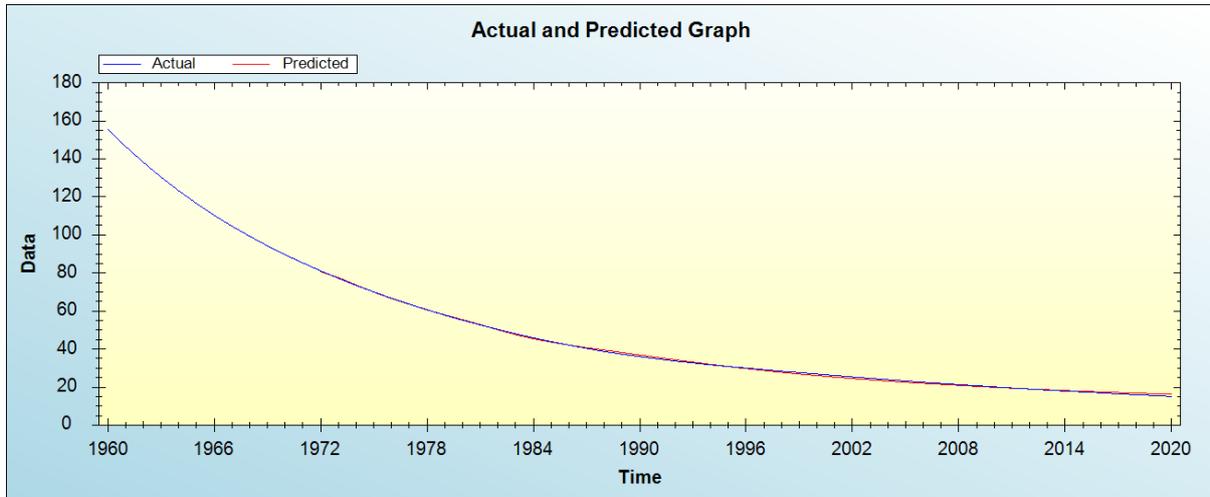
In-sample Forecast for X

Figure 2: In-sample forecast for the X series

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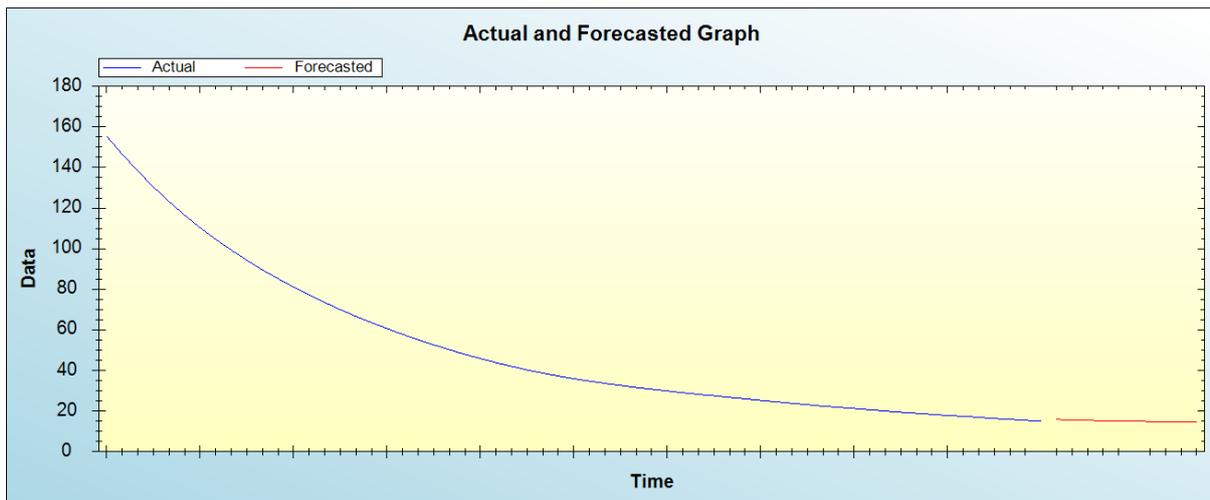

Figure 3: Out-of-sample forecast for X: actual and forecasted graph

Out-of-Sample Forecast for X: Forecasts only

Table 2: Tabulated out-of-sample forecasts

2021	15.9073
2022	15.6082
2023	15.4611
2024	15.3151
2025	15.2820
2026	15.0622
2027	14.8839
2028	14.8202
2029	14.7706
2030	14.6109

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 annual U5MR will continue to decline throughout the out of sample period.

V. POLICY IMPLICATION & CONCLUSION

The government of Jordan has made significant progress in the reduction of under-five mortality. However, neonatal mortality still remains high and requires urgent government action. Forecasting under five mortality rate will inform child health policies, decisions and allocation of resources. This study applies the ANN (12, 12, 1) model to predict future trends of under-five mortality rate for Jordan. The ANN model projections revealed that U5MR will continue to decline throughout the out of sample period. Therefore, we implore health authorities in Jordan to design child health policies that will help to address all the health challenges that significantly contribute to under five mortality.

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