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Forecasting Future Trends of Under Five Mortality Rate for Guatemala Using Artificial Neural Networks

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***Abstract* - This study uses annual time series data on under five mortality rate for Guatemala from 1960 to 2020 to predict future trends of under-five mortality rate over the period 2021 to 2030. Residuals and forecast evaluation criteria indicate that the applied model is stable in forecasting U5MR. The ANN (12, 12, 1) model projections revealed that annual U5MR will continue to decline over the out of sample period. Therefore, we implore health authorities in Guatemala to address the various challenges that affect the health of under five children especially that of children living in the rural areas and disadvantaged communities across the country.**

Keywords: ANN, Forecasting, U5MR.

I. INTRODUCTION

Under five mortality is still a public health challenge in Guatemala with rural areas reporting worrying trends of neonatal mortality (World Bank, 2019). The majority of deliveries in rural Guatemala are home deliveries under the care of lay midwives (World Bank, 2019; Juarez et al. 2019). Tracking progress towards achieving SDG3 by 2030 is essential for planning, decision making and allocation of resources. The ultimate goal is to bring down neonatal and under five deaths to as low as 12 deaths per 1000 live births and 25 deaths per 1000 live births respectively (UN, 2020; WHO, 2019; UNICEF, 2019; UNICEF, 2018). Tracking indicator 3.2.1 will help in designing appropriate child health strategies that will trigger a rapid decline in under five mortality (UN, 2016; UN, 2015). In line with Vision 2030, this research applies artificial neural networks to forecast future trends of under-five mortality rate in Guatemala and the findings will trigger a timeous response to challenges affecting under five children.

II. LITERATURE REVIEW

Iriondo *et al.* (2020) developed and validated different mortality forecasting models, using Spanish data, to be applicable to centers with similar morbidity and mortality. Infants born alive, admitted in NICU, and registered in the SEN1500 database, were included. Multivariable regression models were used for the different time periods. The study concluded that using dynamic models to predict individual mortality can improve outcome estimations. Development of models in the prenatal period, first 24 hours, and during hospital admission, cover key stages of mortality prediction in preterm infants. Juarez *et al.* (2020) conducted a quality improvement study to increase the detection of neonatal complications by lay midwives in rural Guatemala, thereby increasing referrals to a higher level of care. A quality improvement team in Guatemala reviewed drivers of neonatal health services provided by lay midwives. Improvement interventions included training on neonatal warning signs, optimized mobile health technology to standardize assessments and financial incentives for providers. The primary quality outcome was the rate of neonatal referral to a higher level of care. It was found that structured improvement interventions, including mobile health decision support and financial incentives, significantly increased the detection of neonatal complications and referral of neonates to higher levels of care by lay midwives operating in rural home-based settings in Guatemala. A study by Bhatia *et al.* (2019) analyzed the patterns and trends in the mortality rates of infants and children under the age of 5 in India (1992–2016) and quantified the variation in performance between different geographical states through three rounds of nationally representative household surveys. Three rounds of cross-sectional survey data. The study is conducted at the national level: India and its selected good-performing states, namely Haryana, Kerala, Maharashtra, Punjab and Tamil Nadu, and selected poor-performing states, namely Bihar, Chhattisgarh, Madhya Pradesh and Uttar Pradesh. The study revealed that attempts to reduce infant and child mortality rates in India are heading in the right direction although there is huge variation in performance between states.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.

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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 Guatemala.

Data Issues

This study is based on annual under five mortality rate 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	Z
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	0.016247
MSE	6.313240
MAE	1.500309

Residual Analysis for the Applied Model

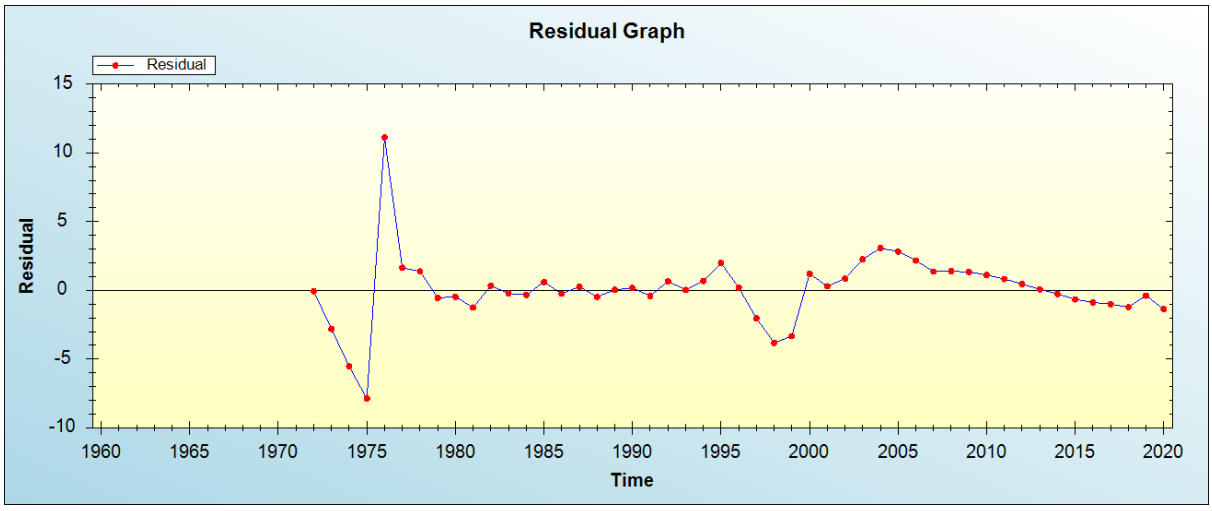

Figure 1: Residual analysis

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In-sample Forecast for Z

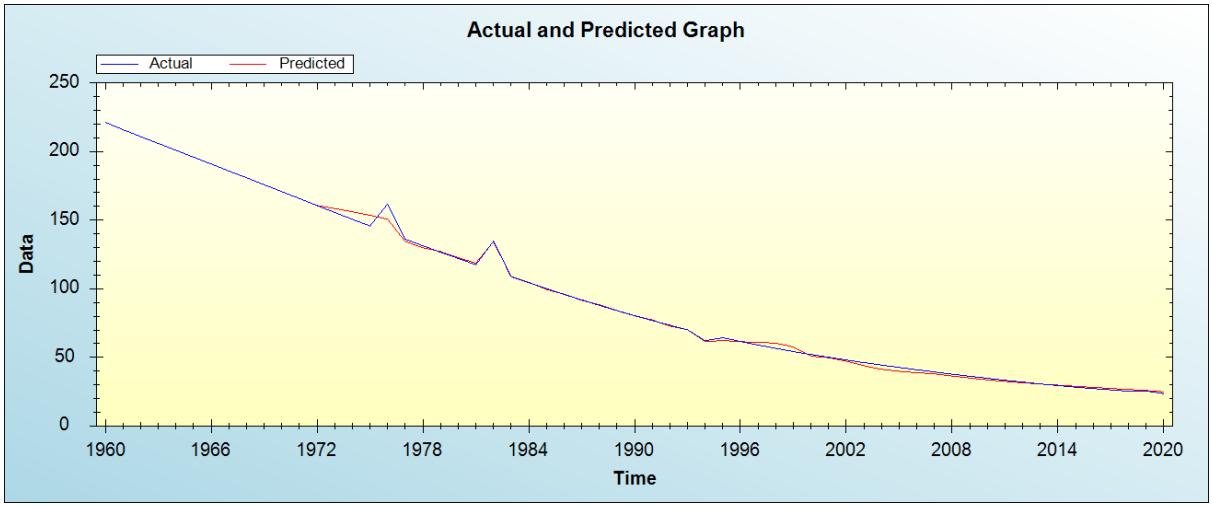

Figure 2: In-sample forecast for the Z series

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

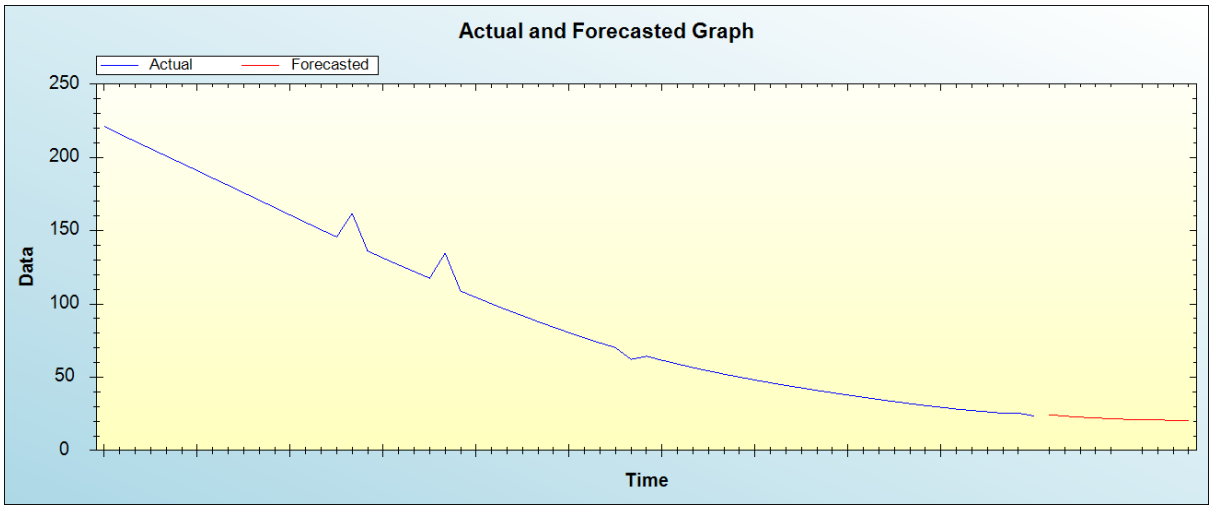

Figure 3: Out-of-sample forecast for Z: actual and forecasted graph

Out-of-Sample Forecast for Z: Forecasts only

Table 2: Tabulated out-of-sample forecasts

2021	24.3326
2022	23.5004
2023	22.7803
2024	22.1634
2025	21.8441
2026	21.2561
2027	21.1206
2028	20.8705
2029	20.6279
2030	20.3713

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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 over the out of sample period.

V. POLICY IMPLICATION & CONCLUSION

Under five mortality is still a public health problem especially in the rural areas where neonatal mortality trends are an issue of concern. This study applied the artificial neural network approach to predict future trends of under-five mortality rateand the findings indicated that annual U5MR will continue to decline over the out of sample period. Therefore, authorities in Guatemala are encouraged to address various factors that contribute to under five mortality especially in the rural areas and other disadvantaged communities.

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