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Forecasting Future Trends of Under Five Mortality Rate for Peru Using an Artificial Intelligence Technique

[1]Dr. Smartson. P. NYONI, [2]Thabani NYONI

[1]ZICHIRe Project, University of Zimbabwe, Harare, Zimbabwe
[2]Independent Researcher & Health Economist, Harare, Zimbabwe

***Abstract* - This study uses annual time series data on under five mortality rate (U5MR) for Peru 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 ANN (12, 12, 1) model is stable in forecasting under five mortality rate. ANN model projections indicate that U5MR will continue to decline throughout the out of sample period. Therefore, we encourage the government of Peru to continue supporting maternal and child health (MNCH) program activities in the country to keep under five mortality below 25 deaths per 1000 live births.**

Keywords: ANN, Forecasting, U5MR.

I. INTRODUCTION

Addressing the problem of under-five mortality is the objective of the 3rd sustainable development goal (SDG3) (UN, 2016; UN, 2015). Ending all preventable under five deaths requires all stakeholders to work together in harmony in order to solve this persistent problem. High quality maternal and newborn care interventions have been shown to substantially reduce neonatal and under five mortality (UN, 2020; UNICEF, 2019; WHO, 2019; UNICEF, 2018; Kamath-Rayne et al, 2015; Bhutta *et al*. 2014; Mason *et al*. 2014; Dickson *et al*. 2014). It is encouraging to mention that all UN member countries are reporting a downward trend in under five and neonatal mortality, however developing countries continue to witness high absolute numbers of newborn and under five deaths (World Bank, 2019). Lack of adequate resources and home deliveries have been found to be among the causes of mortality in low and middle income countries (Kumar *et al*. 2014; Manasyan *et al*. 2013).In line with Vision 2030, the objective of this study is to model and project future trends of under-five mortality rate for Peru using a machine learning algorithm. The findings of this paper will trigger an appropriate timeous response to the factors that are associated with mortality among children below 5years.

II. LITERATURE REVIEW

Juarez et al. (2020) conducted a quality improvement study to improve 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. Soleman *et al*. (2020) conducted a cross-sectional study in Indonesia to describe trends and main causes of children mortality in Indonesia from 2000 to 2017. The data was taken from World Health Organization Maternal Child Epidemiology Estimation from 2000 to 2017. The study found that the trend of three parameters of child mortality declined within 17 years and the main causes of mortality were premature birth in neonates, ARI in post neonates and premature birth in under five children. Another study by 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 similar forecasting study by Nyoni & Nyoni, 2020 utilized the ARIMA model to model and forecast infant mortality in Zimbabwe. The ARIMA (1, 2, 5) was the best model and the forecast results indicated that the number of infant deaths per year, over the out-of-sample period, will follow a downward trend.

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

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activation function. This paper applies the Artificial Neural Network (ANN) approach in predicting annual under five mortality rate for Peru.

Data Issues

This study is based on annual under five mortality rate in Peru 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	H
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	0.000824
MSE	0.425936
MAE	0.481259

Residual Analysis for the Applied Model

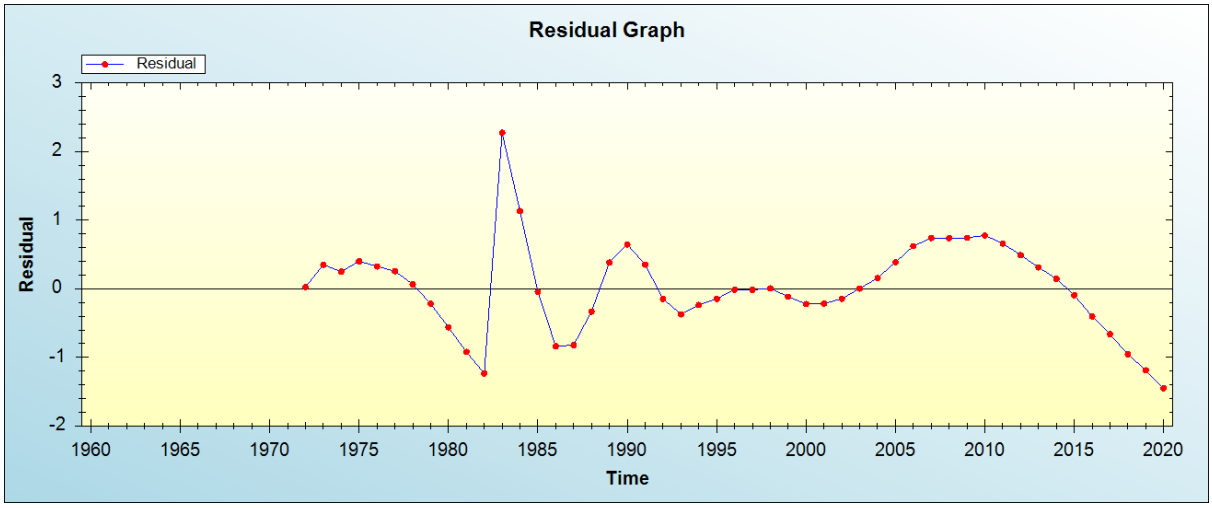

Figure 1: Residual analysis

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In-sample Forecast for H

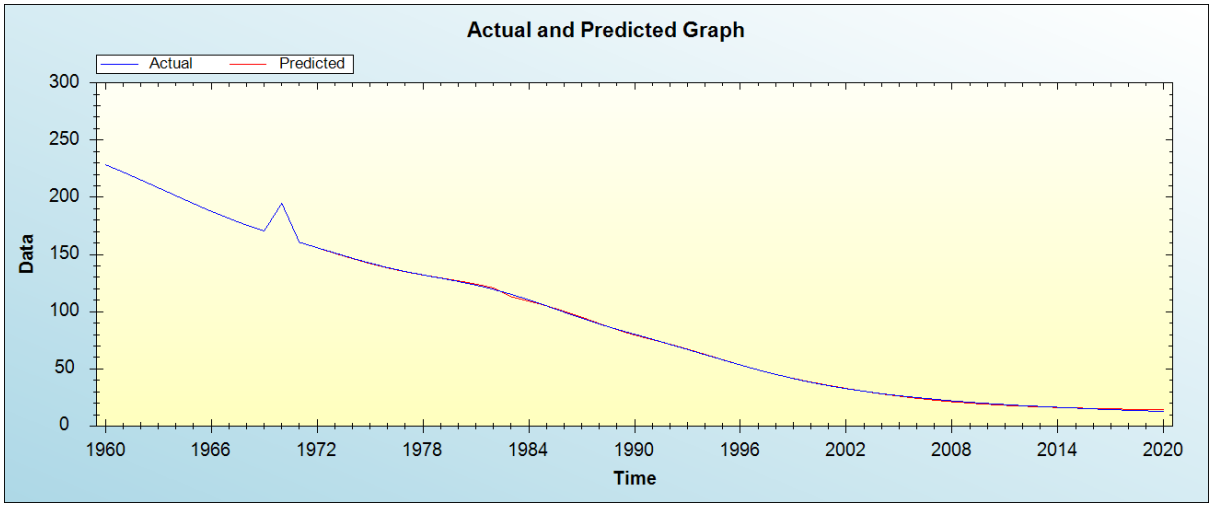

Figure 2: In-sample forecast for the H series

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

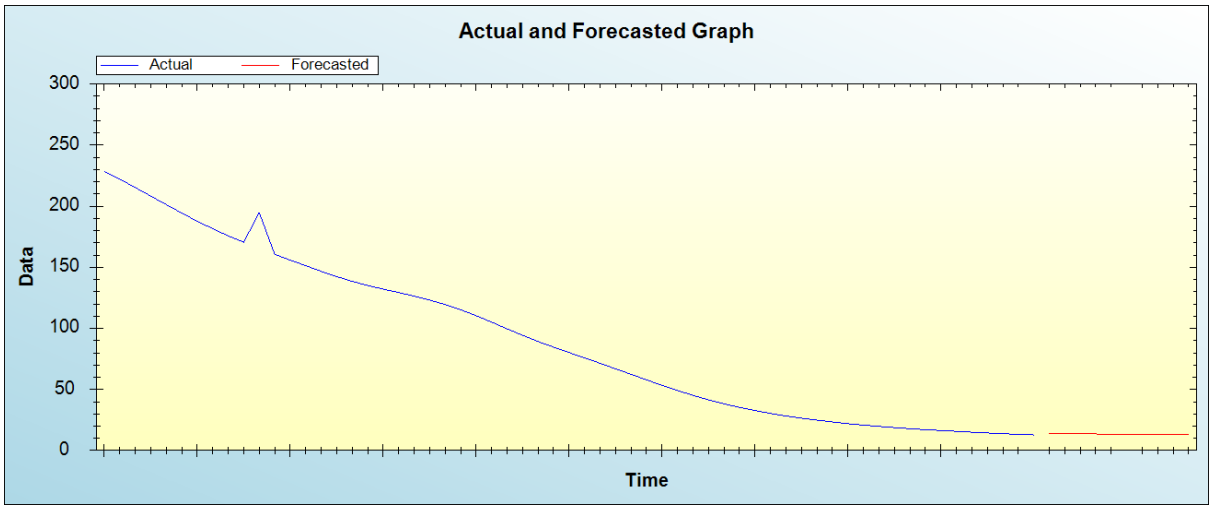

Figure 3: Out-of-sample forecast for H: actual and forecasted graph

Out-of-Sample Forecast for H: Forecasts only

Table 2: Tabulated out-of-sample forecasts

2021	14.0414
2022	13.7882
2023	13.7157
2024	13.6036
2025	13.4910
2026	13.3740
2027	13.2640
2028	13.1731
2029	13.1110
2030	13.0753

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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 throughout the out of sample period.

V. POLICY IMPLICATION & CONCLUSION

The 3rd sustainable development goal focuses on ensuring good health and promotion of well-being for all at every stage of life. Ending all preventable under five deaths must be prioritized by every UN member state. In this study we applied the ANN model and the forecast results revealed that U5MR will continue to decline throughout the out of sample period. Therefore, we encourage the government of Peru to continue supporting maternal and child health program activities in order to keep under five mortality below 25 deaths per 1000 live births.

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