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Tracking Future Trends of Under Five Mortality Rate for Malawi Using Artificial Neural Networks

[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 Malawi from 1961 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 revealed that annual U5MR will decline from around 40 to 35.6 deaths per 1000 live births over the out of sample period. Therefore, we encourage the Malawian government to address all the major challenges that hinder the success of the maternal and child health (MNCH) program particularly in the rural areas.**

Keywords: ANN, Forecasting, U5MR.

I. INTRODUCTION

Ending all preventable deaths of under-five children remains a global health challenge particularly in developing countries (WHO, 2020; UNICEF, 2018; UN, 2016; UN, 2015). However, it is worthy to recognize the significant progress made so far to achieve this goal and other health related sustainable development goals (SDGs) (Ouedraogo *et al*. 2020; World Bank, 2019).As it is stated in the global action plan, governments and global partners should direct their efforts towards addressing the health concerns of women and children. Even in the midst of serious challenges there is still hope to contribute a lot towards changing the lives of many women and children by ensuring that there is universal health coverage and access to quality and affordable health care services (UN, 2020; UNICEF, 2019; WHO, 2019; UNICEF, 2018). It is also important to channel resources to programs that are designed to reduce poverty, hunger and other deprivations (UN, 2015). In line with the agenda 2030 for sustainable, this study applies the artificial neural network approach to forecast future trends of under-five mortality rate in Malawi and the results will enable formulation of appropriate MNCH policies that are meant to end all preventable under five deaths by 2030.

II. LITERATURE REVIEW

Olack *et al.* (2021) investigated the causes of neonatal LBW and preterm mortality in Migori County, among participants of the PTBI-K (Preterm Birth Initiative-Kenya) study. Verbal and social autopsy (VASA) interviews were conducted with caregivers of deceased LBW and preterm neonates delivered within selected 17 health facilities in Migori County, Kenya. The probable cause of death was assigned using the WHO International Classification of Diseases (ICD-10). The findings indicated that deaths among LBW and preterm neonates occur early in life due to preventable causes.Masaba & Phetoe (2020) described the trends of neonatal mortality within the two sub-Saharan countries. The study concluded that in 2018, the neonatal mortality rate for Kenya was 19.6 deaths per 1000 live births. The neonatal mortality rate had fallen gradually from 35.4 deaths per 1000 live births in 1975. On the other hand, South Africa had its neonatal mortality rate fall from 27.9 deaths per 1000 live births in 1975 to 10.7 deaths per 1000 live births in 2018. Gage & Bauhoff (2020) assessed the impact of PBF on early neonatal health outcomes and associated health care utilization and quality in Burundi, Lesotho, Senegal, Zambia and Zimbabwe. Authors utilized data from Demographic and Health Surveys and Multiple Indicator Cluster Surveys and applied difference-in-differences analysis to estimate the effect of PBF projects supported by the World Bank on early neonatal mortality and low birth weight and concluded that PBF had no impact on early neonatal health outcomes in the five African countries studied and had limited and variable effects on the utilization and quality of neonatal health care.Kayode *et al*. (2017) conducted an ecological study which revealed that there is a wide variation in neonatal mortality in SSA. A substantial part of this variation can be explained by differences in the quality of healthcare governance, prevalence of HIV and socioeconomic deprivation. Rhoda *et al*. (2018) reviewed efforts made by the South African government to reduce neonatal mortality. Indications from the study showed that high-impact interventions, providing an adequate number of appropriately trained healthcare providers and a more active role played by ward-based community health workers and district clinical specialist teams was pivotal to achieve substantial reduction in neonatal deaths.

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

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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 Malawi.

Data Issues

This study is based on annual under five mortality rate in Malawi for the period 1961– 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	W
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	0.004865
MSE	7.667408
MAE	1.672330

Residual Analysis for the Applied Model

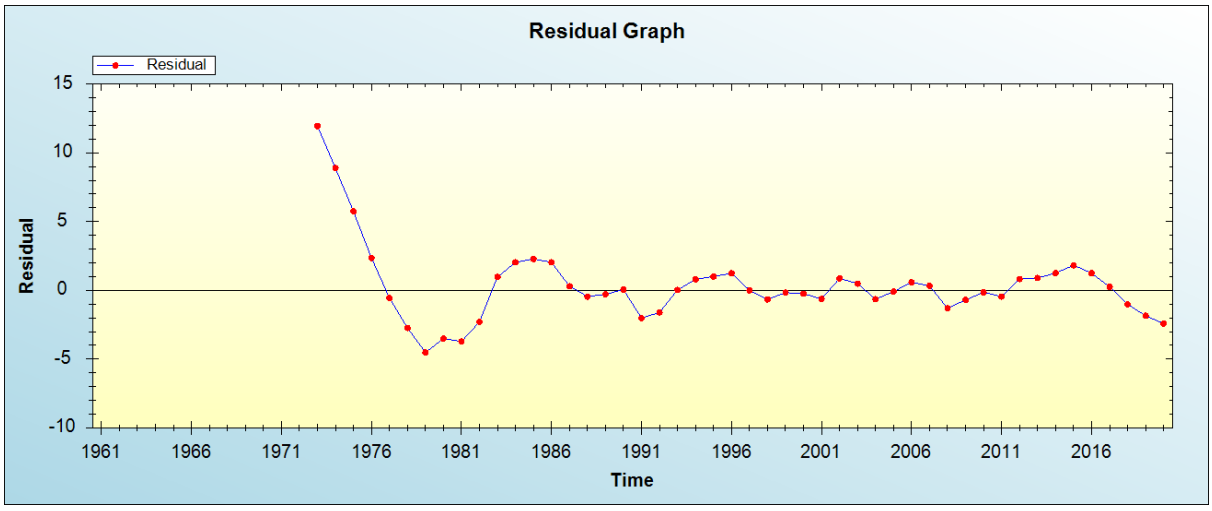

Figure 1: Residual analysis

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In-sample Forecast for W

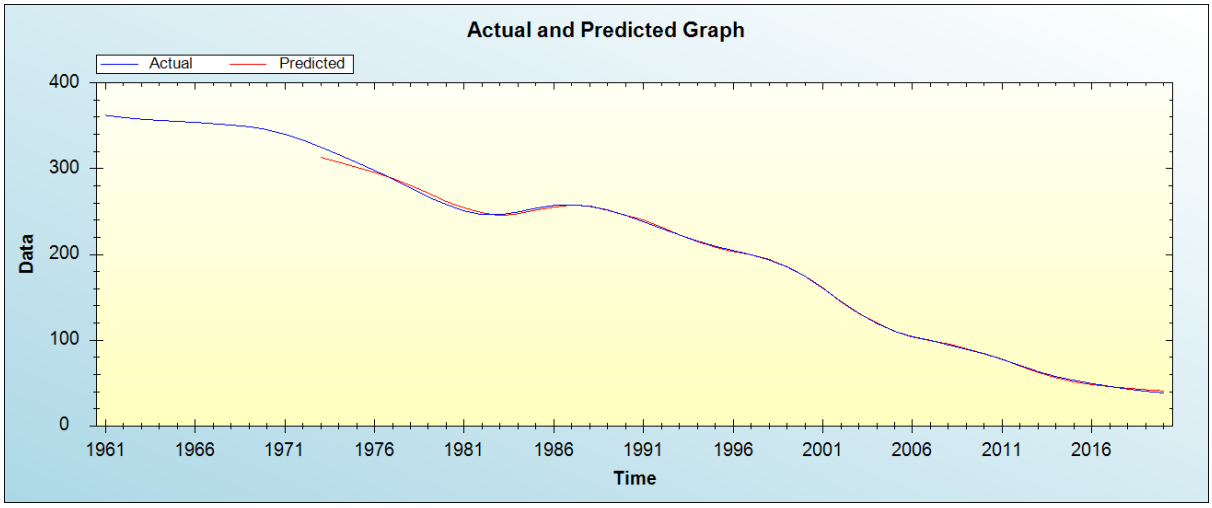

Figure 2: In-sample forecast for the W series

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

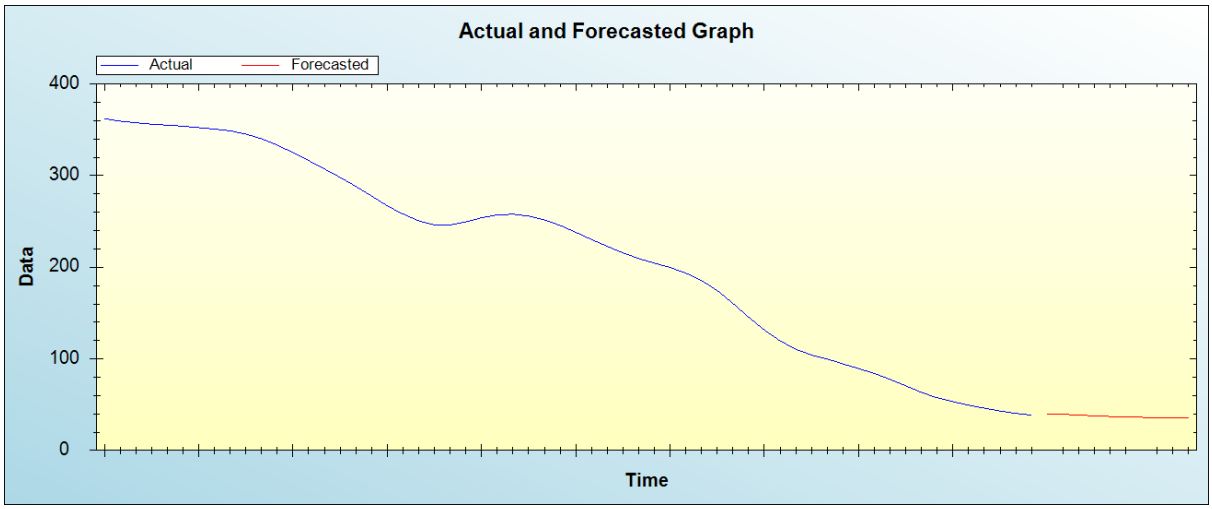

Figure 3: Out-of-sample forecast for W: actual and forecasted graph

Out-of-Sample Forecast for W: Forecasts only

Table 2: Tabulated out-of-sample forecasts

2021	39.9077
2022	39.5883
2023	38.7960
2024	37.8189
2025	37.2186
2026	36.7230
2027	36.2568
2028	36.1379
2029	35.9377
2030	35.6391

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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 decline from around 40 to 35.6 deaths per 1000 live births over the out of sample period.

V. POLICY IMPLICATION & CONCLUSION

Ending all preventable deaths should be a priority of every UN member state. Although Malawi has reported a decline in under five mortality over the past decades, absolute numbers of under five deaths still remain high as a result of numerous challenges that exist across the country. Forecasting under five mortality rate is expected to guide maternal and child health policies, decisions and allocation of resources to the maternal and child health program in the country. This study proposes the artificial neural network approach to forecast future trends of under-five mortality rate in Malawi. The findings of the study indicate that annual U5MR will decline from around 40 to 35.6 deaths per 1000 live births over the out of sample period. Therefore, we encourage health authorities in Malawi to address all the major challenges that hinder the success of the maternal and child health (MNCH) program especially in the rural areas.

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