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Assessing the Feasibility of Achieving Substantial Reduction of Under Five Mortality in Sierra Leone Using Artificial Neural Networks

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***Abstract* - This study uses annual time series data on under five mortality rate for Sierra Leone 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. ANN model projections indicate that annual U5MR will decline but still remain high throughout the out of sample period. Therefore, we encourage the government of Sierra Leone to allocate more resources to the maternal and child health program and attend to various challenges that affect the quality of pediatric healthcare services across the country.**

Keywords: ANN, Forecasting, U5MR.

I. INTRODUCTION

One of the priority areas of sustainable development goals is solving the global population health problems. The aim is to ensure universal health coverage and access to affordable and quality health services (UN, 2016; UN, 2015). Ending preventable deaths from various causes is the emphasis of sustainable development goal 3. Substantial reduction of maternal and under five mortality is the expected outcome of SD3 targets 3.1 and 3.2.The majority of maternal and child mortalities which occur in developing countries are largely avoidable (WHO, 2019). Poor quality of care, limited access and shortage of skilled manpower are the main causes of maternal and neonatal deaths (Lang *et al*. 2018; Mattern, 2017). The global neonatal mortality rates have declined from 37 deaths per 1000 live births in 1990 to 18 deaths per 1000 live births in 2018 with Sub-Saharan Africa contributing 41% of the global neonatal deaths (UNICEF *et al*. 2019; Hug *et al*. 2019). Surveillance tools are important as they help in the detection of abnormal trends and track progress towards achieving the set SDG targets. The artificial neural network model was proposed in this study to model and project future trends of under-five mortality rate for Sierra Leone. This will facilitate planning, decision making and allocation of resources for MNCH programs in the country.

II. LITERATURE REVIEW

A multisite retrospective Kenyan cohort study was carried out by Irimu *et al. (*2021) to establish the proportion of all admissions and deaths in the neonatal age group and examine morbidity and mortality patterns, stratified by birth weight, and their variation across hospitals. Intrapartum related complications was the single most common diagnosis among the neonates with birth weight of 2000 g or more who died. A threefold variation in mortality across hospitals was observed for birth weight categories 1000– 1499 g and 1500–1999g.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.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.Bitew *et al.* (2020) determined the incidence density rate and predictors of neonatal mortality by utilizing electronic databases. The study findings indicated that the incidence density rate of neonatal mortality in Sub-Saharan Africa is significantly high. Multiple factors (neonatal and maternal) were found to be independent predictors. In another study, Simeoni *et al*. (2019) analyzed the infant (IMR) and neonatal (NMR) mortality rates of Italian and foreign children and evaluated if there is a disparity among geographical macro-areas. Data from 2006 to 2015 were collected by the Italian Statistics Bureau (ISTAT) and extracted from two different national databases, which considered i) underlying cause of death and ii) birth registry. The main analyses were made comparing Italian versus foreigners as a single category as well as by country origin and contrasting Northern residents

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versus Southern ones. Comparisons between groups were done using relative risks. The study findings indicated that Inequalities in neonatal and infant mortality are evident between Italians and immigrants and among geographical macro-areas.

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 Sierra Leone.

Data Issues

This study is based on annual under five mortality rate in Sierra Leone 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	V
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	0.001822
MSE	1.718477
MAE	0.662110

Residual Analysis for the Applied Model

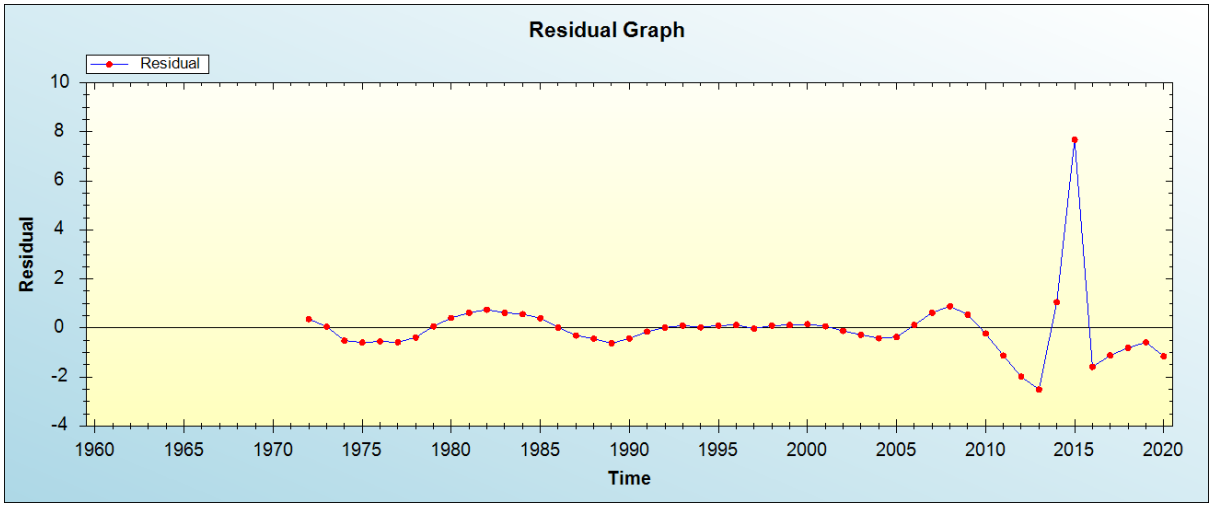

Figure 1: Residual analysis

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In-sample Forecast for V

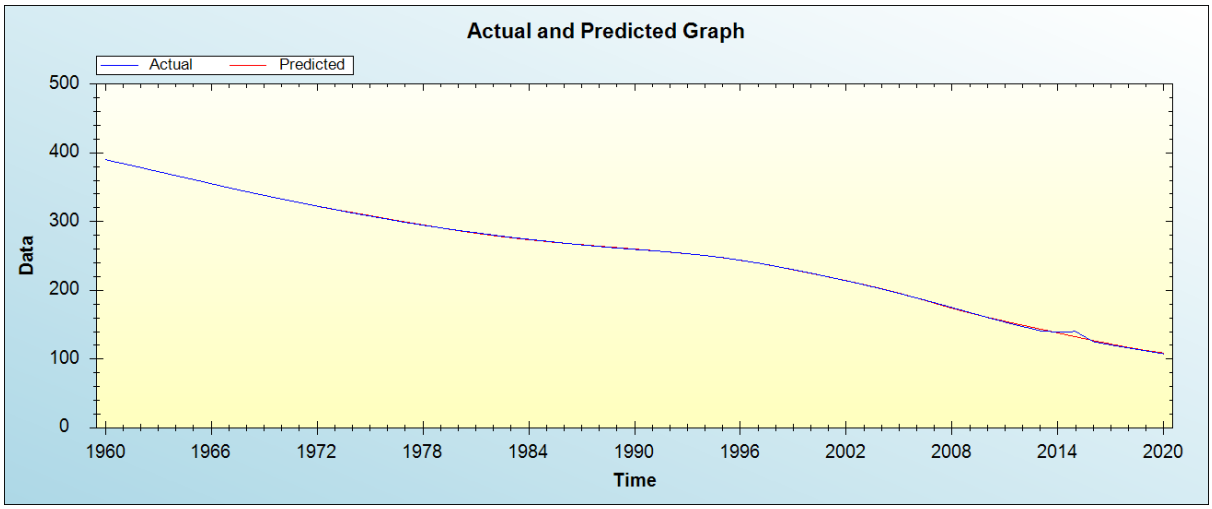

Figure 2: In-sample forecast for the V series

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

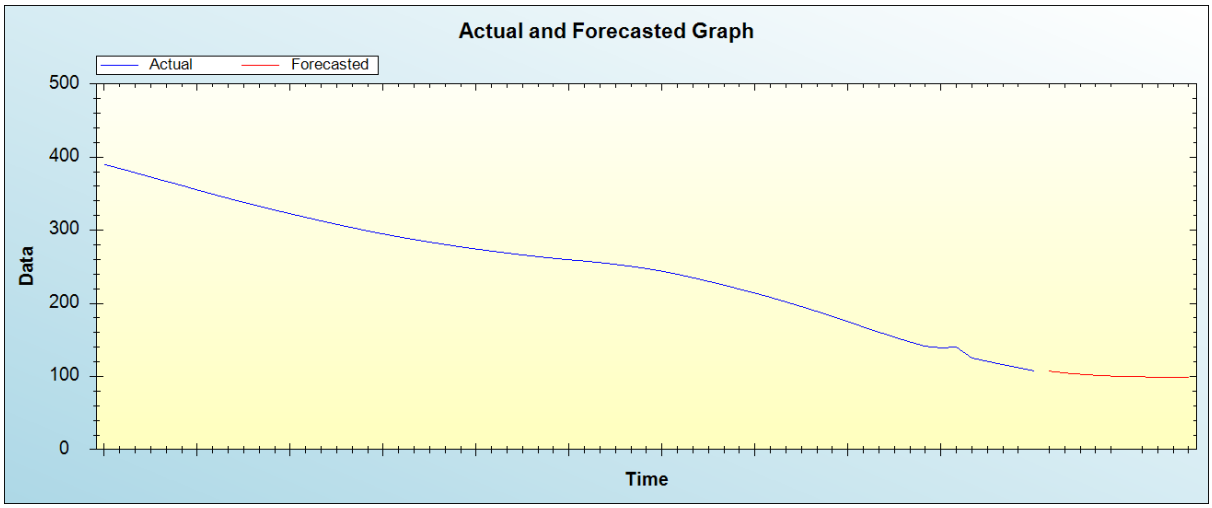

Figure 3: Out-of-sample forecast for V: actual and forecasted graph

Out-of-Sample Forecast for V: Forecasts only

Table 2: Tabulated out-of-sample forecasts

2021	107.2674
2022	104.8861
2023	103.1349
2024	101.5973
2025	100.6502
2026	100.1517
2027	99.5642
2028	98.8452
2029	98.5571
2030	98.3171

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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 but still remain high throughout the out of sample period.

V. POLICY IMPLICATION & CONCLUSION

Sierra Leone recorded a downward trend of under-five and neonatal mortality rates over the past decades as a result of government's desire to address all the challenges that affect the success of the maternal and child health program. The aim of every UN member state is to substantially reduce under five mortality rate to levels as low as 25 deaths per 1000 live births. Projection of under-five mortality rate will inform child health policies, decisions and allocation of resources. The ANN model was applied in this study to forecast future trends of under-five mortality rate for Sierra Leone and forecast results revealed that annual U5MR will decline but still remain high throughout the out of sample period. Therefore, we implore the government to allocate more resources to the maternal and child health program and attend to the various challenges that affect the quality of pediatric healthcare services across the country.

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