

Assessing the Feasibility of Achieving Substantial Reduction of Under Five Mortality in Papua New Guinea Using Artificial Neural Networks

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Abstract - This study uses annual time series data on under five mortality rate (U5MR) for Papua New Guinea 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 remain around 40 deaths per 1000 live births throughout the out of sample period. Therefore, we encourage health authorities in Papua New Guinea to channel more resources to the maternal and child health (MNCH) program to ensure availability of medical supplies and health professionals at every level of healthcare in the country.

Keywords: ANN, Forecasting, U5MR.

I. INTRODUCTION

The application of machine learning (ML) and traditional statistical techniques in time series forecasting in public health continues to attract the attention of many researchers around the globe. Public health data can be huge and complex hence the use of machine learning approaches becomes important since they have demonstrated the ability of analyzing nonlinear complex data ((Zhao *et al.* 2020; Nyoni *et al.* 2020; Kaushik & Sahi, 2018; Fojnica *et al.* 2016; Zhang, 2003). Statistical methods such as the ARIMA are still relevant and useful in modelling linear data (Nyoni, 2018; Box & Jenkins, 1970). The GARCH model and its variants are known as volatility models because they are designed for modelling conditional variance (Gujarat & Porter, 2008). Exponential smoothing models generate forecasts by assigning weights to past values of the historical data with more recent values having more weights than those in the more distant past (Gujarat & Porter, 2008). This study specifically applies a machine learning algorithm to model and project future trends of under-five mortality for Papua New Guinea. The results are envisioned to highlight likely future trends of U5MR in the country. This will assist in child health policy formulation, planning and allocation of resources to MNCH program activities that are meant to end all preventable under five deaths.

II. LITERATURE REVIEW

Kassebaum (2021) investigated current rates, recent trends, and potential trajectories of child mortality for the next decade. The author presented the Global Burden of Diseases, Injuries, and Risk Factors Study (GBD) 2019 findings for all-cause mortality and cause-specific mortality in children younger than 5 years of age, with multiple scenarios for child mortality in 2030 that include the consideration of potential effects of COVID-19, and a novel framework for quantifying optimal child survival. It was found that Global child mortality declined by almost half between 2000 and 2019, but progress remains slower in neonates and 65 (32%) of 204 countries, mostly in sub-Saharan Africa and south Asia, are not on track to meet either SDG 3.2 target by 2030. A description of household factors associated with under-five mortality in Bankass, a remote region in central Mali was done by Boettiger *et al.* (2021). The authors analyzed baseline household survey data from a trial being conducted in Bankass. The survey was administered to households between December 2016 and January 2017. Under-five deaths in the five years prior to baseline were documented along with detailed information on household factors and women's birth histories. Factors associated with under-five mortality were analyzed using Cox regression. The study concluded that U5 mortality is very high in Bankass and is associated with living a greater distance from healthcare and several other household factors that may be amenable to intervention or facilitate program targeting. A forecasting 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. Brault *et al.* (2018) examined factors contributing to the reductions in under-five mortality in Postwar Liberia by conducting a case study mixed methods approach drawing on data from quantitative indicators, national documents and qualitative interviews were used to describe factors that enabled Liberia to rebuild their maternal, neonatal and child health (MNCH) programmes and reduce under-five mortality following the country's civil war. The findings revealed that three main factors contributed to the reduction in under-five mortality: national prioritization of MNCH after the civil war; implementation of integrated packages of services that expanded access to key interventions and promoted

inter-sectoral collaborations; and use of outreach campaigns, community health workers and trained traditional midwives to expand access to care and improve referrals.

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 Papua New Guinea.

Data Issues

This study is based on annual under five mortality rate in Papua New Guinea 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	G
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	0.000503
MSE	0.144959
MAE	0.293136

Residual Analysis for the Applied Model

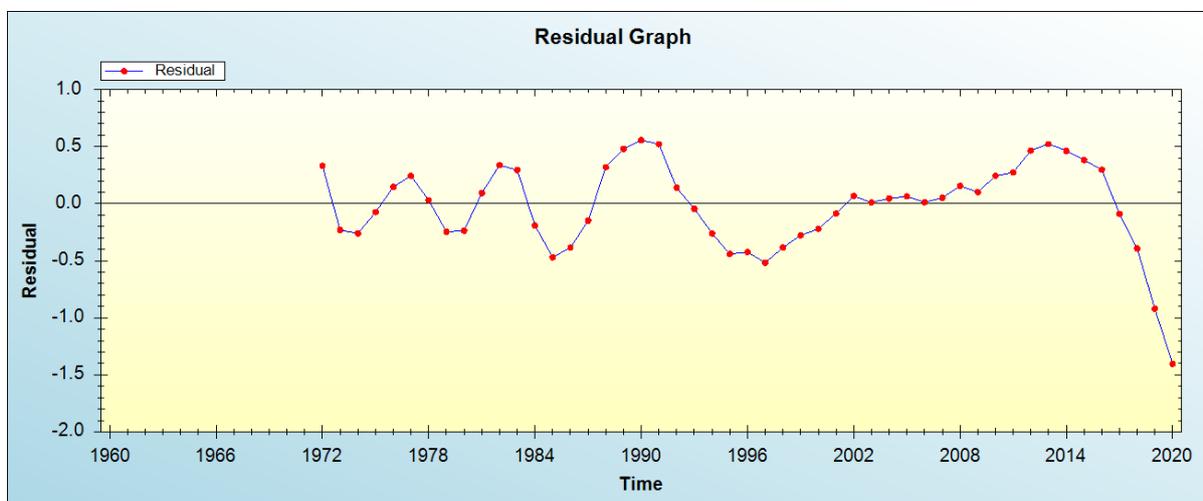


Figure 1: Residual analysis

In-sample Forecast for

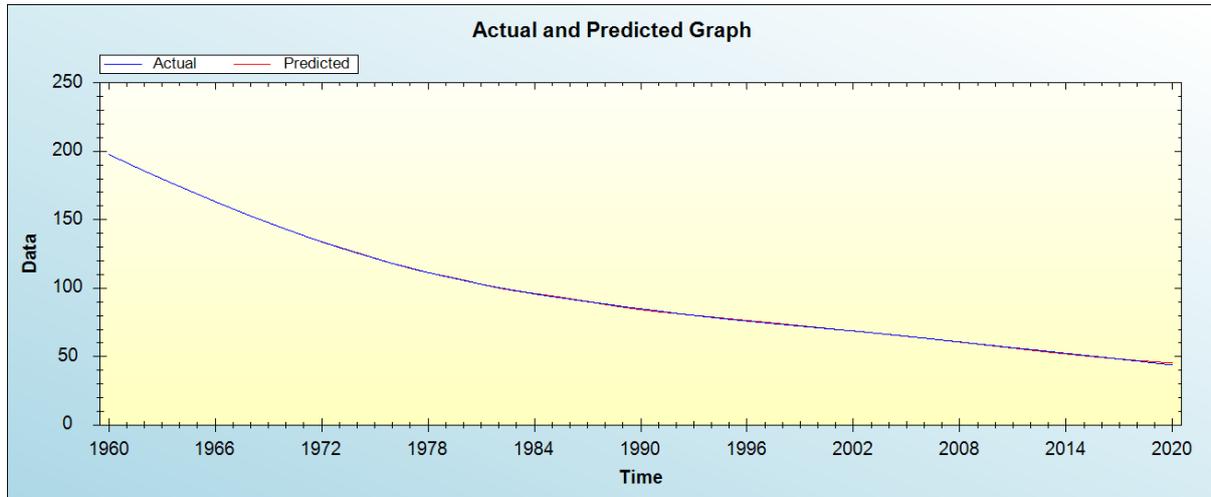


Figure 2: In-sample forecast for the G series

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

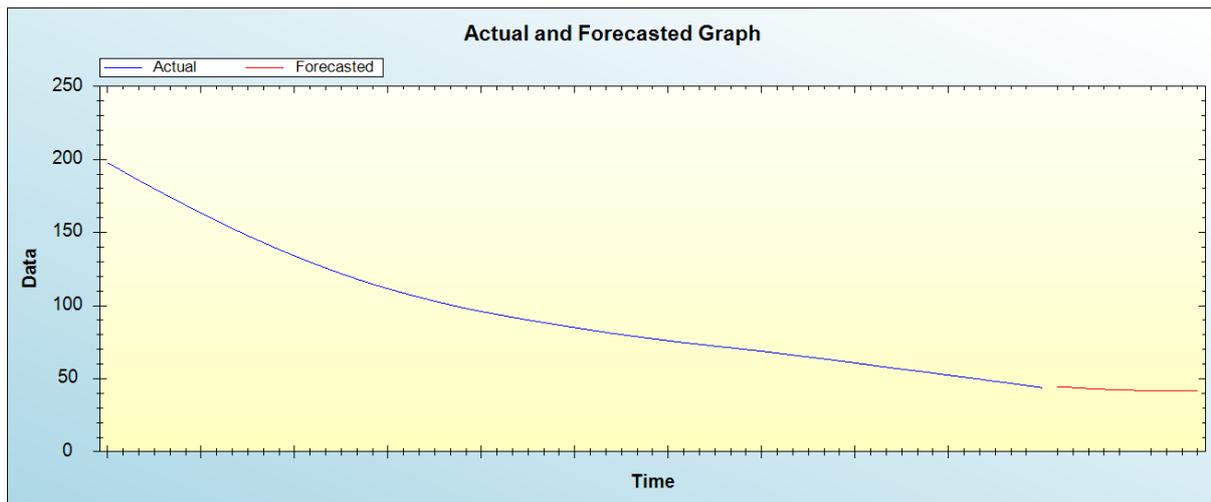


Figure 3: Out-of-sample forecast for G: actual and forecasted graph

Out-of-Sample Forecast for G: Forecasts only

Table 2: Tabulated out-of-sample forecasts

2021	44.4610
2022	43.9620
2023	43.2845
2024	42.7893
2025	42.5222
2026	42.0924
2027	41.9333
2028	41.8136
2029	41.6932
2030	41.7660

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 remain around 40 deaths per 1000 live births throughout the out of sample period.

V. POLICY IMPLICATION & CONCLUSION

Most African states are battling the problem of under-five mortality as shown by high absolute numbers of under five deaths. Papua New Guinea has made commendable progress in the reduction of under-five mortality as reflected by the decline in under five and neonatal mortality rates over the past decades. This study applied the ANN model to forecast future trends of under-five mortality rate and forecast results indicate that U5MR will remain around 40 deaths per 1000 live births throughout the out of sample period. Therefore, we encourage the government of Papua New Guinea to channel more resources to the maternal and child health program to ensure availability of medical supplies and health professionals at all levels of healthcare in the country.

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