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Analysis of Under Five Mortality Rate for Tanzania Using Artificial Neural Networks

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***Abstract* - This study uses annual time series data on under five mortality rate (U5MR) for Tanzania 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) is stable in forecasting under five mortality rate. The ANN model projections revealed thatU5MR will remain high throughout the out of sample period. Therefore, we encourage the Tanzanian government to address all the challenges that significantly contribute to under five mortality and affect the quality of the maternal and child health program.**

Keywords: ANN, Forecasting, U5MR.

I. INTRODUCTION

The global sustainable development goals (SDGs) are supposed to deal with several challenges that affect the human race around the globe (UN, 2020; UNICEF, 2019; WHO, 2019; UNICEF, 2018; UN, 2016; UN, 2015). One of the problems is mortality across various age groups caused by different reasons. The SDGs were crafted to reduce mortality significantly by 2030 thereby improving the quality of life for all the people especially that of women and children. Pregnant mothers and under five children are vulnerable to many circumstances such as poverty, hunger, civil wars, epidemic diseases and poor hygiene related diseases (UN, 2016; UN, 2015). Several efforts have been made by UN member states to address the various causes of mortality among pregnant mothers and children. This is evidenced by the decrease in maternal, neonatal and under five mortality rates for most countries (World Bank, 2020; DATASUS, 2020; Huge *et al*. 2019; World Bank, 2019;WHO, 2018). However, some countries continue to report high absolute numbers of deaths among neonates, under five children and pregnant mothers especially in sub-Saharan Africa and Asia (World Bank, 2020; World Bank, 2019; UNICEF, 2018Lawn *et al*. 2016). The objective of maternal and child health (MNCH) programs around the world is to ensure a substantial reduction of global maternal mortality ratio to levels below 70 deaths per 100 000 live births by 2030, significant decline of neonatal and under five deaths to as low as 12 deaths per 1000 live births and 25 deaths per 1000 live births accordingly by 2030 (UNICEF, 2019). This can be achieved through integration of SDGs into regional, national and local government plans and budgets. Involvement of all stakeholders is key to get the vital support and resources needed in the MNCH program.

The aim of this paper is to predict future trends of under-five mortality rate for Tanzania using a machine learning algorithm and the results are expected to inform MNCH policies and allocation of resources in order to sufficiently deal with under five mortality in the country.

II. LITERATURE REVIEW

A retrospective cohort study was conducted by Mangu *et al*. (2021) to investigatetrends, patterns and causes of neonatal mortality in hospitals in Tanzania during 2006–2015. This retrospective study was conducted in 35 hospitals. Mortality data were obtained from inpatient registers, death registers and International Classification of Diseases-10 report forms. Annual specific hospital-based neonatal mortality rates were calculated and discussed. Two periods of 2006–2010 and 2011–2015 were assessed separately to account for data availability and interventions. The study revealed was that neonatal mortality rate was 3.7/1000 during 2006–2010 and 10.4/1000 during 2011–2015, both periods indicating a stagnant trend in the years between. The leading causes of early neonatal death were birth asphyxia (22.3%) and respiratory distress (20.8%), while those of late neonatal death were sepsis (29.1%) and respiratory distress (20.0%). 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.Khasawneh & Khriesat (2020)assessed the rate of prematurity and determine the mortality rate and short-term outcomes among premature infants admitted at King Abdullah University Hospital (KAUH) in Jordan.A retrospective cross-sectional review of all premature infants admitted at KAUH between August 2016 and

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August 2018 was conducted. The study revealed a high rate of prematurity, the majority were late preterm with reassuring outcomes. A cross-sectional study conducted by Edem *et al*. (2020) examined the health practices, care-seeking behavior, and referral of sick out-born neonates to a district and regional hospital in the Upper West Region of Ghana. The study findings revealed that socio-cultural factors strongly influence health seeking behavior and the health outcome of neonates in this setting. 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 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 Tanzania.

Data Issues

This study is based on annual under five mortality rate in Tanzania 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	0.002105
MSE	0.948865
MAE	0.618657

Residual Analysis for the Applied Model

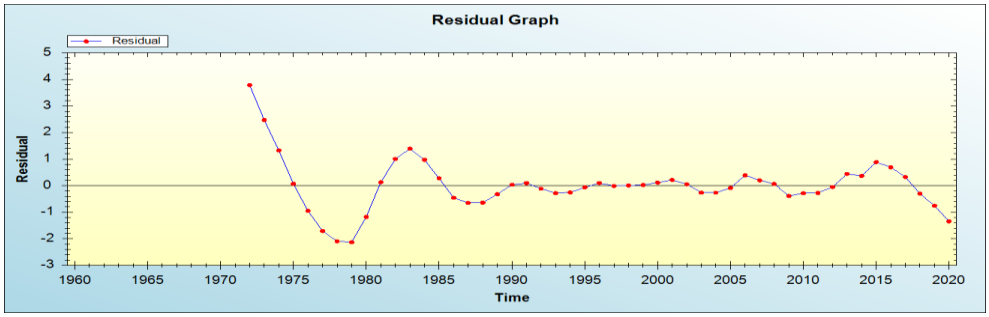

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Figure 1: Residual analysis

In-sample Forecast for Z

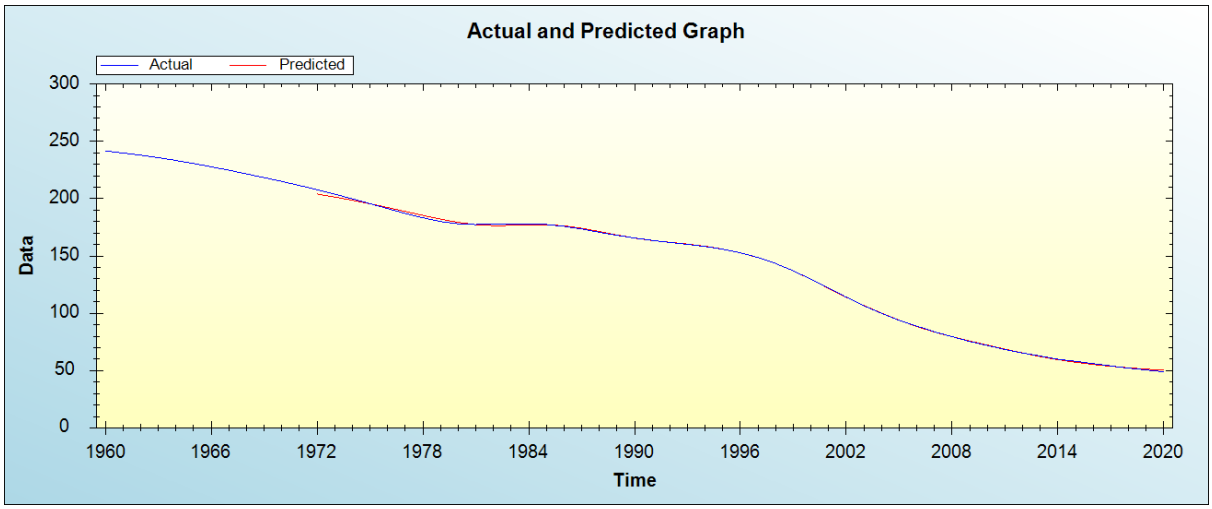

Figure 2: In-sample forecast for the Z series

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

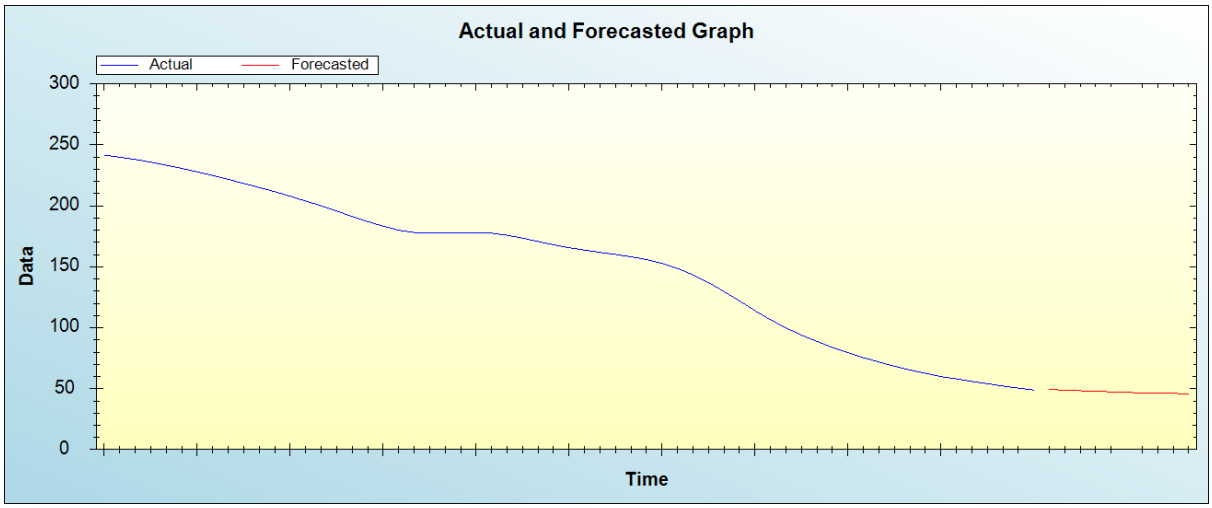

Figure 3: Out-of-sample forecast for Z: actual and forecasted graph

Out-of-Sample Forecast for Z: Forecasts only

Table 2: Tabulated out-of-sample forecasts

2021	49.3889
2022	48.7931
2023	48.3297
2024	47.8936
2025	47.4507
2026	46.9735
2027	46.5622
2028	46.3063
2029	46.1006
2030	45.9115

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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 remain high throughout the out of sample period.

V. POLICY IMPLICATION & CONCLUSION

High numbers of teenage pregnancies in Tanzania have been found to contribute to adverse maternal and child health outcomes. Under five mortality is still a cause for concern as the country continues to report high absolute numbers of under five deaths. This study applied the ANN model to project future trends of under-five mortality rate and forecast results revealed thatU5MR will remain high throughout the out of sample period. Therefore, we encourage the Tanzanian government to address all the factors that contribute to under five mortality in the country and affect the quality of the maternal and child health program in the country.

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