

# Analysis of Under Five Mortality Rate for Senegal Using Artificial Neural Networks

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**Abstract** - This study uses annual time series data on under five mortality rate (U5MR) for Senegal 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 suggested that U5MR will continue to decline over the out of sample period. Hence, the Senegalese government must allocate more resources to the maternal and child health program and address all the pertinent issues affecting under five children across the country.

**Keywords:** ANN, Forecasting, U5MR.

## I. INTRODUCTION

The entire world is currently facing immense health challenges especially the emergency of highly infectious diseases such as COVID-19 which has crippled the global economy. This pandemic has shifted the attention of public health practitioners thereby neglecting other diseases of public health importance such as TB, HIV and Malaria. The 3<sup>rd</sup> sustainable development goal focuses on good health and promotion of well-being for all at all stages of life. It aims at ending all preventable deaths by 2030 (UN, 2016; UN, 2015). All UN member states must achieve a significant reduction in deaths as a result of various causes such as epidemic diseases, neglected tropical diseases, non-communicable diseases, industrial pollutants, substance abuse, and road traffic accidents (UN, 2016). This goal is strongly connected with other sustainable development goals. Poverty and hunger negatively affects the health of a population and a healthy population will drive economic growth and development thus contributing positively to the reduction of poverty and hunger (WHO, 2019; UNICEF, 2019; UNICEF, 2018). Maternal, newborn and under five deaths will remain at the centre of global population health discussions. Although there has been significant progress made in the reduction of maternal and under five mortality, the absolute numbers of maternal and under five deaths remain a huge concern in developing countries (WHO, 2019; Gulmezoglu *et al.* 2016). MNCH funding should be availed to aggressively address this problem in order to meet the set SDG 3 targets by 2030. This research applies the artificial neural network approach to forecast future trends of under-five mortality rate for Senegal. The findings are expected to inform MNCH policies and allocation of resources to effectively deal with under five deaths in the country.

## II. LITERATURE REVIEW

Adjei *et al.* (2021) examined the effect of community-, household- and individual-level factors on the risk of neonatal mortality in two districts in Ghana. The longitudinal study used the Kintampo Health and Demographic Surveillance System as a platform to select 30,132 neonatal singletons with 634 deaths. Multilevel cox frailty model was used to examine the effect of community-, household- and individual-level factors on the risk of neonatal mortality. The conclusion from the study was that there is risk of neonatal mortality at the individual- and household-levels in the Kintampo Districts. A cross-sectional study carried out by Edem *et al.* (2020) investigated 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. 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.

### 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 Senegal.

#### Data Issues

This study is based on annual under five mortality rate in Senegal 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	X
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	0.001286
MSE	0.997327
MAE	0.732074

#### Residual Analysis for the Applied Model

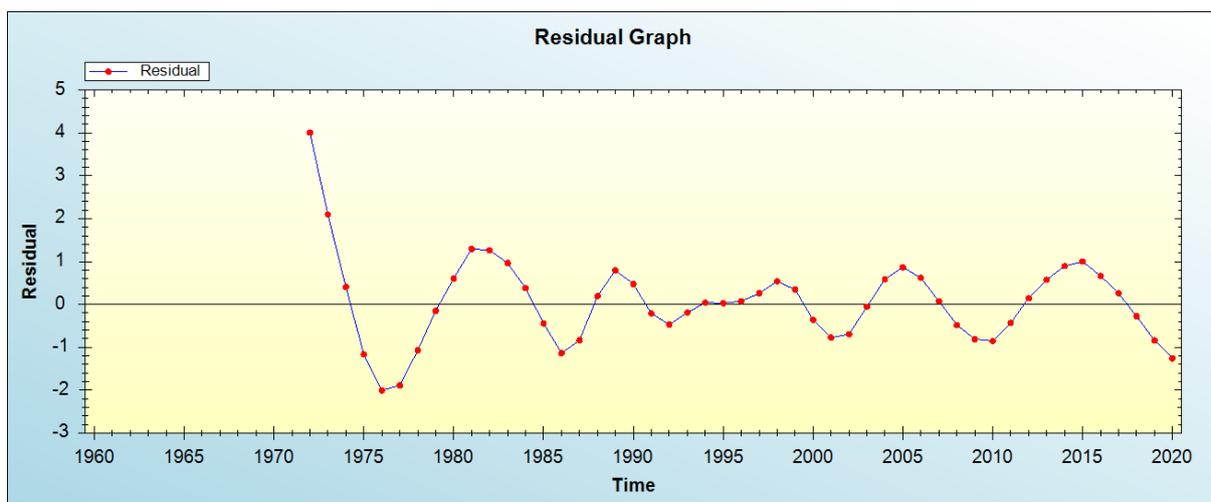


Figure 1: Residual analysis

In-sample Forecast for X

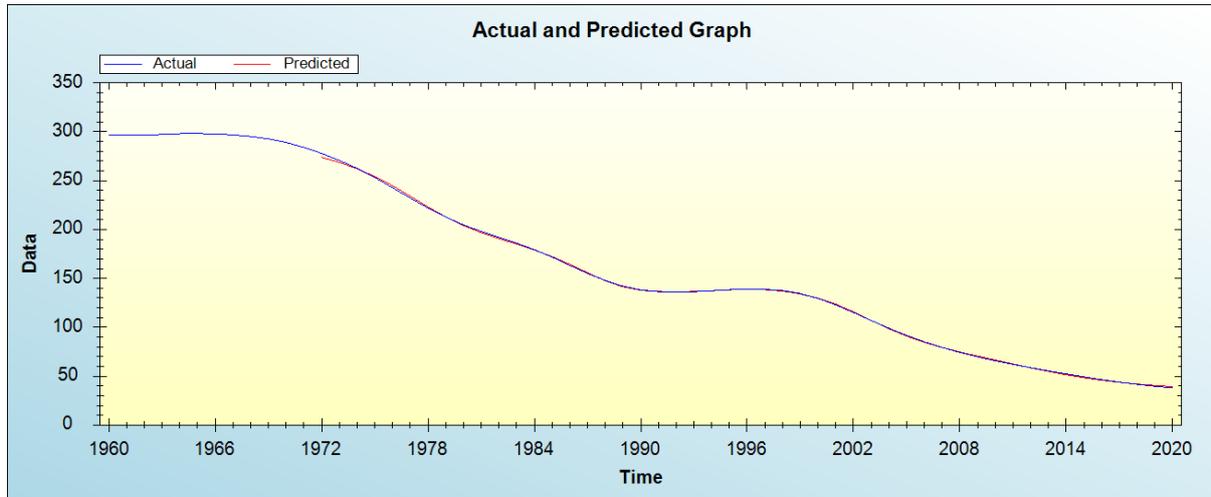


Figure 2: In-sample forecast for the X series

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

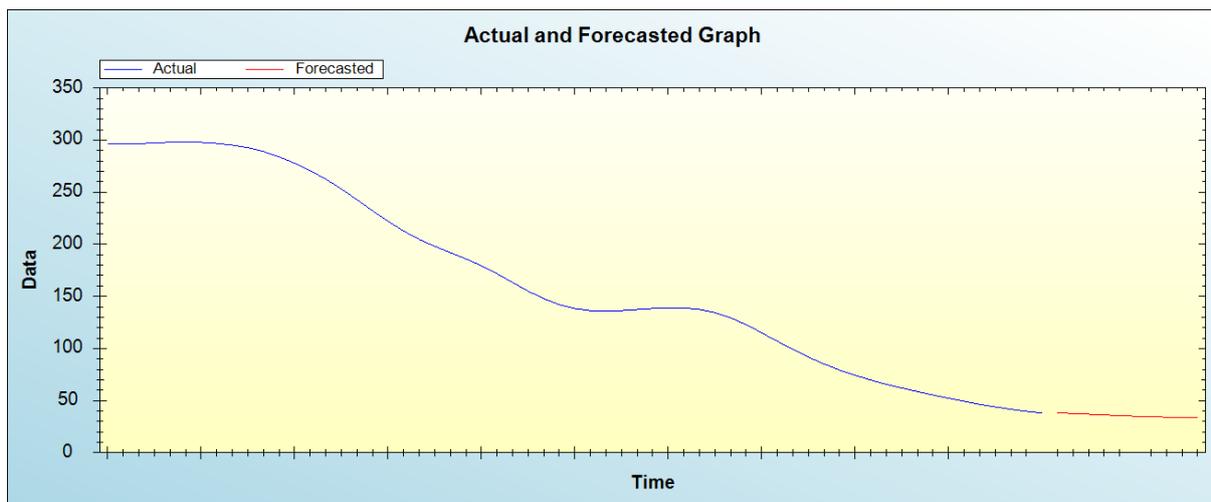


Figure 3: Out-of-sample forecast for X: actual and forecasted graph

Out-of-Sample Forecast for X: Forecasts only

Table 2: Tabulated out-of-sample forecasts

2021	38.3729
2022	37.5687
2023	36.9973
2024	36.3528
2025	35.7019
2026	35.0896
2027	34.6949
2028	34.2515
2029	34.0044
2030	33.8413

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 over the out of sample period.

## V. POLICY IMPLICATION & CONCLUSION

Sub-Saharan Africa is facing numerous challenges that will hinder the success of the agenda 2030 for sustainable development. Many African countries are affected by hunger, poverty, natural disasters and mass exodus of experienced healthcare workers. If these problems persist most countries will miss their SDG targets by end of 2030. Prediction of under-five mortality rate will guide policies, planning and allocation of resources. The ANN model was applied in this study to predict future trends of under-five mortality rate in Senegal and forecast results indicate that U5MR will continue to decline over the out of sample period. Therefore, the Senegalese government must allocate more resources to the MNCH program and solve all the issues affecting under five children across the country.

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