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Projecting Future Trends of Under Five Mortality Rate for Jamaica Using Artificial Neural Networks

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Abstract **- This study uses annual time series data on under five mortality rate (U5MR) for Jamaica from 1960 to 2020 to predict future trends of U5MR over the period 2021 to 2030. Residuals and forecast evaluation indicate that the applied model is stable in stable in forecasting under five mortality rate. The ANN (12, 12, 1) model projections revealed thatU5MR will continue to decline throughout the out of sample period. Therefore, we encourage the Jamaican government to continue supporting maternal and child health (MNCH) program and address all the challenges that contribute to under five mortality.**

Keywords: ANN, Forecasting, U5MR

I. INTRODUCTION

Tracking progress on achieving sustainable development goals (SDGs) is the responsibility of every UN member state (UN, 2016; UN, 2015). Each country should endeavor to attend to all the major global issues highlighted in the Agenda 2030 for sustainable development. Among them is ensuring good health and promotion of well-being for all at all stages of life (UN, 2020; UNICEF, 2019; WHO, 2019; UNICEF, 2018).Jamaica isa Caribbean island country with an economy largely dependent on tourism (50%)(WHO, 2018). In 2015 the country reported an under 5 mortality rate of 15.7 per 1000 live births, neonatal mortality rate (NMR) was 11.6 deaths per 1000 and Maternal mortality ratio of 89 deaths per 100 000 live births (World Bank, 2019; WHO, 2018). The country's national development plan vision 2030 is an effective policy document that integrates sustainable development goals (SDGs) into the national plan and budget. SDG3 Target 3.2 aims to reduce neonatal and under five mortality rate to at least 12 per 1000 live births and 25 deaths per 1000 live births in every country by 2030 (UN, 2020; UNICEF, 2019; WHO, 2019; UNICEF, 2018). In line with agenda 2030 and the Jamaica's national development plan vision 2030, this study utilizes time series data on U5MR to project future trends of under-five mortality rate for Jamaica using artificial neural networks. We expect the results to guide policy and allocation of resources to MNCH program activities with a goal to prevent under five deaths in the country.

II. LITERATURE REVIEW

Rasmussen *et al.*(2021) investigated the recent figures and explored if potential differences could be explained by the well-known educational and income inequalities in stillbirth and infant death using a novel approach. Stillbirth and infant mortality varied considerably according to country of origin, with only immigrants from China, Norway, and Poland having an overall lower risk than Danish women. Women of Pakistani, Turkish, and Somali origin had a particularly high risk of both outcomes. In another study, Norris *et al*. (2021) examined urban–rural NMR disparities among 21 SSA countries with four or more DHS, at least one of which was before 2000, using the DHS Stat Compiler. For Tanzania DHS 2015–2016, descriptive statistics were carried out disaggregated by urban and rural areas, followed by bivariate and multivariable logistic regression modelling the association between urban/rural residence and neonatal mortality, adjusting for other risk factors. The study concluded that several factors were significantly associated with higher NMR, including multiplicity of pregnancy, being the first child, higher maternal education, and male child sex. In multivariable models, urban residence remained associated with double the odds of neonatal mortality compared with rural. Zeitlin *et al*. (2020) examined the patterns of stillbirth and neonatal mortality rates in Europe between 2004 and 2010. Data about live births, stillbirths and neonatal deaths by gestational age (GA) were collected using a common protocol by the Euro-Peristat project in 2004 and 2010. The study concluded that stillbirths and neonatal deaths declined at all gestational ages in countries with both high and low levels of mortality in 2004. 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.Damian *et al.* (2019) demonstrated that estimates from both global

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metrics and institutional reporting, although widely divergent, indicate South Africa has not achieved MDG 4a and 5a goals but made a significant progress in reducing maternal and neonatal mortality.

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 Jamaica.

Data Issues

This study is based on annual under five mortality rate in Jamaica 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	J
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	0.002474
MSE	0.150588
MAE	0.300773

Residual Analysis for the Applied Model

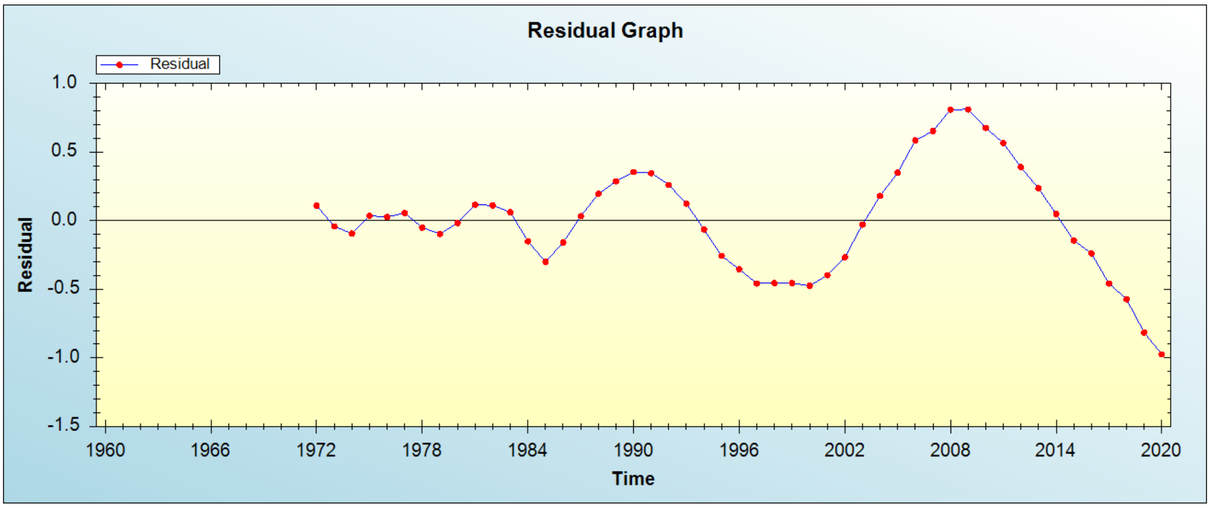

Figure 1: Residual analysis

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In-sample Forecast for J

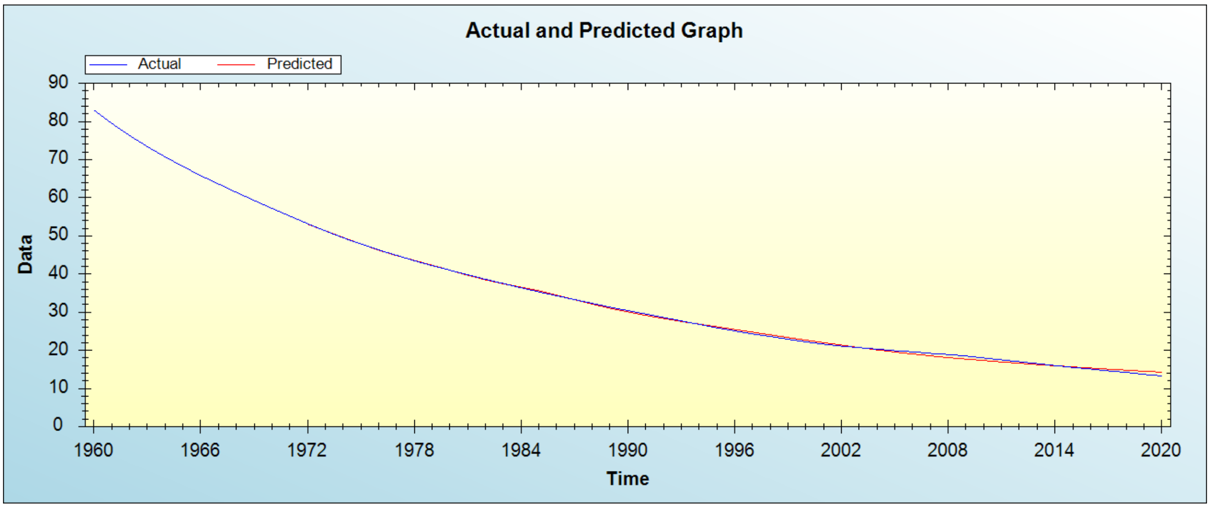

Figure 2: In-sample forecast for the J series

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

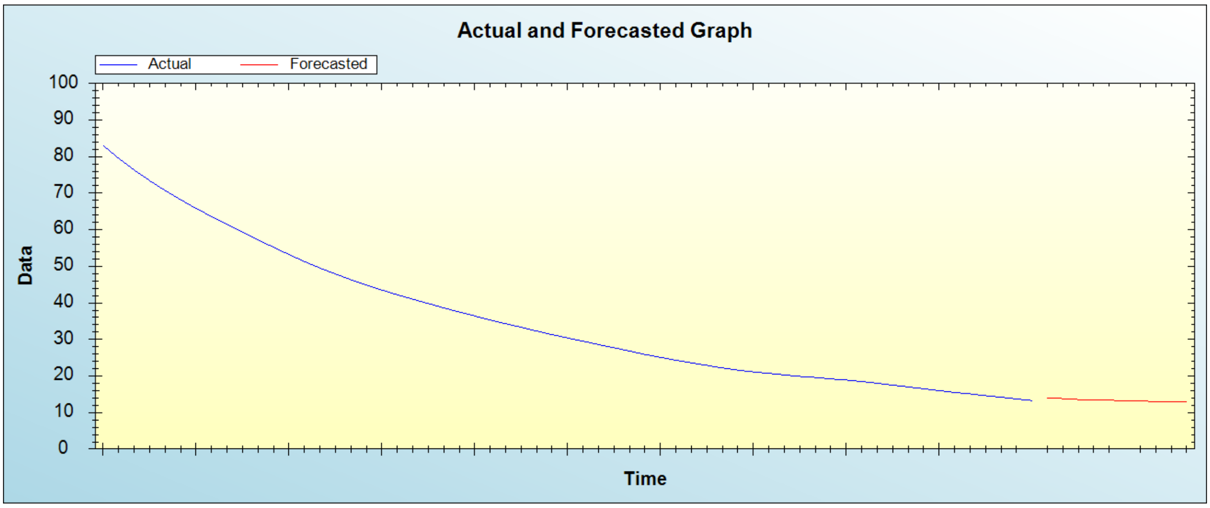

Figure 3: Out-of-sample forecast for J: actual and forecasted graph

Out-of-Sample Forecast for J: Forecasts only

Table 2: Tabulated out-of-sample forecasts

2021	14.0083
2022	13.8185
2023	13.5764
2024	13.4143
2025	13.3964
2026	13.2008
2027	13.1430
2028	13.0378
2029	12.9753
2030	12.8593

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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 continue to decline throughout the out of sample period.

V. POLICY IMPLICATION & CONCLUSION

Machine learning techniques are useful in the prediction of health related events due to their high predictive accuracy. In this study we applied the multilayer perceptron to forecast under five mortality rate for Jamaica. The results of the study showed that U5MR will continue to decline throughout the out of sample period. Therefore, we encourage the Jamaican government to continue supporting the maternal and child health (MNCH) program and address all the challenges that contribute significantly to under five mortality.

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