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Tracking Future Trends of Under Five Mortality Rate for Marshall Islands Using Artificial Neural Networks

[1]Dr. Smartson. P. NYONI, [2]Thabani NYONI

[1]ZICHIRe Project, University of Zimbabwe, Harare, Zimbabwe
[2]Independent Researcher & Health Economist, Harare, Zimbabwe

***Abstract* - This study uses annual time series data on under five mortality rate (U5MR) for Marshall Islands from 1960 to 2020 to predict future trends of U5MR over the period 2021 to 2030. Residuals and model evaluation statistics of the applied ANN (12, 12, 1) model indicate that the model is stable in forecasting under five mortality rate. The ANN model predictions suggest that U5MR will hover around 30 deaths per 1000 live births throughout the out of sample period. Therefore, we encourage authorities in Marshall Islands to address all the existing challenges that may hinder the successful implementation of the maternal and child health program to keep under five mortality below 25 deaths per 1000 live births.**

Keywords: ANN, Forecasting, U5MR.

I. INTRODUCTION

learning (ML) approaches are increasingly becoming predominant in the field of human medicine. The scientific concept of machine learning was derived from Allan Turing in the 1950s who started the idea of artificial intelligence (AI). Artificial intelligence is a scientific discipline having its roots anchored in mathematics, physics and computer science (Park *et al.* 2019; Panch *et al.* 2018). Allan Turing analyzed the physiological function of the human brain and he came up with an idea of computers performing tasks after getting experience or examples similar to the function of the human brain. Different computer programs or algorithms perform specific tasks like regression analysis, time series prediction, pattern recognition and automation of processes. Examples of machine learning algorithms include artificial neural networks, support vector machine, decision trees and Bayesian networks (Zhao *et al.* 2020; Nyoni *et al.* 2020; Topol, 2019; Kaushik & Sahi, 2018; Lee *et al.* 2017).In this study we applied the artificial neural network approach to forecast future trends of under-five mortality rate for Marshall Islands. The results are envisioned to guide policies, planning and allocation of resources to MNCH programs with the aim of ending all preventable under five deaths.

II. LITERATURE REVIEW

Harpur *et al.* (2021) investigated trends in infant mortality rates (IMR) and stillbirth rates by socio-economic position (SEP) in Scotland, between 2000 and 2018, inclusive. Data for live births, infant deaths, and stillbirths between 2000 and 2018 were obtained from National Records of Scotland. Annual IMR and stillbirth rates were calculated and visualized for all of Scotland and when stratified by SEP. Negative binomial regression models were used to estimate the association between SEP and infant mortality and stillbirth events, and to assess for break points in trends over time. The study revealed that IMR fell from 5.7 to 3.2 deaths per 1000 live births between 2000 and 2018, with no change in trend identified. Stillbirth rates were relatively static between 2000 and 2008 but experienced accelerated reduction from 2009 onwards. When stratified by SEP, inequalities in IMR and stillbirth rates persisted throughout the study and were greatest amongst the sub-group of post-neonates. 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. Kayode *et al*. (2017) conducted an ecological study which revealed that there is a wide variation in neonatal mortality in SSA. A substantial part of this variation can be explained by differences in the quality of healthcare governance, prevalence of HIV and socioeconomic deprivation. Rhoda *et al*. (2018) reviewed efforts made by the South African government to reduce neonatal mortality. Indications from the study showed that high-impact interventions, providing an adequate number of appropriately

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trained healthcare providers and a more active role played by ward-based community health workers and district clinical specialist teams was pivotal to achieve substantial reduction in neonatal deaths.

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 in Marshall Islands.

Data Issues

This study is based on annual under five mortality rate in Marshall Islands 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	0.001354
MSE	0.132720
MAE	0.302493

Residual Analysis for the Applied Model

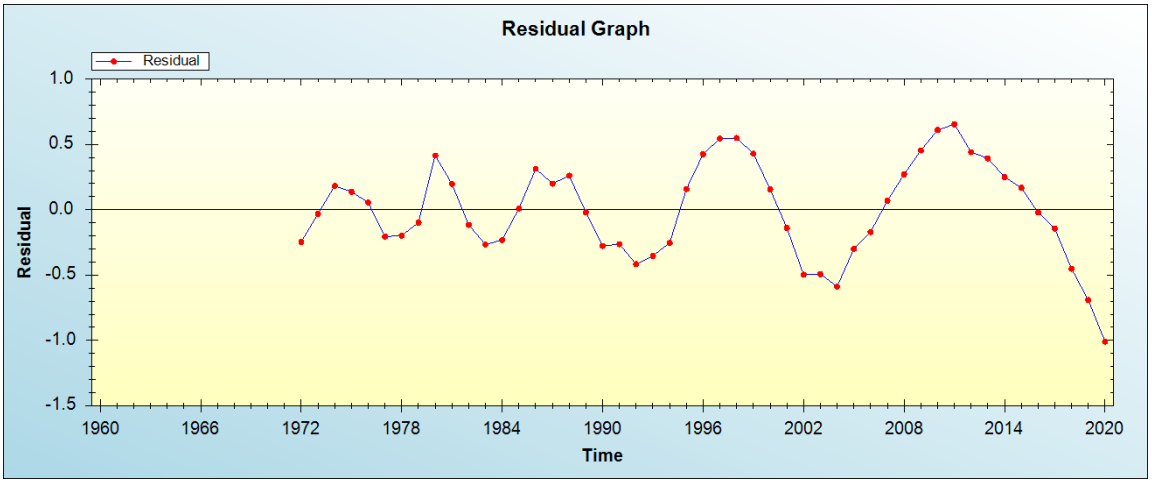

Figure 1: Residual analysis

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In-sample Forecast for V

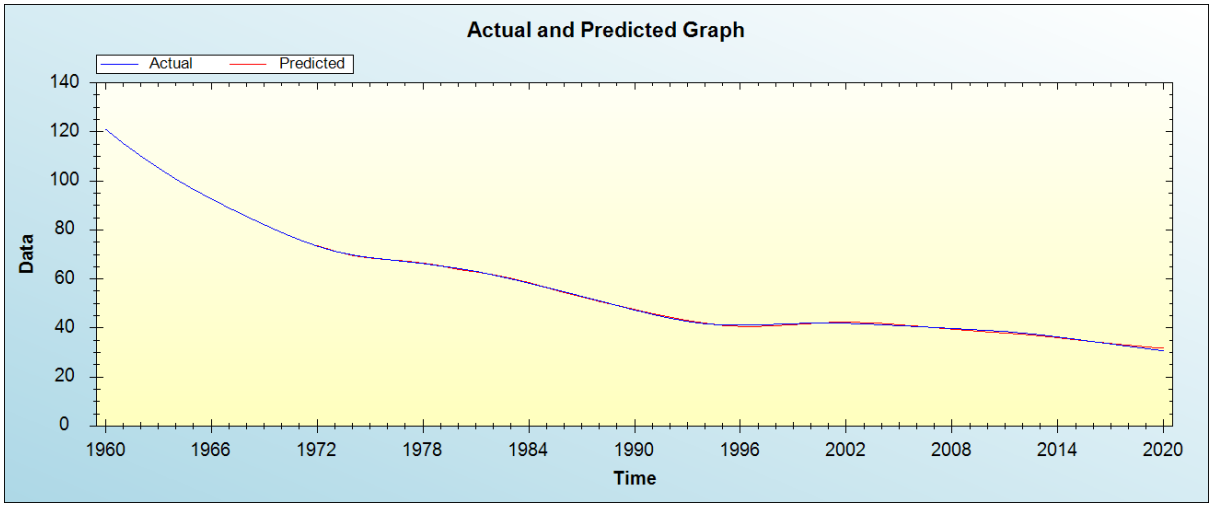

Figure 2: In-sample forecast for the V series

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

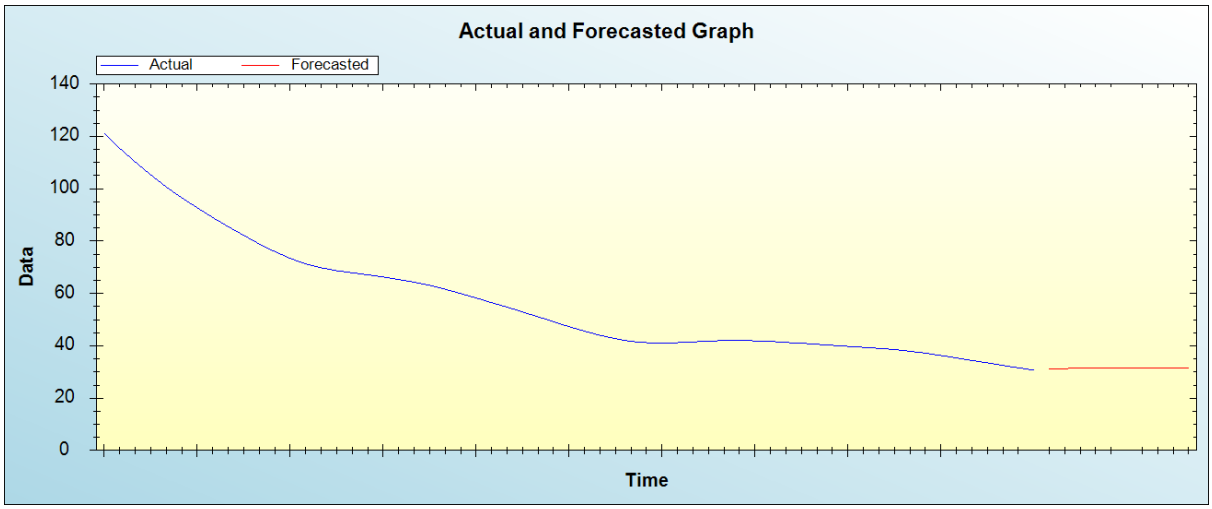

Figure 3: Out-of-sample forecast for V: actual and forecasted graph

Out-of-Sample Forecast for V: Forecasts only

Table 2: Tabulated out-of-sample forecasts

2021	31.1970
2022	31.3141
2023	31.4312
2024	31.4940
2025	31.4695
2026	31.4007
2027	31.4620
2028	31.4491
2029	31.5274
2030	31.5564

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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 hover around 30 deaths per 1000 live births throughout the out of sample period.

V. POLICY IMPLICATION & CONCLUSION

Machine learning approaches are known for their high predictive accuracy and capability of analyzing big data hence we applied the ANN model to predict under five mortality rate in Marshall Islands. The ANN model projections indicate that U5MR will hover around 30 deaths per 1000 live births throughout the out of sample period. Therefore, we encourage authorities in Marshall Islands to address all the existing challenges that may hinder the successful implementation of the maternal and child health program in order to keep under five mortality below 25 deaths per 1000 live births.

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