

# Analysis of Under Five Mortality Rate for Uruguay Using a Machine Learning Approach

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**Abstract** - This study uses annual time series data on under five mortality rate (U5MR) for Uruguay 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. The ANN model projections revealed that annual U5MR will hover around 6 deaths per 1000 live births throughout the out of sample period. Therefore, authorities in Uruguay must continue providing financial support to the maternal and child health program in order to end all preventable under five deaths in the country.

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

## I. INTRODUCTION

The welfare of women and children is always part of every global agenda including the 2030 Agenda for sustainable development (UN, 2016, UN, 2015). They are vulnerable to sexual and physical abuse, hunger, poverty, sickness and death. Most of the times they are victims of circumstances during war and civil conflict (Dejong *et al.* 2017; Devakumar *et al.* 2015; Bhutta *et al.* 2010). All UN member states agreed to respect human rights including sexual and reproductive health rights of women and girls. Every woman has the right to choose a sexual partner of her choice, determine the number of children to have and birth intervals, and use an appropriate family planning method of her choice. Women have the right to education and equal employment opportunities as their male counterparts. SDG3 targets 3.1 and 3.2 concentrate on the welfare of women and children, hence monitoring the relevant indicators will help in assessing the progress made in improving their quality of life (UN, 2020; WHO, 2019; UNICEF, 2019; UNICEF, 2018). This study applies the artificial neural network approach to predict future trends of under-five mortality rate for Uruguay. The results are expected to inform policy, planning and allocation of resources to keep under five mortality under control.

## II. LITERATURE REVIEW

Regression analysis was employed by Jawad *et al.* (2021) to assess the association between conflict and maternal and child health globally. Data for 181 countries (2000–2019) from the Uppsala Conflict Data Program and World Bank were analyzed using panel regression models. The study findings showed that armed conflict is associated with substantial and persistent excess maternal and child deaths globally. Weiland *et al.* (2021), in Portugal, examined the effects of the 2006 National Program of Maternal and Neonatal Health policy on spatial inequalities in access to care and consequently avoidable infant mortality. A thematic analysis of qualitative data including interviews and surveys and a quantitative spatial analysis using Geographic Information Systems was applied. Spatial inequalities were found which may lead to avoidable infant mortality. Inequalities exist in freedom of choice and autonomy in care, within a medicalized system. 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. 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. 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.

### 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 Uruguay.

#### Data Issues

This study is based on annual under five mortality rate in Uruguay 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	
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	0.002799
MSE	0.099762
MAE	0.241557

#### Residual Analysis for the Applied Model

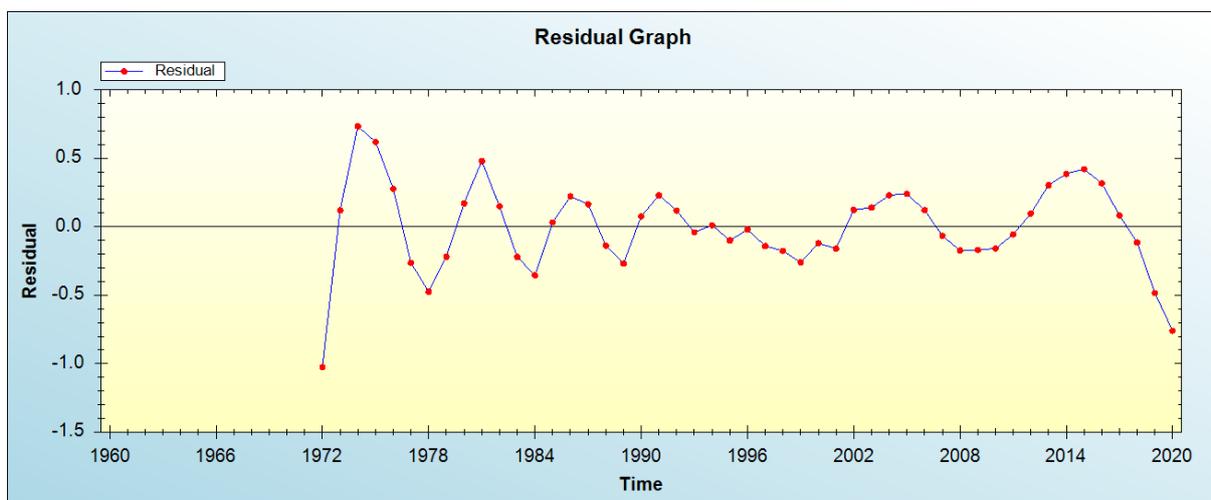


Figure 1: Residual analysis

In-sample Forecast for C

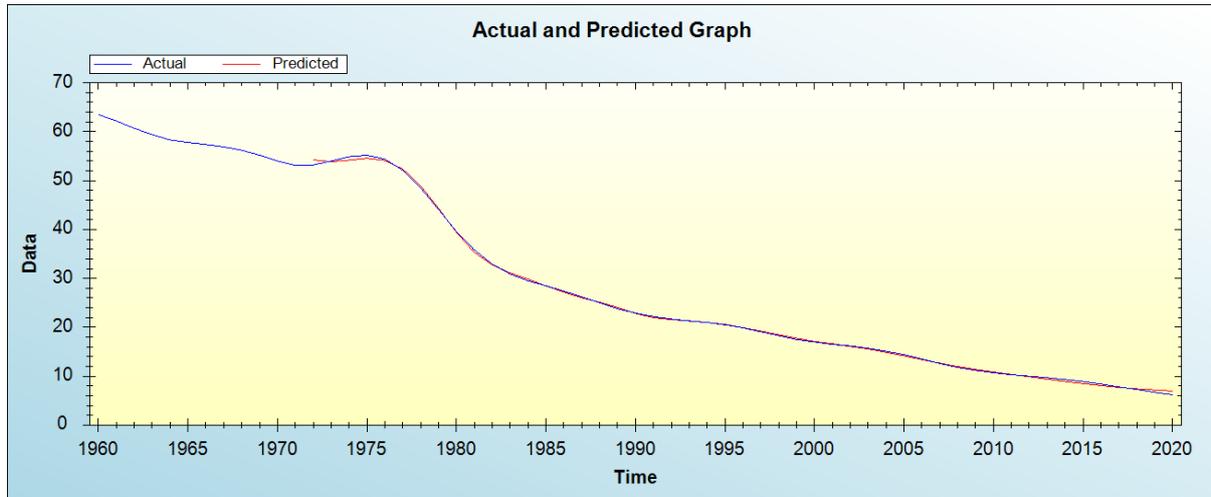


Figure 2: In-sample forecast for the C series

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

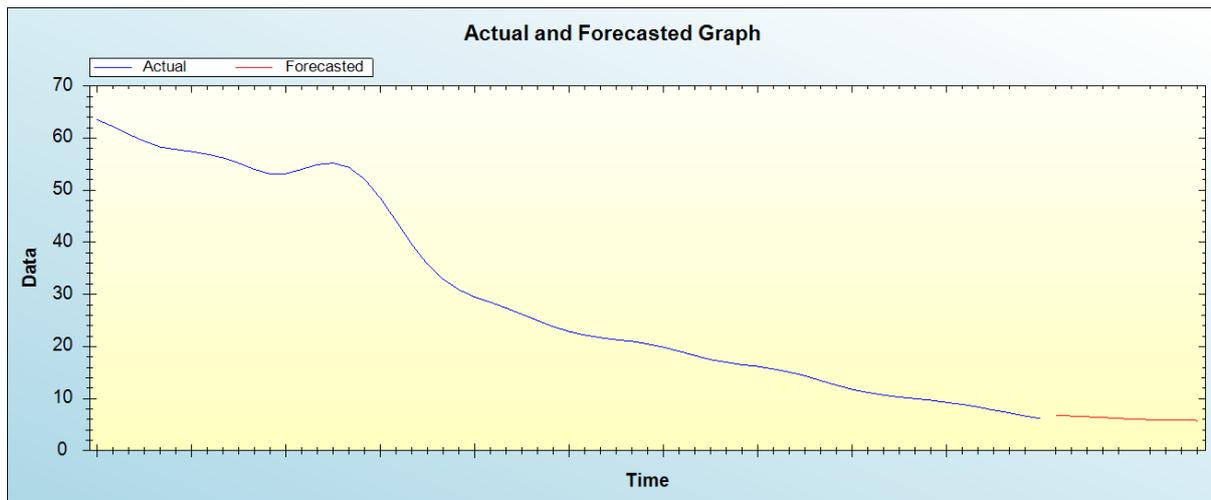


Figure 3: Out-of-sample forecast for C: actual and forecasted graph

Out-of-Sample Forecast for C: Forecasts only

Table 2: Tabulated out-of-sample forecasts

2021	6.7593
2022	6.6851
2023	6.5303
2024	6.3954
2025	6.2011
2026	6.0660
2027	5.9628
2028	5.9709
2029	5.8895
2030	5.8019

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 6 deaths per 1000 live births throughout the out of sample period.

## V. POLICY IMPLICATION & CONCLUSION

Millions of children in Sub-Saharan Africa and Asia are suffering from hunger, poverty and malnutrition. Developed countries on the hand have done very well in controlling under five mortality as a result of strong healthcare systems. However, neonatal mortality remains a challenge in many first world countries therefore new strategies must be implemented to address this problem. In this study we applied the ANN model to project the future path of under-five mortality rate in Uruguay and forecast results indicated that annual U5MR will hover around 6 deaths per 1000 live births throughout the out of sample period. Therefore, we encourage authorities in Uruguay to continue providing financial support to the maternal and child health program in order to end all preventable under five deaths in the country.

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### Citation of this Article:

Dr. Smartson. P. NYONI, Thabani NYONI, “Analysis of Under Five Mortality Rate for Uruguay Using a Machine Learning Approach” Published in *International Research Journal of Innovations in Engineering and Technology - IRJIET*, Volume 6, Issue 7, pp 537-540, July 2022. Article DOI <https://doi.org/10.47001/IRJIET/2022.607120>

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