Thailand's Success Story in Controlling under Five Mortality: Evidence from a Machine Learning Algorithm

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Abstract - **This study uses annual time series data on under five mortality rate (U5MR) for Thailand 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 model is stable in forecasting under five mortality rate. ANN model projections revealed thatU5MR will remain below 10 deaths per 1000 live births throughout the out of sample period. Therefore, we encourage the Thai government to attend to all the challenges that affect the quality of child healthcare services across the country.**

Keywords: ANN, Forecasting, U5MR.

I. INTRODUCTION

The main pillars of a public health program are service delivery, transport, logistics and supply, quality assurance, monitoring and evaluation, support and supervision, administration and finance. When planning and budgeting it is critical for public health specialists to ensure adequate allocation of resources to all the pillars (Gergen *et al.* 2017; Kandpal, 2016; Basinga *et al.* 2011). In addition, it is important to incorporate sustainable development goals (SDGs)into national budgets and plans (UN, 2016; UN, 2015). The global sustainable development goals are there to help governments to attend to the various challenges such as poverty, hunger, gender inequalities, human rights abuses, diseases, lack of education, unemployment and economic problems.

The maternal and child health program in various regions of the world has brought good results as most countries at least have managed to report a downward trajectory of maternal, neonatal and under five mortality. However, the absolute numbers of these deaths still remain very high particularly in Sub-Saharan Africa and South Central Asia (UNIGME report, 2017; UNIGME report, 2014). The major causes of mortality are predominantly preventable and are categorized into demographic, social, cultural, economic and health system related factors (Lang *et al.* 2018; Mattern, 2017; Morris *et al.* 2014). Home deliveries, long distances from health facilities and poor road infrastructure are among the factors that have contributed significantly to maternal and under five mortality in low and middle income countries (Madagascar, 2018). Sustainable development goal 3(SDG 3) target 3.1 and target 3.2 are meant to address maternal, neonatal and under five mortality in developing and developed countries. The expected outcome is a significant decline in mortality of neonates and under five children to as low as 12 deaths per 1000 live births and 25 deaths per 1000 live births respectively by 2030, and global maternal mortality should drop to levels beneath 70 deaths per 100 000 live births by 2030 (UN, 2020; WHO, 2019; UNICEF, 2019;IOM, 2019; UNFPA, 2018; UNICEF, 2018;Gulmezoglu *et al.* 2016).

The aim of this study is to forecast future trends of under-five mortality rate in Thailand using the artificial neural network approach. We expect the findings of this study to assist in child health policy making, planning and allocation of resources to MNCH program activities in order to keep under five mortality under control.

II. LITERATURE REVIEW

Li *et al.* (2021) examined the proportion of mothers with history of neonatal deaths using the most recent Demographic and Health Surveys from 56 low- and middle-income countries. Logistic regression models were used to assess the association between maternal history of neonatal death and subsequent neonatal mortality. The adjusted models controlled for socioeconomic, child, and pregnancy-related factors. Country-specific analyses were performed to assess heterogeneity in this association across countries. Study findings indicated that maternal history of neonatal death could be an effective early identifier of high-risk pregnancies in resource-poor countries. In another study by Khader *et al.* (2021) explored the healthcare professionals' perception about the usability of JSANDS. A descriptive qualitative approach, using focus group discussions, was adopted. A total of 5 focus groups including 23 focal points were conducted in five participating hospitals in Jordan. The study findings revealed that JSANDS was perceived positively by the current users. According to them, it provides a formative and comprehensive data on stillbirths and neonatal deaths and their causes. Masaba & Phetoe (2020) described the trends of neonatal mortality within the two sub-Saharan countries. The authors found out 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.

Gayawan *et al*. (2016) examined the residual geographical variations in infant and child mortality and how the different categories of the risk factors account for the spatial inequality in West African countries. Authors pooled data for 10 of the countries extracted from Demographic and Health Surveys and used the spatial extension of discrete-time survival model to examine how the variables exert influence on infant and child mortality across space. Inference was Bayesian based on the computational efficient MCMC technique. They found different geographical patterns for infant and child mortality. In the case of children under five, demographic factors inherent to the mother and child as well as maternal status variables when explained away a good part of the huge variations observed in the crude rates.

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 Thailand.

Data Issues

This study is based on annual total under five mortality rate in Thailand 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	0.000513
MSE	0.117099
MAE	0.275061

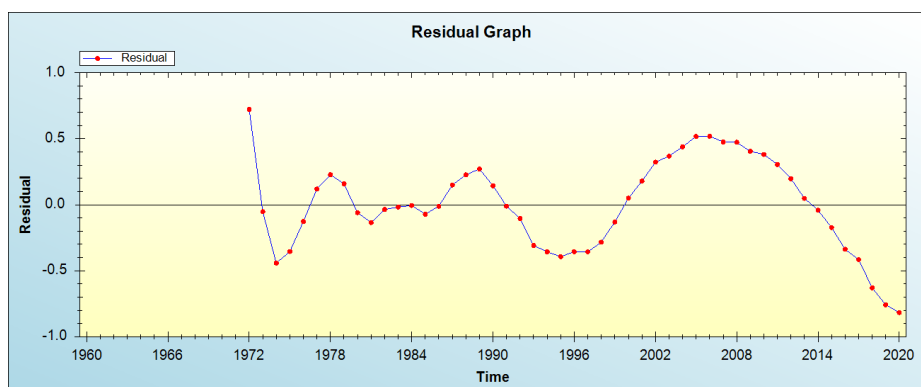Residual Analysis for the Applied Model

Figure 1: Residual analysis
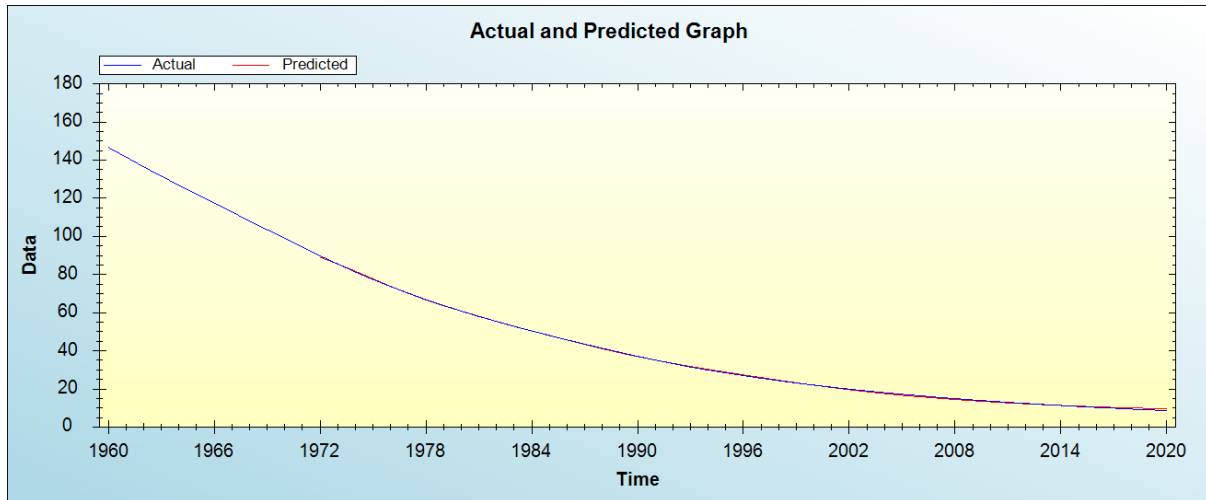
In-sample Forecast for Z

Figure 2: In-sample forecast for the Z series

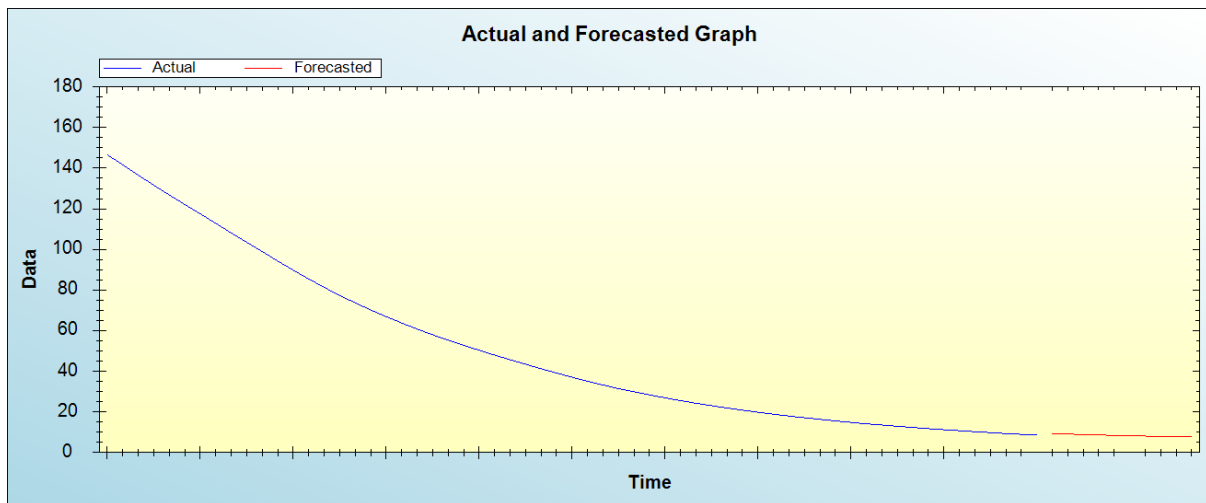Out-of-Sample Forecast for Z: Actual and Forecasted Graph

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	9.2971
2022	9.1485
2023	8.9223
2024	8.6935
2025	8.5071
2026	8.3074
2027	8.1644
2028	8.0097
2029	7.9394
2030	7.9111

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 below 10 deaths per 1000 live births throughout the out of sample period.

V. POLICY IMPLICATION & CONCLUSION

Planning is essential for any public health program. Inclusion of sustainable development goals in national plans and budgets is equally important to accelerate the implementation of SDGs. This study applied the ANN model to forecast future trends of under-five mortality for Thailand. The results of the study indicate thatU5MR will remain below 10 deaths per 1000 live births throughout the out of sample period. Therefore, we encourage the Thai government to attend to all the challenges that affect the quality of child healthcare services across the country.

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