

DETERMINATION OF ANNUAL MATERNAL MORTALITY RATE FOR MALDIVES USING A MACHINE LEARNING APPROACH

Smartson. P. NYONI¹

Thabani NYONI²

¹Independent Researcher & Medical Doctor, Harare, Zimbabwe

²Independent Researcher & Health Economist, Harare, Zimbabwe

ABSTRACT

This research article employs annual time series data on MMR for Maldives from 1985 to 2023 to predict future trends of MMR over the period 2024 to 2035. The forecast evaluation criteria of the applied model indicate that the ANN (12, 12, 1) model is stable. The neural network model projections revealed that MMR will hover around 43 deaths per 100 000 live births throughout the out of sample period. Therefore, we encourage the government to address local causes of preventable maternal deaths and continue routine surveillance of severe maternal morbidity.

Keywords: ANN, Forecasting, Maternal Mortality Ratio

INTRODUCTION

Maternal mortality is a worldwide public health issue of concern which requires international collaboration because its negative consequences on the family, community and nation are both immediate and long term. Nearly 800 women die each day from preventable causes related to pregnancy or childbirth (WHO, 2023). Hemorrhage, hypertensive disorders, and sepsis are responsible for over 50% of maternal deaths worldwide (Khan et al. 2006). In Sub-Saharan Africa, 65% of maternal deaths from obstetric bleeding that takes place after delivery (Campbell et al. 2006; Li et al, 1996). Maternal mortality affects low-middle countries more than the developed countries. The burden remains high in low-and middle-income countries (LMICs), with 95% of the burden of maternal mortality and the majority of deaths occurring in sub-Saharan Africa (SSA) (WHO, 2023). According to the WHO, at the global level, the maternal mortality ratio in 2020 was estimated at 233 per 100,000 live births (WHO, 2020). However, during the recent years, a significant decline of maternal mortality ratio at the global level was noted, with a reduction of 34.3% between 2000 and 2020, an average rate of reduction of 2.9% per year (WHO, 2023; WBG, 2023; WHO, 2020). The objective of this paper is to model and forecast MMR for Maldives using a machine learning approach. The research findings are expected to guide planning and allocation of resources to the health in order to further reduce preventable maternal mortality.

LITERATURE REVIEW

Author(s)	Objective(s)	Methodology	Main finding(s)
Tsushima et al. (2026)	To determine the long-term incidence of dysglycemia and dyslipidemia after GDM and evaluated whether postpartum changes in body mass index (BMI) independently predicted these outcomes.	Prospective cohort study	Postpartum BMI increase was independently associated with new-onset dysglycemia. No independent predictor of T2DM progression was identified. Dyslipidemia was independently associated with higher pre-pregnancy BMI and multiparity, whereas postpartum BMI change was not independently associated after multivariable adjustment
Yue et al. (2026)	to perform an umbrella review to summarize the current evidence to provide a reference for clinicians and future research	Systematic review	Positive aPLs significantly increased the risk of miscarriage rate in assisted reproductive technology (ART) and were also associated with total fetal loss, PE, intrauterine growth retardation and placental abruption
Nunn et al. (2025)	To explore whether changes in key characteristics among Victorian Aboriginal and/or Torres Strait Islander women contributed to reduced perinatal death rates	Retrospective population-based cohort study of all births in Victoria from 2000–2019	Changes in key maternal characteristics may have contributed to improved perinatal death rates among babies of Victorian Aboriginal and/or Torres Strait Islander women
Haninger-Va cariu et al. (2024)	To describe pregnancy and delivery outcomes in women with Fabry disease	Retrospective cohort-study of women with Fabry disease in Austria using a specific questionnaire and the Austrian Mother–Child Health Passport	The cohort-study in women with Fabry disease showed an increase of pain burden during pregnancies and clearly points to an increased risk for preeclampsia, prematurity, and neonates small for gestational age. With a substantial number of high-risk pregnancies, neonatal outcomes are somewhat worse in Fabry disease than in the general public
Kornyicki & Fedor (2024)	to publish findings on the lifestyle factors of pregnant women in Hungary and their impact on early childhood health status by examining changes over time and regional/geographical disparities	Secondary analysis of raw indicators reported by health visitors as per mandatory annual report data for the period of 1997–2019 in Hungary	Interventions to improve early childhood health in some counties of Hungary are urgently needed to reduce regional disparities

Diguisto et al. (2022)	To compare maternal mortality in eight countries with enhanced surveillance systems	Descriptive multi-country population-based study	Variations in maternal mortality ratios exist between high income European countries with enhanced surveillance systems
Wami et al. (2022)	To explore both real maternal and fetal-neonatal characteristics associated with Hungarian homebirths	Retrospective cohort study	Aggregated maternal complications (primary uterine inertia, prolonged second stage labor, and third stage hemorrhage) were prevalent among homebirth cases (1.29% vs. 0.72%, $p < 0.05$) and were associated with an average of 11.77% rate of transfer to a health care institution. On the other hand, the rate of operative (vaginal or caesarean) delivery was 26.31% among institutionalized births
Schildberger et al. (2017)	To investigate the personal meanings and experiences of women with disabilities in regard to pregnancy, childbirth and the puerperium	Conducted semi-structured interviews	Participants reported limited acceptance of their life decisions and experienced an environment of discriminatory attitudes. They experienced a lack of support and lack of confidence in their parenting abilities, which negatively influenced their self-efficacy and self-awareness. Violations of personal borders and a feeling of being watched and controlled were reported

METHODOLOGY

The Artificial Neural Network (ANN) approach, which is flexible and capable of nonlinear modelling; 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 maternal mortality ratio (MMR) for Maldives.

Data Issues

This study is based on annual MMR in Maldives for the period 1985 – 2023. The out-of-sample forecast covers the period 2024 – 2035. All the data employed in this research paper was gathered from the World Bank online database.

Findings of the study

ANN Model Summary

Table 1: ANN model summary

Variable	M
Observations	27 (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	0.004235
MSE	25.590051
MAE	3.579772

Residual Analysis for the Applied Model

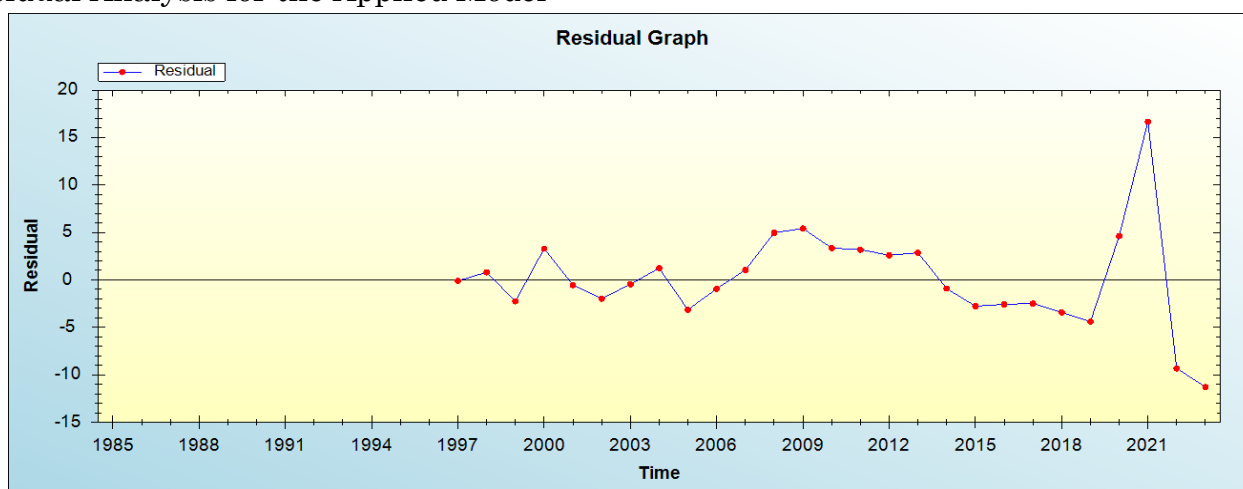


Figure 1: Residual analysis

In-sample Forecast for M

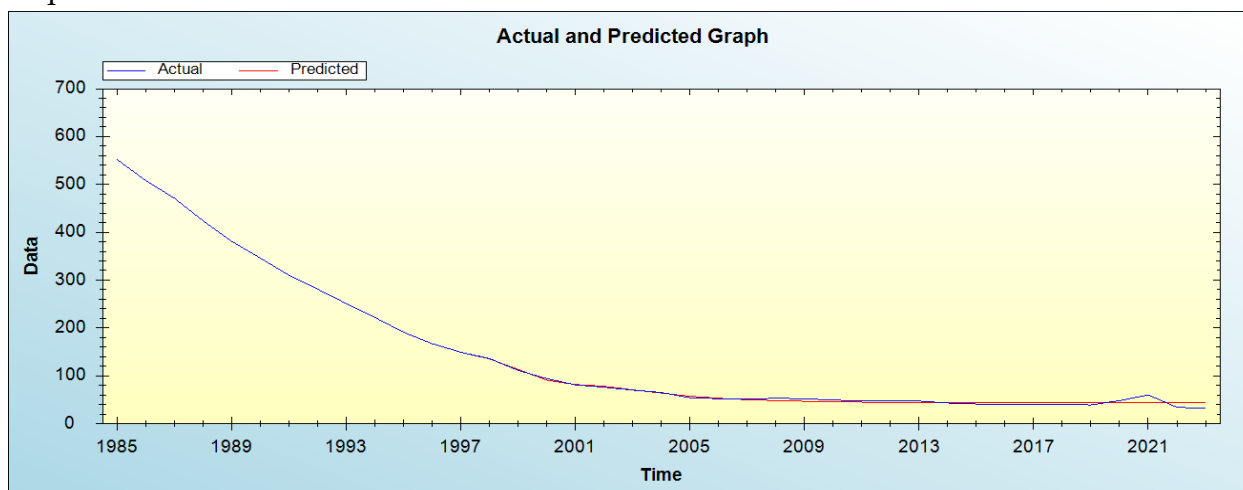


Figure 2: In-sample forecast for the M series

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

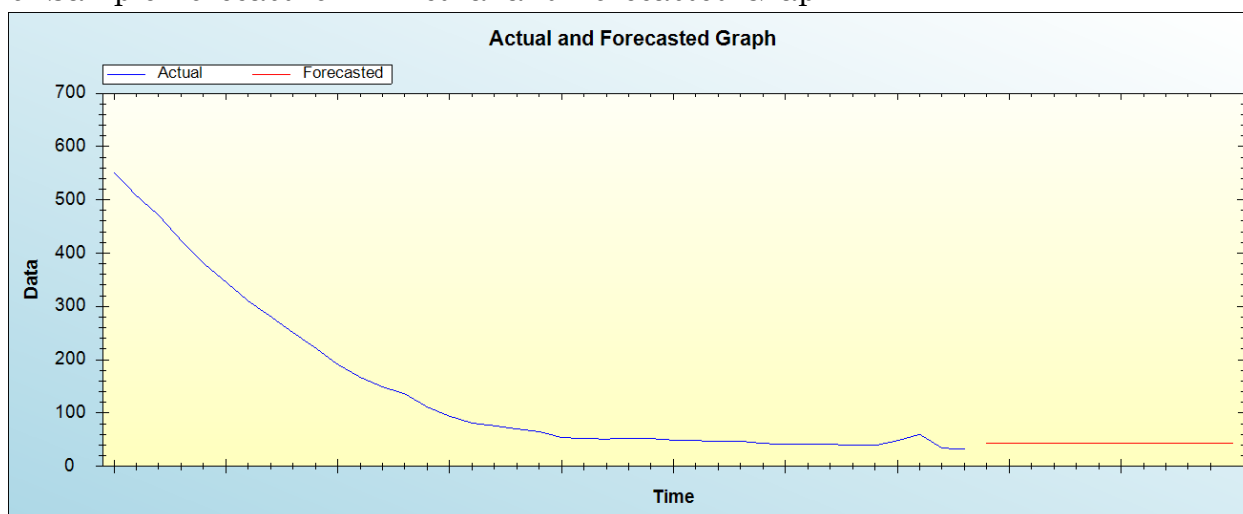


Figure 3: Out-of-sample forecast for M: actual and forecasted graph

Out-of-Sample Forecast for M: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Year	Forecasted MMR
2024	43.2613
2025	43.3491
2026	43.1492
2027	43.1969
2028	43.1538
2029	43.1505
2030	43.3066
2031	43.2243
2032	43.3021
2033	43.2825
2034	43.1111
2035	43.1635

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 MMR will hover around 43 deaths per 100 000 live births throughout the out of sample period.

RECOMMENDATIONS & CONCLUSION

This paper uses a machine learning method to forecast MMR for Maldives and findings indicate that MMR will hover around 43 deaths per 100 000 live births throughout the out of sample period. Hence, we encourage authorities to attend to local causes of maternal deaths and continue routine reporting of severe maternal morbidities.

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