

PREDICTION OF MATERNAL MORTALITY FOR IRAN USING A MACHINE LEARNING APPROACH

Smartson. P. NYONI ¹

Thabani NYONI ²

¹Independent Researcher & Medical Doctor, Harare, Zimbabwe

²Independent Researcher & Health Economist, Harare, Zimbabwe

ABSTRACT

This research article employs annual time series data on MMR for the Islamic Republic of Iran 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 24 deaths per 100 000 live births throughout the out of sample period. Therefore, we encourage the government to relentlessly address local causes of maternal deaths.

Keywords: ANN, Forecasting, Maternal Mortality Ratio.

INTRODUCTION

The WHO defines maternal death as the demise of a woman while pregnant or within 6 weeks of termination of pregnancy, from any cause related to or aggravated by the pregnancy or its management, but not from accidental or incidental causes (Rahimi et al. 2019). The Maternal Mortality Ratio (MMR) is a relevant indicator of health and socio-economic status that shows the overall quality and effectiveness of health policies, healthcare services, and women's health status in society (Najafian et al. 2025). In addition, MMR is an essential indicator of a country's overall health and is reflected in its health infrastructure (Pouyanfar et al. 2022; Jenabi & Khazaei, 2019; Isogai & Kamiya, 2019). WHO data highlighted that MMR in the Islamic Republic of Iran dropped from 48 to 16 per 100,000 live births over the period 2000-2017, indicating an annual decline of close to 6.3 percent (Khalili et al. 2023). A round 80 percent of pregnancy-related mortality is directly linked to complications of pregnancy, childbirth, the postpartum period, and inappropriate interventions or treatments (Khalili et al. 2023; Karimi-Zarchi et al. 2016). Maternal deaths due to pregnancy complications are mainly caused by factors like increased maternal age, inequality in access to health services, and a higher prevalence of chronic diseases (Howell, 2018; Nyfløt & Sitras, 2018). However, data from government maternal mortality review committees highlight that many of the risk factors in this area are preventable. Evidence shows that higher risks of maternal mortality are influenced by factors such as low education, lack of prenatal care visits, cesarean delivery, hemorrhage, and high blood pressure (Diana et al. 2020; Bauserman et al. 2015).

The objective of this study is to model and forecast future trends of MMR for Indonesia using a machine learning approach. The study findings are expected to inform policy, planning and allocation of resources to the maternal and child health program. The ultimate goal is to reduce further preventable maternal deaths.

LITERATURE REVIEW

Author (s)	Objective(s)	Methodology	Main finding(s)
Babaey et al. (2025)	To analyze policies and interventions aimed at reducing maternal mortality in Iran	Qualitative study	This analysis demonstrates that policies and interventions within the Iranian health system have significantly reduced maternal mortality
Cresswell et al. (2025)	To obtain updated evidence on causes of maternal death to accelerate SDG progress	conducted a multi-strategy systematic review to identify causes of maternal deaths occurring in 2009–20	Hemorrhage remains the leading cause of death, despite the existence of effective clinical interventions, emphasizing the need for improved access to quality health care
Kama et al. (2025)	to establish the period prevalence of MNM and mortality index, and to compare near-miss cases with maternal mortality and to identify their risk factors and causes	Cross-sectional study	The leading causes of MNM were eclampsia (47.8%), abruptio placentae (19.7%) and postpartum hemorrhage (8.3%), and the leading causes of maternal death were eclampsia (29.2%), puerperal sepsis (25%) and postpartum hemorrhage (12.5%)
Najafian et al. (2025)	to identify the causes and risk factors associated with maternal mortality in Ahvaz, Iran, to inform targeted interventions	A case-control study was conducted in Ahvaz from 2017 to 2023, involving 100 cases of maternal deaths and 117 controls (mothers with successful pregnancies)	maternal mortality in Ahvaz is largely influenced by preventable factors such as anemia, hypertension, preeclampsia, and hemorrhage. Additionally, low education and limited access to healthcare services played a significant role in this issue
Sadoughi et al. (2025)	to design an evaluation model for the National Maternal Mortality Surveillance System (MMSS) in Iran	mix method study which was carried out in four phases	The obtained model includes four axes: (a) the description of the surveillance system (b) the general evaluation planning (c) implementation of the evaluation and (d) post-evaluation follow-ups. Some components of this model are: the purpose and operation of the system, triggers, purpose and objectives of the evaluation, data collection methods and tools, the method of

			presenting the findings and giving feedback
Bhalotra & Clarke (2024)	to investigate the association of women's education with maternal and child mortality	Panel regression	moving an additional 1 percentage point of women into primary education reduces rates of maternal death by 4.6%, and reduces the rate of infant deaths by 1.9%
Duka et al. (2024)	to quantify the inequalities in the distribution of nurses in Albania, analyzing the nurse-to-population ratio and its impact on the quality of healthcare	Descriptive analytic study	The average nurse-to-population ratio in Albania is 28 nurses per 10,000 inhabitants, with significant variations between regions. Tirana has the highest ratio (60 nurses per 10,000 inhabitants), while Kukës and Dibër have the lowest values (10 per 10,000 inhabitants)
Huda et al. (2024)	to assess process of registering maternal deaths in Iraq and identifying the main causes of death	A cross-sectional study was performed at Iraq Ministry of Health, in which all maternal death records were reviewed. Data concerning demographic characteristics, obstetrical history, and registration process was collected and analyzed using SPSS program	A total of 942 maternal deaths were reviewed, the highest (360 deaths) (Maternal Mortality Ratio 28/100000 live births), registration form was not available in 20.8%. Postpartum hemorrhage was the commonest cause of death (35.1), followed by pulmonary embolism (26.1) and hypertension (15.5). Notification was done in (311; 33.01%) and maternal mortality committee meeting was conducted in 258 (27.4%) of cases
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. In-depth analyses of differences in the quality of care and health system performance at national levels are needed to reduce maternal mortality further by learning from best practices and each other
Pouyanfar et al. (2022)	to investigate the factors affecting the maternal	Systematic review	The leading causes of maternal death were hemorrhage (43.7%),

	mortality ratio (MMR) in different regions of Iran		preeclampsia/eclampsia (24.5%), other hypertensive disorders (24%), and embolism (22.8%)
Gabrani et al. (2020)	to identify key factors influencing the utilization of governmental and private primary healthcare services in Albania	cross- sectional health facility survey using a 4-point Likert scale questionnaire to rank the importance of factors driving services utilization.	The use of primary healthcare is strongly influenced by geographical and financial access for public facility users and availability of equipment for private users. This study found that aspects of acceptability and adequacy of services are equally valued
Zalvand et al. (2019)	To review determinants and causes of maternal mortalities during pregnancy, delivery and the puerperium using the International Classification of Diseases-Maternal Mortality (ICD-MM), introduced by the World Health Organization	Systematic review	The leading direct and indirect causes of death were identified as hemorrhage (30.7%) and hypertensive disorders (17.1%) and circulatory system diseases (8.1%) respectively. Several factors including gravidity, type of delivery, socio-economic status of mothers, locations of birth, death and maternity care venues were found in the original studies as the most important determinant of maternal mortalities in Iran

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 Iran.

Data Issues

This study is based on annual MMR in Iran 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	R
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	0.082655
MSE	37.565600
MAE	3.156574

Residual Analysis for the Applied Model

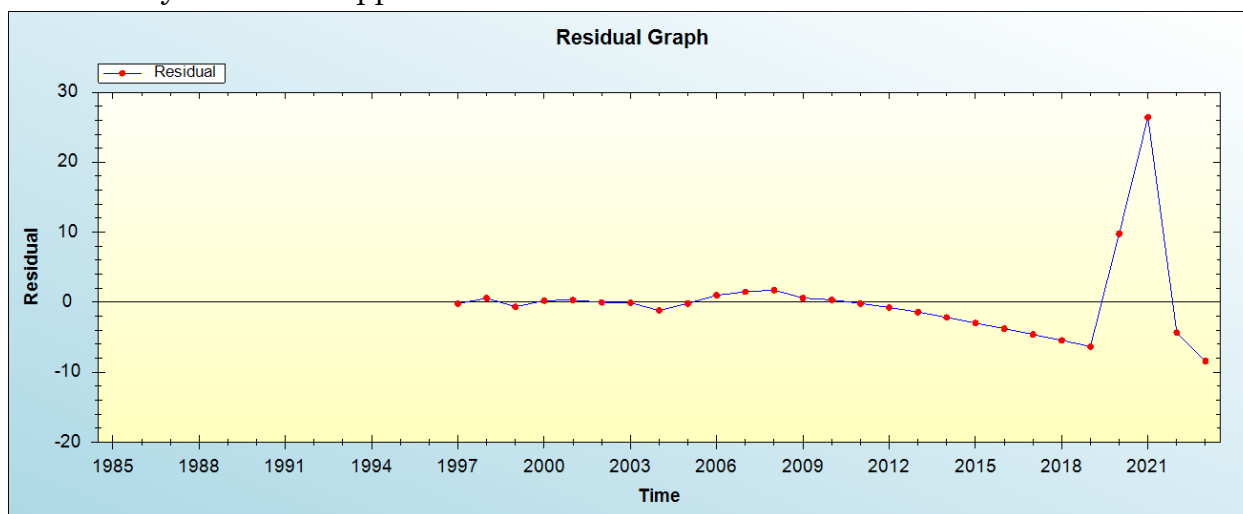


Figure 1: Residual analysis

In-sample Forecast for R

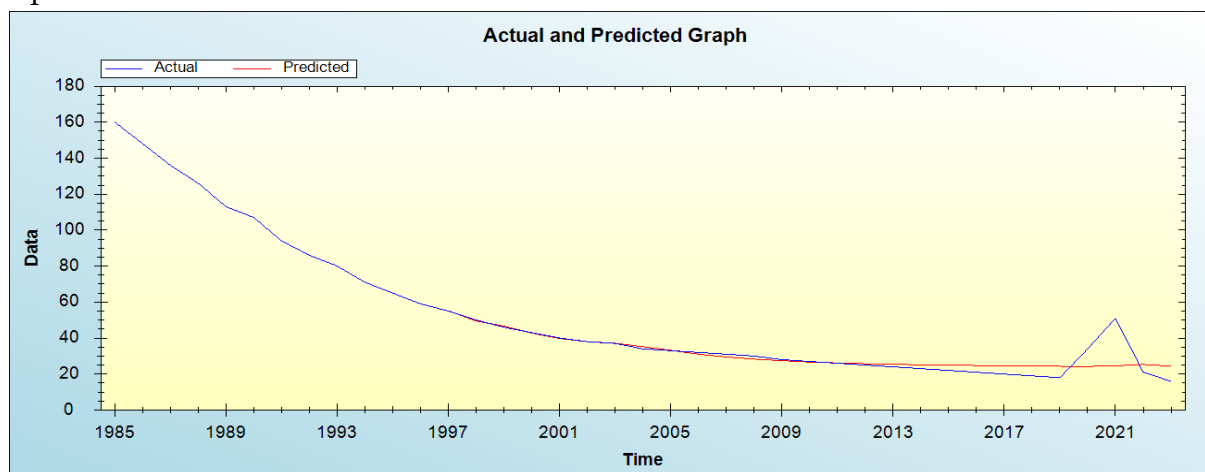


Figure 2: In-sample forecast for the R series

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

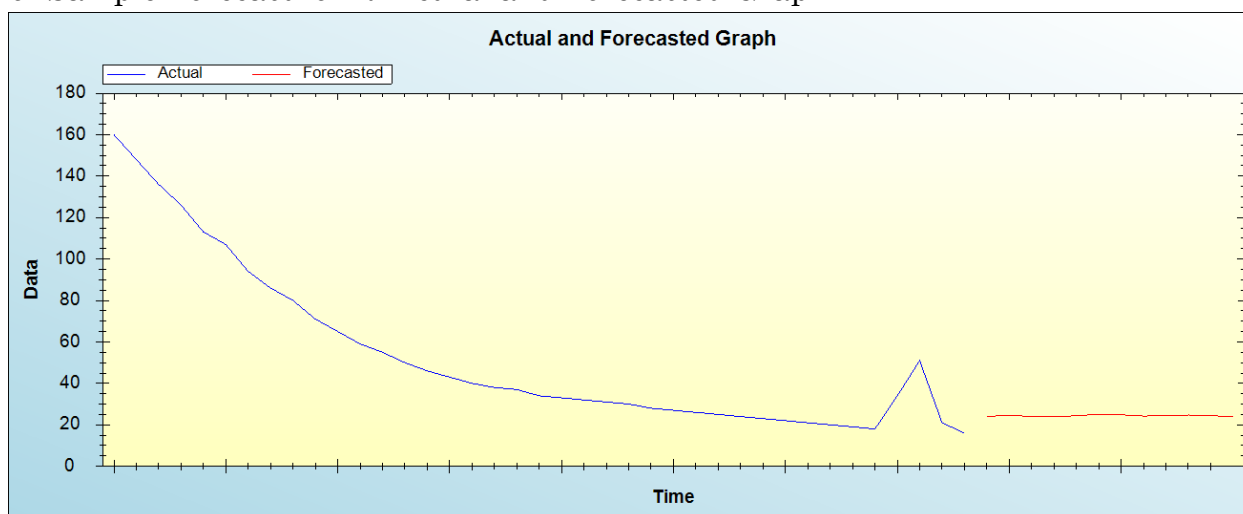


Figure 3: Out-of-sample forecast for R: actual and forecasted graph

Out-of-Sample Forecast for R: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Year	Forecasted MMR
2024	24.1652
2025	24.3962
2026	24.1784
2027	24.0111
2028	24.3242
2029	25.1498
2030	24.8115
2031	24.2275
2032	24.4047
2033	24.7510
2034	24.2944
2035	24.2290

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 24 deaths per 100 000 live births throughout the out of sample period.

RECOMMENDATIONS & CONCLUSION

This study models and forecasts MMR for Iran using a machine learning technique and the results indicate that MMR will hover around 24 deaths per 100 000 live births throughout the out of sample period. Therefore, we encourage Iranian authorities to address major drivers of maternal mortality and to continue routine surveillance of severe maternal morbidities.

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