

Analyzing Maternal Mortality For Ethiopia Using A Machine Learning Technique

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Abstract

This research article employs annual time series data on MMR for Ethiopia 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 190 deaths per 100 000 live births throughout the out of sample period. Therefore, we encourage the government to adopt the suggested 5-fold policy prescription.

Keyword(s): - ANN, Forecasting, Maternal Mortality Ratio

Introduction

During the previous two decades, Ethiopia made significant strides in lowering death rates across the country (UN, 2019). Since 2000, under-five mortality rates declined every year by an average of 5% (UNICEF, 2022; UN, 2019). Despite this remarkable progress, premature mortality remains high, including high maternal (Ministry of Health Ethiopia, 2021; WHO, 2019), neonatal, and under-five mortality (EPHI & ICF, 2021), mainly in the rural areas where more than 80% of Ethiopians live. Access to medical care (Ministry of health Ethiopia, 2021; Centre of excellence for CVRVS systems, 2019) and public health services is particularly low in rural areas (Ministry of health Ethiopia, 2021). Most deaths occur outside health facilities (Mekonnen et al. 2024).

The objective of this paper is to model and forecast MMR for Ethiopia using a machine learning technique. The study findings are anticipated to reveal likely future trends of MMR across the country with a view of implementing appropriate measures to further reduce maternal deaths in the country.

Literature Review

Author(s)	Objective(s)	Methodology	Main finding(s)
Ilboudo et al. (2023)	To examine the effects of this policy on the use of services, health outcomes, and removal of costs.	Interrupted time-series regressions were used to investigate the effects of the policy on the use of health services and health outcomes. In addition, an analysis of household expenditures was conducted to assess the effects of spending on delivery, care for children, and other exempted (antenatal, postnatal, etc.) services on household expenditures	the user fee removal policy significantly increased the use of healthcare facilities for child consultations and reduced mortality from severe malaria in children under the age of five years. It also has increased the use of health facilities for assisted deliveries, complicated deliveries, and second antenatal visits, and reduced

			cesarean deliveries and intrahospital infant mortality, although not significantly
Izedonmwene & Izedonmwene (2023)	to assess maternal mortality rates, risk factors, and related variables in Ethiopia	Systematic review	the research found large regional variations in maternal mortality rates, with obstructed labor, postpartum hemorrhage, and hypertensive disorders of pregnancy emerging as the main risk factors. Disparities in education, age, living in remote areas, and restricted access to antenatal care services were secondary concerns
Rahman et al. (2022)	To analyze ANC visits among adolescent and adult mothers.	Using all available Demographic and Health Survey and Multiple Indicator Cluster Surveys between 2000 and 2019 in 54 LMICs, we estimated proportion of ANC visits among women. Bayesian hierarchical regression models were used to estimate trend, projection, and determinants of single and four ANC visits (ANC1 and ANC4) independently	Determinant analysis found increased odds of receiving ANC visits during pregnancy for adolescent mothers with higher educational levels, frequency of listening/watching mass media, and various household socio-economic status factors
Erismann et al. (2021)	to assess the use of antenatal (ANC) and postnatal care (PNC) services, health facility delivery and infant health services after 4 years of a health systems	Data from a repeated cross-sectional household survey conducted in Yao and Danamadji in 2015 and in 2018 were analyzed	A combination of health systems strengthening interventions was associated with an increased use of certain maternal and

	intervention for improving the infrastructure, supplies, training and sensitization for maternal and infant health in two districts of rural Chad		infant health services
Musarandega et al. (2021)	to identify the leading causes of maternal deaths using the international classification of disease – 10th revision, for maternal mortality (ICD-MM)	Systematic review	Obstetric hemorrhage, hypertensive disorders in pregnancy, non-obstetric complications, and pregnancy-related infections are the leading causes of maternal deaths in SSA
Shiferaw et al. (2020)	to determine the magnitude, causes and contributing factors for maternal deaths in the institution	conducted a retrospective review of maternal deaths from January 2016 to December 2017. Data were analyzed using SPSS version 20	The maternal mortality ratio was lower than the ratios reported from other institutions in Ethiopia. Hypertensive disorders of pregnancy and malaria were the leading cause of direct and indirect causes of maternal deaths respectively. Embolism has become one of the top causes of maternal death in a rate like the developed nations
Zamane et al. (2018)	to study the cases of maternal deaths in the Dori Regional Hospital, Burkina Faso in the Sahel region, by analyzing the epidemiological aspects of these deaths in order to guide decision-making	descriptive cross-sectional study which spanned the period from January 1, 2014 to December 31, 2016. Cases of maternal death and live births that occurred in the hospital during this period were collected by documentary review	A total of 141 maternal deaths and 2,626 live births were recorded with a maternal mortality ratio of 5,369 for 100,000 live births. In 99 (72.20%) cases, death occurred in the postpartum. A home

			delivery had been reported in 33.70% of cases. Direct obstetric causes were found in 72.10% of cases. They were mainly represented by infections (32.40%) and hemorrhages (23%). Anemia was the indirect cause of death in 25 women (17.80%). The delay in health care access and the lack of blood products contributed to maternal deaths in 64.50% and 26.20% of cases
Marquis et al. (2019)	to estimate the use of maternal health services (MHS) and to identify barriers to access MHS in Sila region in southeast Chad	Retrospective cross-sectional, population-based survey using two-stage cluster sampling methodology	In Sila region, use of MHS is low and does not meet WHO-defined standards regarding maternal health. Among all services, use of ANC was better than for other MHS. ANC usage is positively associated with the use of further life-saving MHS including DC and could be used as an entry point to the community

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 Ethiopia.

Data Issues

This study is based on annual MMR in Ethiopia 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	E
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	0.002259
MSE	56.008441
MAE	5.022117

Residual Analysis for the Applied Model

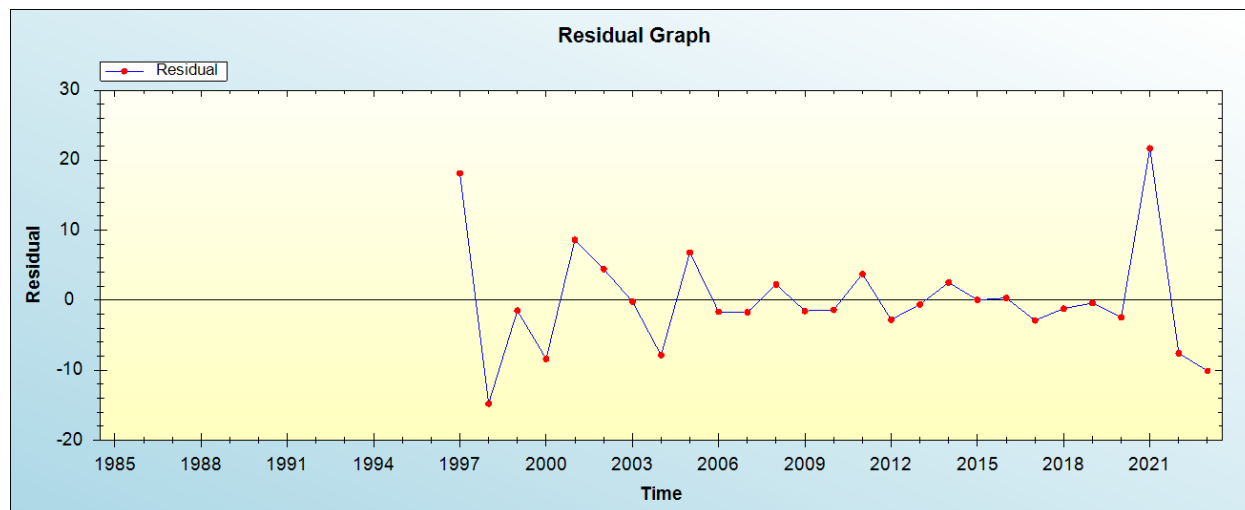


Figure 1: Residual analysis

In-sample Forecast for E

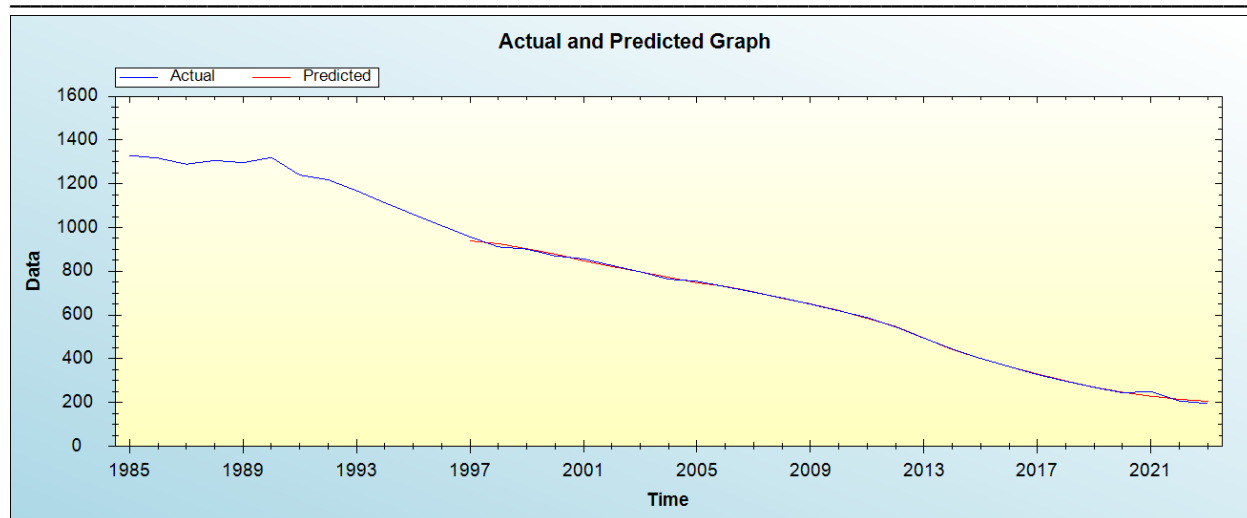


Figure 2: In-sample forecast for the E series

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

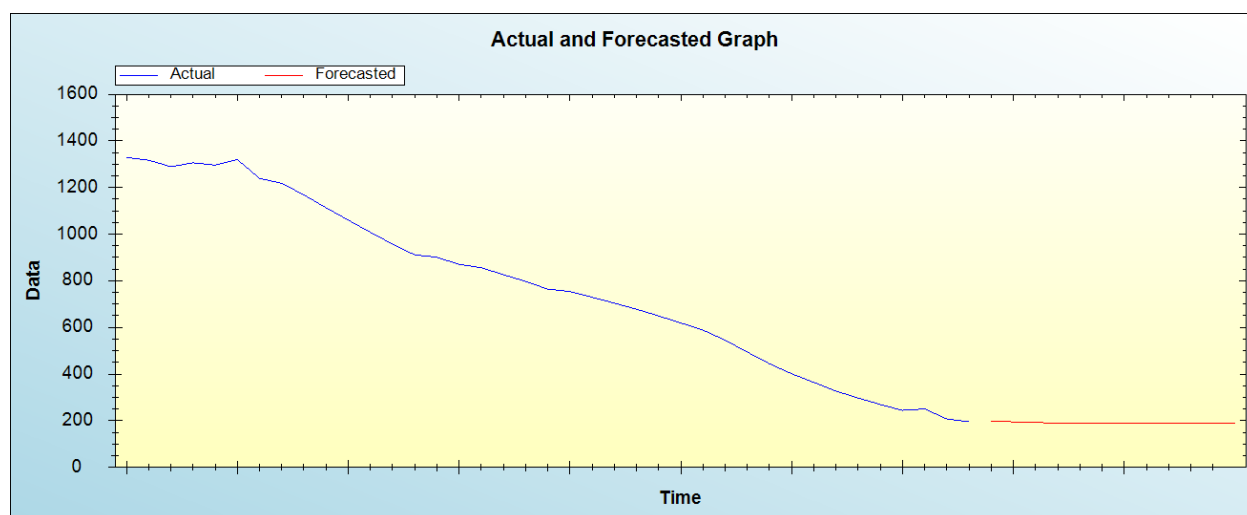


Figure 3: Out-of-sample forecast for E: actual and forecasted graph

Out-of-Sample Forecast for E: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Year	Forecasted MMR
2024	198.6304
2025	194.7611
2026	191.7338
2027	190.1353
2028	189.1526
2029	188.4380

2030	188.0362
2031	187.6994
2032	187.4251
2033	187.3600
2034	187.2035
2035	187.1511

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

Recommendations & Conclusion

Maternal mortality is a huge public health problem in Ethiopia especially in the rural areas where majority of people live. It is also worrisome to say that the majority of these maternal deaths happen outside medical facilities. In this paper we projected MMR for Ethiopia using a machine learning technique and the findings indicated that MMR will hover around 190 deaths per 100 000 live births throughout the out of sample period. Therefore, we encourage the Ethiopian government to adopt the following policy prescription: (1) end teenage pregnancy by enforcing laws that prohibit early child marriage, promote female education and comprehensive sexual and reproductive health education in schools (2) Improve coverage of maternal and child health services across the country with particular focus on increasing institutional deliveries and reducing home deliveries (3) improve quality of maternity services (4) ensure availability of adequate medical supplies and medical staff in all medical facilities and (5) creating posts for obstetricians at government general or district hospitals particularly at high volume sites so that specialist services are accessed at the first referral level. Alternatively, Registrars undergoing Obstetrics & Gynecology training can be attached at high volume district hospitals under the supervision of provincial consultants.

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