

PROJECTING MATERNAL MORTALITY FOR MOZAMBIQUE USING THE MULTILAYER PERCEPTRON

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ABSTRACT

This research article employs annual time series data on MMR for Mozambique 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 decline from around 109 in 2024 to about 81 deaths per 100 000 live births in 2035. Therefore, we encourage the government to adopt the suggested 5-fold policy prescription.

Keywords: ANN, Forecasting, Maternal Mortality Ratio

INTRODUCTION

Maternal mortality remains a huge global challenge particularly for developing countries like Mozambique. Maternal mortality rate in Mozambique remains very high at 127 deaths per 100 000 live births as of 2020 (Mozambique, 2024; World Bank, 2024). Although above 50% of deliveries in Mozambique occur in medical facilities there is still a need for substantial improvements in maternal, neonatal, reproductive and sexual health services (Necochea et al. 2020). The health system faces numerous challenges such as severe shortage of skilled healthcare workers (Mozambique, 2008). Furthermore, the competence of healthcare workers varies, and several constraints affect the quality of maternal and newborn care in Mozambique. These include inadequate healthcare infrastructure, limited space in delivery rooms, shortage of essential medical equipment, and poor training and supervision of health workers (Mozambique, 2008). The objective of this paper is to model and forecast MMR for Mozambique using a machine learning approach. The results of this paper will stimulate an appropriate response so that corrective measures are timeously implemented in order to further reduce preventable maternal mortality across the country.

LITERATURE REVIEW

Author(s)	Objective(s)	Methodology	Main finding(s)
Muhajarine et al. (2024)	To identify Inequalities and factors associated with maternal healthcare services utilization in Mozambique	The study used the population-based, nationwide, cross-sectional Mozambique Demographic and Health Survey 2022–2023 data (n=3808)	Overall, 18.6% of women received all four maternal healthcare services. Maternal healthcare utilization showed significant inequalities favoring wealthier and more empowered women. Regression model suggests that women who were classified in the highest quintile for empowerment index (adjusted OR (aOR)=2.17, 95% CI=1.41 to 3.33), women in the two highest quintiles for wealth index (richer: aOR=2.37, 95% CI=1.41 to 3.98; richest: aOR=2.60, 95% CI=1.41 to 4.79) and

			women residing in urban area (aOR=1.35, 95% CI=0.99 to 1.83) were significantly associated with the utilization of all four healthcare services
Singh et al. (2022)	to inform on potential options for measuring maternal mortality	case study approach	Mozambique's PRMR from household survey method is comparable to Bangladesh and shows an upward trend between 1994 and 2011, whereas the post-census mortality survey estimated a higher MMR for 2007. Bolivia's DHS and post-census mortality survey also estimated comparable MMR during 1998–2003.
Camara et al. (2021)	to synthesize the characteristics and effectiveness of interventions to increase facility births or provision of postpartum care in sub-Saharan Africa.	Scoping review	Strategies identified in the literature as increasing facility births in the sub-Saharan African context include community awareness raising, health expenses reduction (transportation or user fee), non-monetary incentive programs (baby kits), or a combination of these with improvement of care quality (patient's privacy, waiting time, training of provider), and or follow-up of pregnant women to use health facility for birth
Menéndez et al. (2020)	to provide data on clinical diagnostic accuracy to be used for improving quality of care and reducing maternal mortality in Mozambique	did a retrospective analysis of clinicopathological discrepancies in 91 maternal deaths occurring from Nov 1, 2013, to March 31, 2015 (17 month-long period), at a tertiary-level hospital in Mozambique, using complete diagnostic autopsies as the gold standard to ascertain cause of death	Researchers identified a clinicopathological discrepancy in 35 (38%) of 91 women. All diagnostic errors observed were classified as major discrepancies. The sensitivity of the clinical diagnosis for puerperal infections was 17% and the positive predictive value was 50%. The sensitivity for non-obstetric infections was 48%. The sensitivity for eclampsia was 100% but the positive predictive value was 33%. Over the 10-year period, the performance of clinical diagnosis did not improve, and worsened for some diagnoses, such as puerperal infection
Macicame et al. (2018)	To examine the impact of Mozambique's efforts between 1997 and 2015, high lighting the increases in intervention coverage that contributed to saving the most lives.	Conducted a retrospective analysis of available household survey data was conducted using the Lives Saved Tool (LiST)	Mozambique has made impressive gains in reducing child mortality since 1997
Chavane et al. (2018)	to examine the contribution of the delays in relation to the causes of maternal death in facilities in Mozambique	Secondary analysis was performed on data from a national assessment on maternal and neonatal health that included in-depth maternal death reviews, using patient files and facility records with the most comprehensive information available	The delays in reaching and receiving appropriate facility-based care for women facing pregnancy related complications in Mozambique contribute significantly to maternal mortality. Securing referral linkages and health facility readiness for rapid and correct patient management are needed to reduce the impact of these delays within the health system

Firoz et al. (2016)	to identify key community groups' perspectives on the perceived determinants of maternal health in rural areas of southern Mozambique	Qualitative approach	In rural southern Mozambique, community perceptions of the determinants of maternal health included political, economic, socio-cultural and environmental factors. These determinants were closely linked with one another and highlight the importance of including the local history, context, culture and geography in the design of maternal health programs
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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 Mozambique.

Data Issues

This study is based on annual MMR in Mozambique 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	0.003700
MSE	148.468339
MAE	7.037273

Residual Analysis for the Applied Model

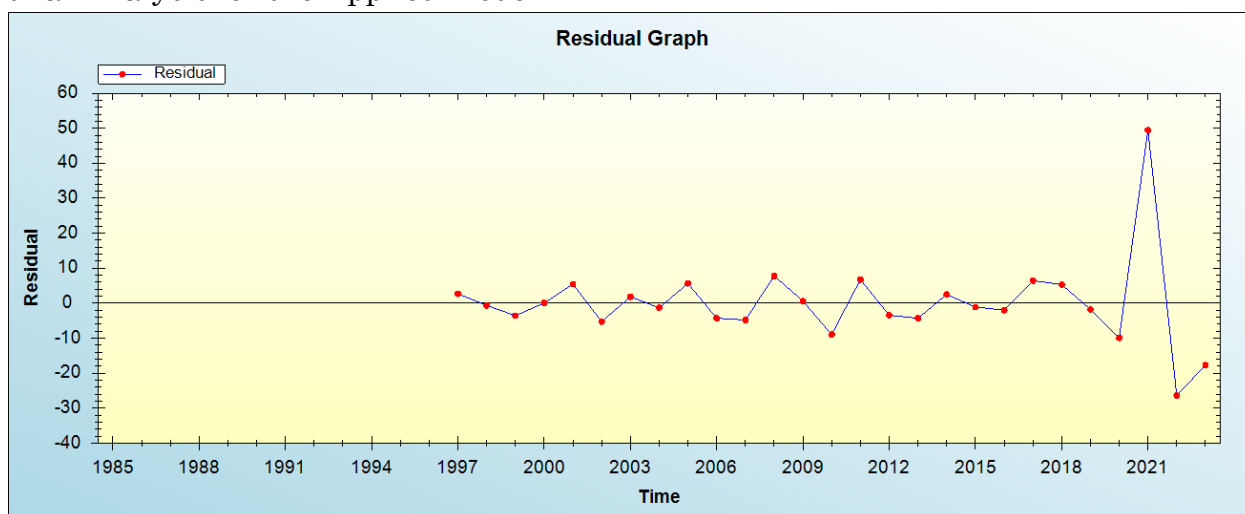


Figure 1: Residual analysis

In-sample Forecast for M

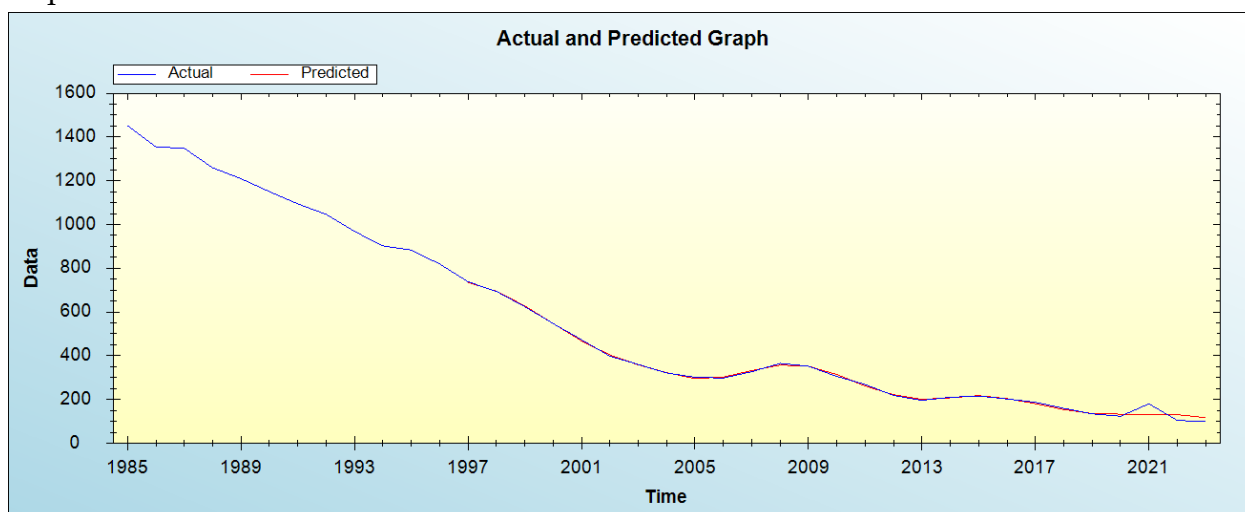


Figure 2: In-sample forecast for the M series

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

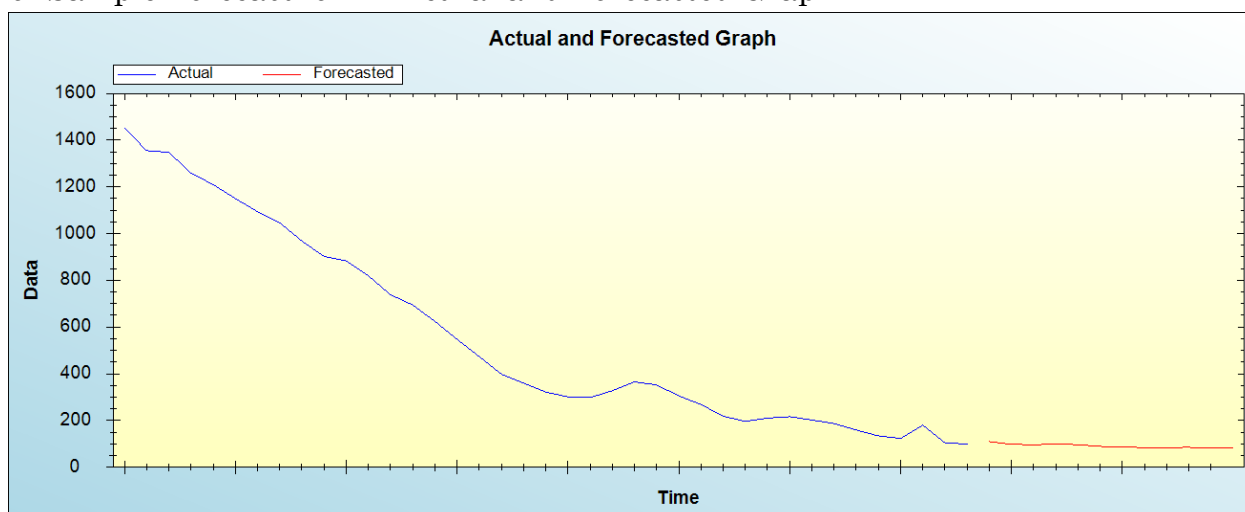


Figure 3: Out-of-sample forecast for M: actual and forecasted graph

Out-of-Sample Forecast for M: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Year	Forecasted MMR
2024	109.2624
2025	98.0694
2026	95.4684
2027	99.5441
2028	96.1816
2029	88.8200
2030	87.1537
2031	83.1922
2032	83.2327
2033	84.9976
2034	81.4784
2035	80.8411

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 decline from around 109 in 2024 to about 81 deaths per 100 000 live births by 2035.

RECOMMENDATIONS & CONCLUSION

Maternal mortality rates are unacceptably high in Mozambique. Shortage healthcare workers, inadequate infrastructure, equipment shortages, poor training and mentorship are among the factors associated with maternal mortality. This study applied a machine learning approach to model and forecast MMR for Mozambique and findings indicate that MMR will decline from around 109 in 2024 to around 81 deaths per 100 000 live births by 2035. Therefore, we encourage health authorities 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 (3) to conduct routine quality improvement activities (4) ensure availability of adequate medical supplies and medical staff in all medical facilities and (5) establish 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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