

Analysis Of Maternal Mortality for Eswatini Using the Multilayer Perceptron

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Abstract

This research article employs annual time series data on MMR for Eswatini Kingdom 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 90 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

Maternal mortality is a global public health problem. Each day close to 800 women die from avoidable causes related to pregnancy or childbirth (WHO, 2023). This scourge affects low-middle countries more than the developed world. According to the WHO, at the global level, the maternal mortality ratio in 2020 stood at 233 per 100,000 live births (WHO, 2020). However, during the recent decades, a huge decline of maternal mortality ratio at the global level was observed, with a decline of 34.3% between 2000 and 2020, an average rate of reduction of 2.9% per year (WHO, 2023; WBG, 2023; WHO, 2020). According to UN estimates in 2020, Eswatini reported maternal mortality rate of around 239.6 deaths per 100 000 live births, in 2022, neonatal mortality was 22.4 deaths per 1000 live births and under five deaths stood at 50.0 deaths per 1000 live births (Eswatini country policy profile 2018). These figures indicate that Eswatini is still very far away from achieving sustainable development goal targets by the end of 2030. The objective of this paper is to model and forecast MMR for Eswatini using a machine learning technique. The findings will assist in policy making and allocation of resources to the maternal and child health program. This is expected to help in further reducing avoidable maternal deaths across the country.

Literature Review

Author(s)	Objective(s)	Methodology	Main finding(s)
Ara et al. (2025)	to summarize the frequencies of sociodemographic characteristics, parity distribution, antenatal care patterns, and causes of death among maternal mortality	Conducted a retrospective study which analyzed maternal mortality at Rangpur Medical College Hospital, Bangladesh, in 2024, reviewing 4,741 birth records with 83 maternal deaths	-Among 83 maternal deaths, majority of deaths occurred among women aged 16–25 (41%) and those from low socioeconomic backgrounds (72.2%). -Parity distribution showed 49.39% had 1–2 children, while 73.4% received no antenatal care

			(ANC), highlighting gaps in healthcare access. - Eclampsia (37.35%) and obstetric hemorrhage (26.50%) were the predominant cause of maternal deaths.
Singh & Swain (2025)	to explore the factors influencing CDMR and its effect on maternal and fetal outcomes	Prospective cohort study	The prevalence of CDMR was 21.35%, which was relatively higher than the World Health Organization's recommended guidelines
Manamo et al. (2023)	to examine the socio-economic differentials of under-five mortality in Botswana within the framework of equality and equity	The was based on the data from 2001 and 2011 Botswana Population and Housing Censuses and the 2017 Botswana Demographic Survey. One census method was used to indirectly estimate under five mortalities for different socio-economic groups using Princeton west model life tables.	socio-economic disparities in under-five mortality disfavoring the worse-off exist in all the selected socio-economic variables
Chacha et al. (2022)	review the current cardiac obstetrics practice, gaps, and potential areas of improvement.	Systematic review	With an increasing number of women with pre-existing cardiac conditions becoming pregnant, the contribution of CVD to maternal mortality is also growing. Consequently, there is a need for accurate diagnosis and appropriate care of pregnant women with

			CVD to minimize adverse outcomes
Teasdale et al. (2021)	To implement a rapid quality improvement project to improve ANC retention at seven health facilities in Eswatini (October-December 2017)	anonymous tablet-based audio assisted computer self-interview (ACASI) surveys	The type of rapid quality improvement intervention implemented may be useful in improving patient-provider relationships although whether it can improve retention remains unclear
Isaacson et al. (2021)	to evaluate the prevalence and outcome of twin pregnancies in Botswana	Quantitative analysis	Adverse birth outcomes are common among twins in Botswana, and are often severe
Akhter et al. (2018)	to present, analyze and interrelate recent data to find barriers to achieving set MDG 5 targets by 2015	literature review has been done as a main method of data collection from Elsevier, Lancet, WHO, UNICEF, BBMS, NIPORT published from 2001 to May 2018	approximately 80% of maternal deaths could be averted if women had access to essential maternity and basic health care services
Madzimbamuto et al. (2014)	To determine the underlying causes of maternal deaths reported in 2010, to categorize contributory factors and to prioritize appropriate interventions based on the identified causes, to prevent further deaths.	Case-notes for maternal deaths were reviewed by a panel of five clinicians, initially independently then discussed together to achieve consensus on assigning contributory factors, cause of death and whether each death was avoidable or not at presentation to hospital. Factors contributing to maternal deaths were categorized into organizational/management, personnel, technology/equipment/supplies, environment and barriers to accessing healthcare	The high number of contributory factors demonstrates poor quality of care even where deaths were not avoidable: 14/23 (61%) of direct deaths were considered avoidable compared to 12/32 (38%) indirect deaths. Highest ranking categories were: failure to recognize seriousness of patients'

			condition (71% of cases); lack of knowledge (67%); failure to follow recommended practice (53%); lack of or failure to implement policies, protocols and guidelines (44%); and poor organizational arrangements (35%). Half the deaths had some barrier to accessing health services
Alvarez et al. (2009)	to describe and determine different factors associated with the maternal mortality ratio in Sub Saharan countries	An ecological multi-group study compared variables between many countries in Sub Saharan Africa using data collected between 1997 and 2006. The dependent variable was the maternal mortality ratio, and Health care system-related, educational and economic indicators were the independent variables. Information sources included the WHO, World Bank, UNICEF and UNDP	Education and an effective and efficient health system, especially during pregnancy and delivery, are strongly related to maternal death

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 Eswatini Kingdom.

Data Issues

This study is based on annual MMR in Eswatini Kingdom 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	0.002419
MSE	27.130934
MAE	3.346998

Residual Analysis for the Applied Model

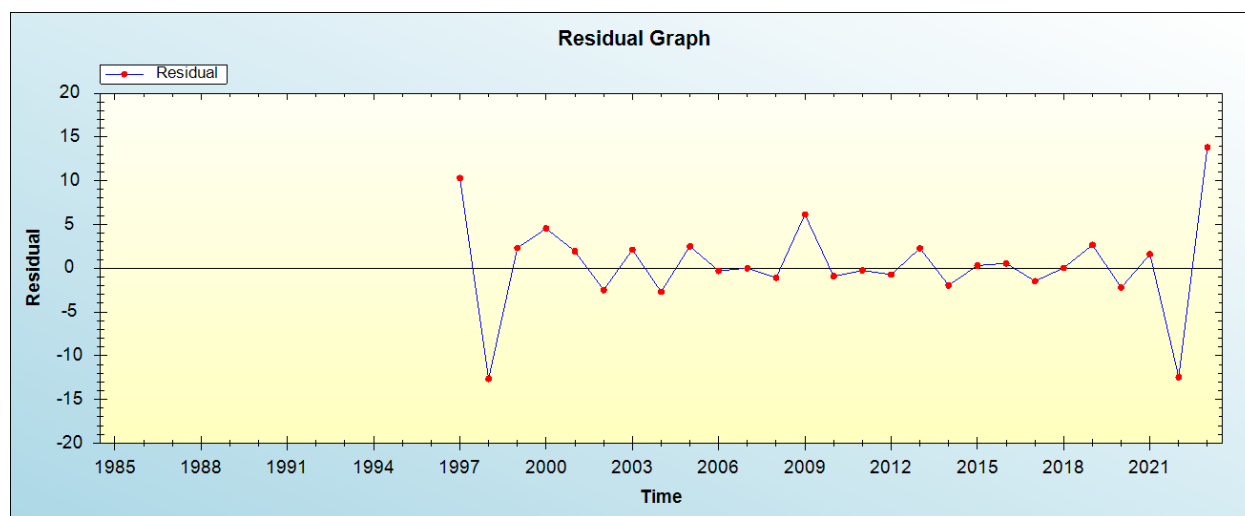


Figure 1: Residual analysis

In-sample Forecast for E

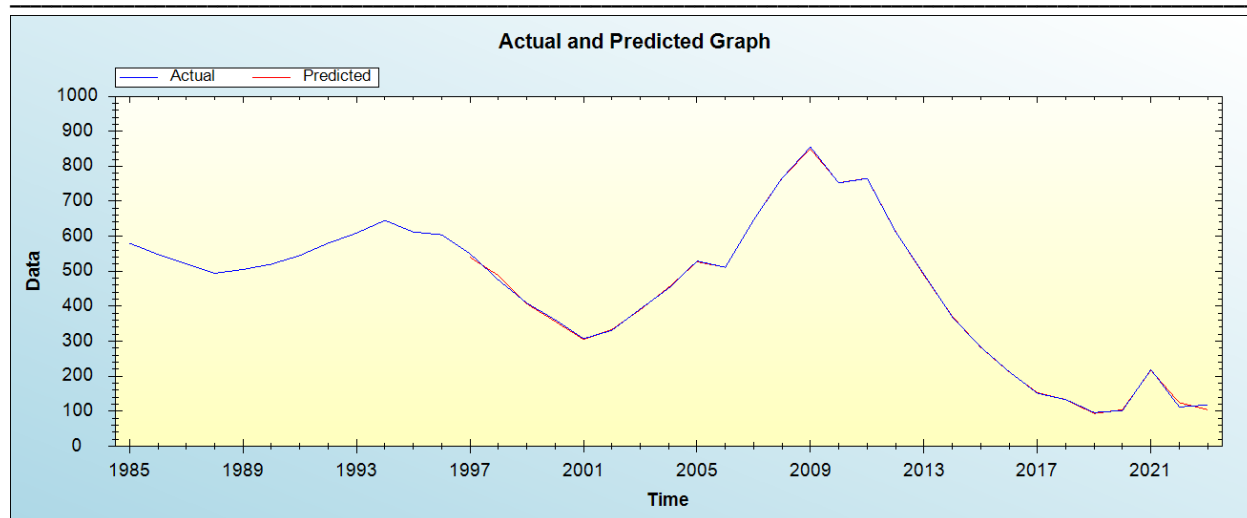


Figure 2: In-sample forecast for the E series

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

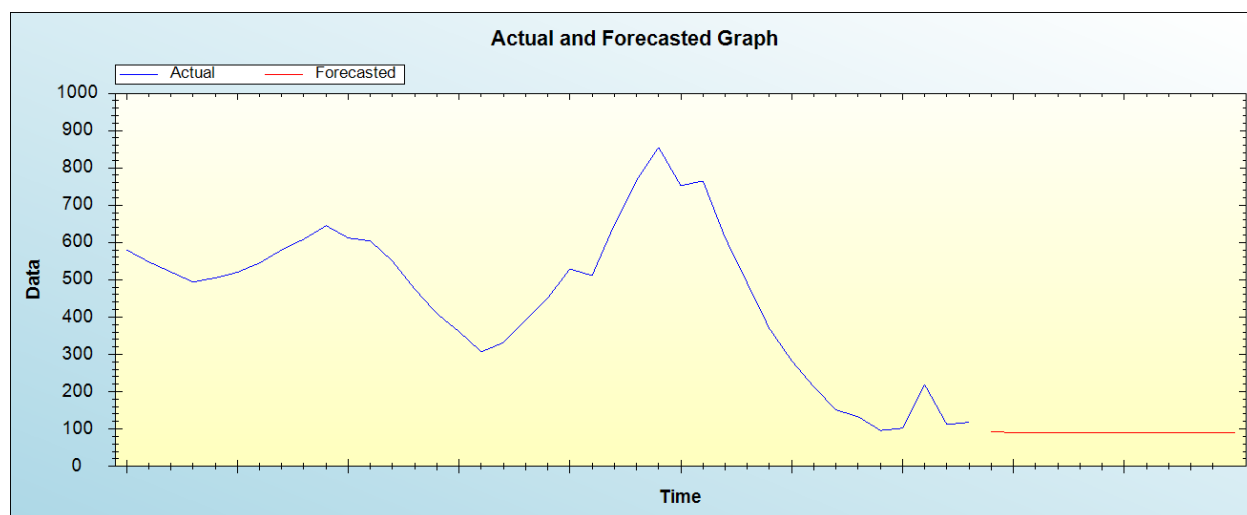


Figure 3: Out-of-sample forecast for E: actual and forecasted graph

Out-of-Sample Forecast for E: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Year	Forecasted MMR
2024	92.7718
2025	90.4037
2026	89.8787

2027	89.6313
2028	89.5721
2029	89.5572
2030	89.4759
2031	89.4588
2032	89.4929
2033	89.4882
2034	89.4579
2035	89.4512

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 90 deaths per 100 000 live births in the out of sample period.

Recommendations & Conclusion

Eswatini is still struggling to control maternal mortality as evidenced by high maternal mortality rates. These high mortality rates indicate insufficiencies in the continuum of care. This study projected MMR for Eswatini using a machine learning technique and the results showed that MMR will hover around 90 deaths throughout the out of sample period. 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) improve quality of maternity services (4) ensure availability of adequate medical supplies and offer staff retention schemes 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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