



MATERNAL MORTALITY FORECASTING FOR NAMIBIA USING A MACHINE LEARNING TECHNIQUE

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Abstract

This research article employs annual time series data on MMR for Namibia 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 is expected to increase and remain very high throughout the out of sample period. 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 health issue because of the negative effects it has on the surviving child, family and community (Geetika et al. 2015). Nearly 80% are as a result of causes directly related to pregnancy (Kwale et al. 2005). The World Health Organization (WHO) statistics indicate that above a quarter million women die worldwide because of complications during childbirth or pregnancy (WHO, 2014), with the majority of these deaths occurring in developing countries. For every woman who dies from obstetric complications, many more face injuries, disabilities and infections (WHO, 2010). Most of these deaths and complications could be prevented if all women gave birth with the assistance of skilled midwives (Khanal et al. 2015). The purpose of antenatal care is to improve and monitor the welfare of both mother and fetus, identify potential problems, prepare women for childbirth and child rearing and respond to their



complaints (WHO, 2009). Namibia has a high maternal mortality ratio (MMR) of an estimated 215/100,000 live births in 2020 (World Health Organization, 2023). This is three times higher than the average reported MMR for upper-middle-income countries. The objective of this paper is to model and forecast MMR for Namibia using a machine learning technique. The results of this paper will inform policy and allocation of resources to the health sector with a view of further lowering preventable maternal mortality 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
Heemelaar et al. (2023)	to describe review findings and compare these with available findings of previous reviews in Namibia	Confidential Enquiry into Maternal Deaths methodology was used to review maternal deaths	Reported maternal mortality ratio increased with 48% (92/100,000 live births compared to 62/100,000 in 2012–2015). Obstetric hemorrhage was leading cause of death in the past three reviews.
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	socio-economic disparities in under-five mortality disfavoring the worse-off exist in all the selected socio-economic variables



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		mortalities for different socio-economic groups using Princeton west model life tables.	
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
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
Heemelaar et al. (2020)	To analyze and improve the Namibian maternity care system by implementing maternal near-miss surveillance during 1 October 2018 and 31 March 2019, and identifying the challenges and benefits of such data collection.	-From the results of an initial feasibility study, researchers adapted the World Health Organization's criteria defining a maternal near miss to the Namibian health-care system - researchers visited most (27 out of 35) participating facilities before implementation and provided training on maternal near-miss identification and data collection - all facilities were visited at the end of the surveillance period to verify recorded data and to give staff the opportunity to provide feedback	obstetric hemorrhage and hypertensive disorders were the most common causes of maternal near misses (each 92/298; 30.9%). Of the 49 maternal near misses due to pregnancies with abortive outcomes, ectopic pregnancy was the most common cause (36/298; 12.1%). Fetal or neonatal outcomes were poor; only 50.3% (157/312) of the infants born to maternal near-miss mothers went home with their mother
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
Wesson et al. (2018)	To examine cultural and structural factors that influence maternity care workers' attitudes and practices, and a maternal and neonatal mortality study explored community perceptions about	Qualitative study	Namibia's public sector hospital maternity units confront health workers and clients with structural and cultural impediments to quality care. Negative interactions between health workers and laboring women were reported as



	maternity care in Namibia		common, despite high health worker commitment to babies' welfare
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

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 Namibia.

Data Issues

This study is based on annual MMR in Namibia 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	N
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	0.002569
MSE	9.799082
MAE	1.723951

Residual Analysis for the Applied Model

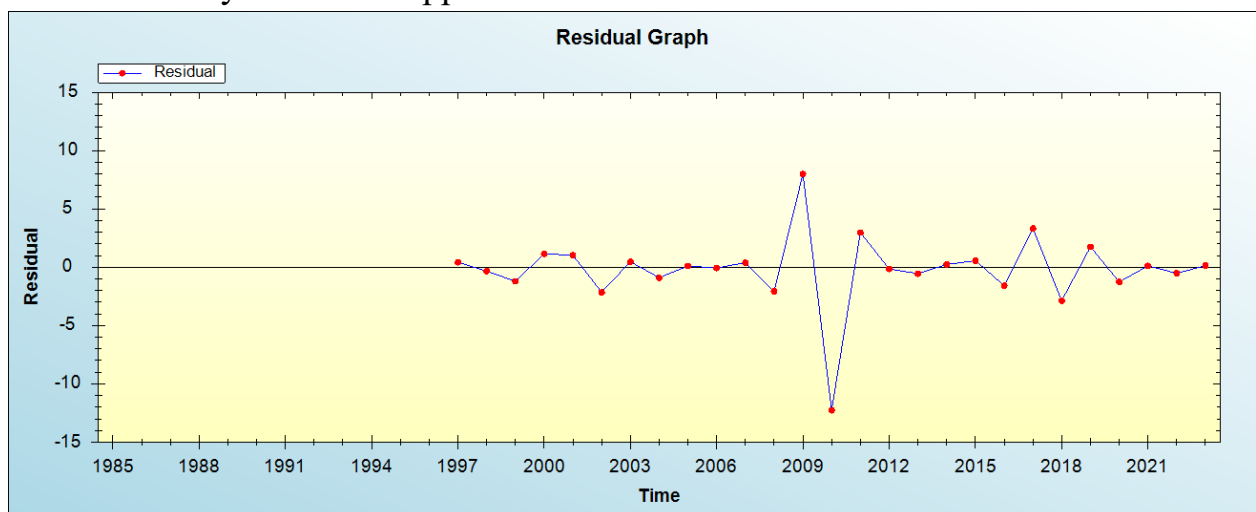


Figure 1: Residual analysis



In-sample Forecast for N

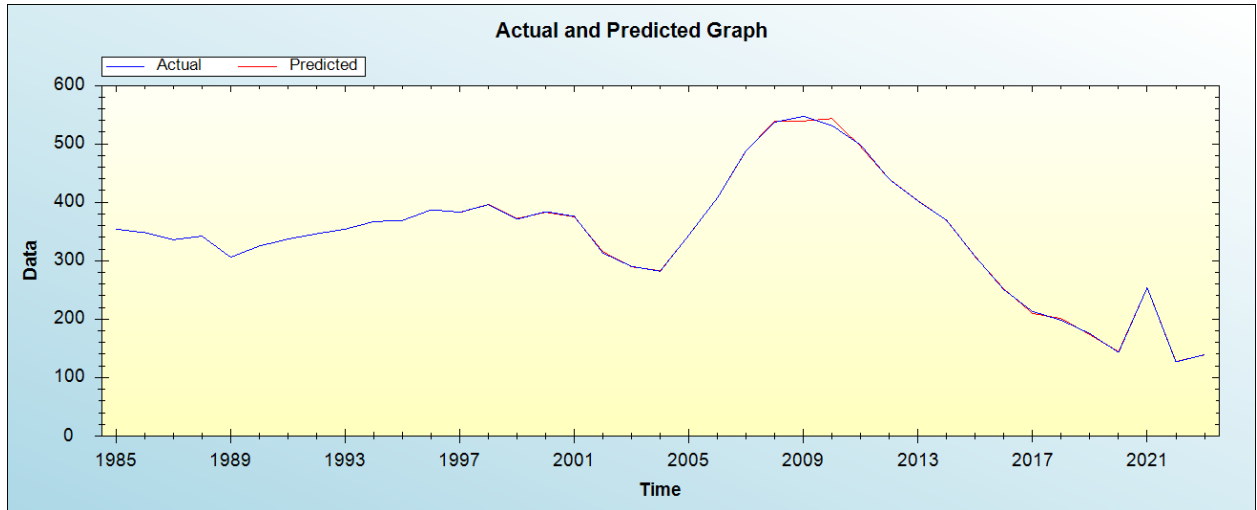


Figure 2: In-sample forecast for the N series

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

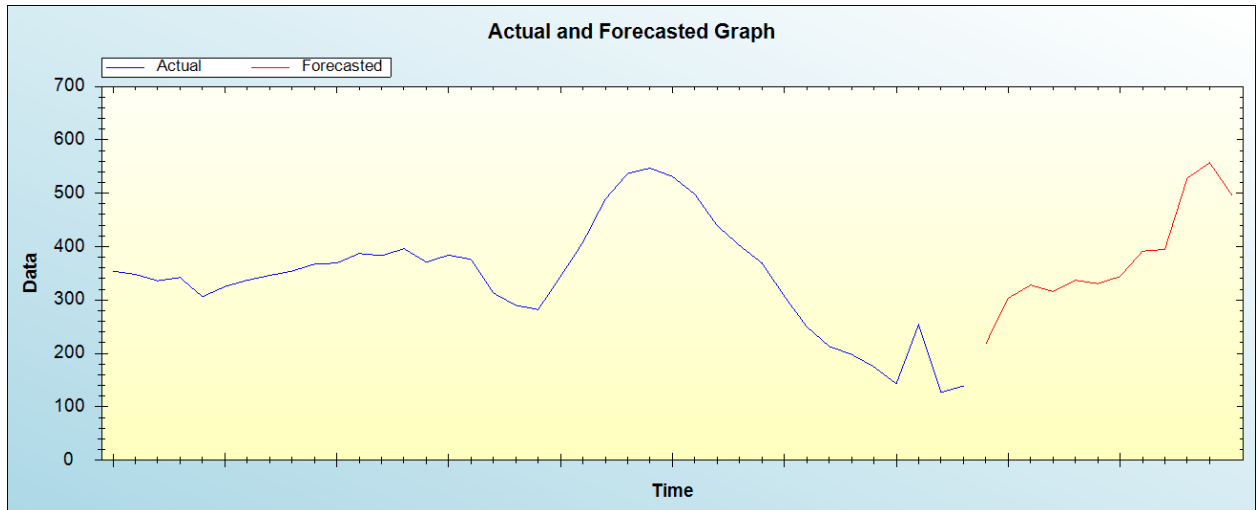


Figure 3: Out-of-sample forecast for N: actual and forecasted graph



Out-of-Sample Forecast for N: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Year	Forecasted MMR
2024	218.1343
2025	303.5028
2026	327.6862
2027	315.7039
2028	336.9122
2029	330.5711
2030	344.1173
2031	391.4434
2032	394.7294
2033	528.0073
2034	557.1002
2035	496.5280

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 increase and remain very high over the out of sample period.

Recommendations & Conclusion

Namibia is committed to the United Nations' Agenda for sustainable development and is mandated to lower its maternal mortality to levels below 70 maternal deaths per 100 000 live births by 2030. Over the previous decades, a decline of MMR was observed, however maternal mortality remains high. This is a call for authorities to review and reconfigure the current maternal health policy in order to drastically reduce preventable maternal deaths over the next four years although prospects of achieving SDG3 target 3.1 are reduced. This paper applied the machine learning approach to model and forecast MMR for Namibia and results indicate that MMR is expected to increase and remain very high over the out of sample period. Therefore, we encourage health authorities to adopt the



following policy prescription: (1) end adolescent 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) conduct routine quality improvement activities such as refresher courses and mentorship programs (4) ensure availability of adequate medical supplies and medical staff in all medical facilities and (5) create 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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