

Eurasian Scientific Herald 	Maternal Mortality Projection For Bangladesh Using The Multilayer Perceptron Neural Network
Smartson. P. NYONI ¹	¹ Independent Researcher & Medical Doctor, Harare, Zimbabwe
Thabani NYONI ²	² Independent Researcher & Health Economist, Harare, Zimbabwe
ABSTRACT	<i>This research article employs annual time series data on MMR for Bangladesh 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 annual MMR will remain high throughout the out of sample period. Therefore, we encourage the government to adopt the suggested 4-fold policy recommendation.</i>
Keywords:	ANN, Forecasting, Maternal Mortality Ratio

Introduction

A maternal death is defined as the demise of a woman during pregnancy or within 42 days of pregnancy termination, irrespective of the pregnancy’s duration or location (WHO, 2024). Direct obstetric causes include hemorrhage and infection, while indirect causes encompass conditions like cardiac disease (WHO, 2012). The global maternal mortality ratios (MMR) vary significantly due to factors such as maternal age, parity, pre-pregnancy comorbidities, obstetric service accessibility/quality, socioeconomic/cultural contexts, and external environments (Souza et al. 2024; Alsharif et al. 2023; Seifu et al. 2023; Ward et al. 2023; Mohamed et al. 2022; Tajvar et al, 2022; Ray et al. 2018; McCall et al. 2017). Bangladesh has made significant progress in

Literature Review

Author(s)	Objective(s)	Methodology	Main finding(s)
Ara et al. (2025)	to summarize the frequencies of	Conducted a retrospective study	-Among 83 maternal deaths, majority of

providing safe motherhood. Its MMR declined from 322 deaths per 100,000 live births in 2001 to 194 deaths per 100,000 live-births in 2010 (Begum et al. 2017). Access to basic and comprehensive emergency obstetric care (EmOC) has improved but the major contribution came from private sector facilities. Bangladesh Demographic and Health Survey (BDHS) 2014 highlighted that of 37 percent of facility delivery, 60 percent were reported by private sector hospitals. The objective of this paper is to model and forecast MMR for Bangladesh using the multilayer perceptron. The results of the study are expected to stimulate a national response to the unresolved problem of maternal mortality across the country.

	sociodemographic characteristics, parity distribution, antenatal care patterns, and causes of death among maternal mortality	which analyzed maternal mortality at Rangpur Medical College Hospital, Bangladesh, in 2024, reviewing 4,741 birth records with 83 maternal deaths.	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.
Feng et al. (2025)	-to analyze trends (1990–2021) and projected (to 2050) MMR in Southeast Asia using the Global Burden of Disease (GBD) 2021 database and addressing gaps in regional granularity	-Data GBD 2021, covering MMR and age-standardized MMR (ASMR) for 1990–2021, stratified by country, age group, and cause -Trend assessment was conducted using the estimated annual percentage change (EAPC), while 30-year projections were generated via an autoregressive integrated moving average (ARIMA) model	The ASMR in Southeast Asia fell by 59%, dropping from 255.88 in 1990 to 104.56 per 100,000 live births by 2021. This decline was primarily driven by reduced rates of maternal hemorrhage and hypertensive disorders. Progress slowed during the 1997 Asian financial crisis yet picked up pace after 2000
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

Hossain et al. (2023)	To report the current level and major causes of maternal deaths in Bangladesh, focusing on care-seeking practices, timing, and place of deaths	-analyzed data from the 2016 Bangladesh Maternal Mortality and Health Care Survey (BMMS), conducted with nationally representative sample of 298 284 households -adapted the World Health Organization's 2014 verbal autopsy (VA) questionnaire. Trained physicians reviewed the responses and assigned the cause of death based on the International Classification of Diseases (ICD-10)	Nineteen per cent of the maternal deaths occurred at home, another 19% in-transit, almost half (49%) in a public facility, and 13% in a private hospital. Hemorrhage contributed to 31% and eclampsia to 23% of the maternal deaths. Twenty-one per cent of the maternal deaths occurred due to indirect causes
Jabeen et al. (2023)	To examine the current levels, trends, time of death, and care-seeking practices for hemorrhage-related maternal deaths in Bangladesh	-conducted a secondary analysis with data from the nationally representative 2001, 2010, and 2016 Bangladesh Maternal Mortality Surveys (BMMS) -The cause of death information was collected through verbal autopsy (VA) interviews using a country-adapted version of the standard World Health Organization VA questionnaire	Postpartum hemorrhage remains the primary cause of maternal mortality in Bangladesh
Singh et al. (2022)	to inform on potential options for measuring maternal mortality	Applied a case study approach to compare methodologies and estimates of pregnancy-related mortality ratio	For Bangladesh, PRMR from the 2011 census falls closely in line with the 2010 household survey and SVRS estimates, while SVRS' MMR

		(PRMR)/maternal mortality ratio (MMR) obtained from four different data sources from similar time periods in Bangladesh, Mozambique, and Bolivia—national population census; post-census mortality survey; household sample survey; and sample vital registration system (SVRS)	estimates are closer to the PRMR estimates obtained from the household survey. Mozambique's PRMR from household survey method is comparable 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
Akhter, & Alam. (2019)	-to present the trends of maternal and neonatal mortality - to explain the maternal and neonatal mortality rate by background characteristics and the causes of maternal and neonatal deaths in Bangladesh on the basis of South Asian perspective	The main source of data collection and analysis was the secondary sources, from different journals and project reports published between the years 2001 to May 2018	In Bangladesh, 35% maternal deaths occurred as indirect causes and 9% causes of deaths are still remaining unidentified. hemorrhage (31%) and pre-eclampsia-eclampsia (20%) are found two vital causes of maternal deaths with two more causes which are due to obstructed labor (7%), and termination of pregnancy (1%)
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	approximately 80% of maternal deaths could be averted if women had access to essential maternity and basic health care services

		published from 2001 to May 2018	
Begum et al. (2017)	To identify indications and determinants of C-sections	Retrospective study	During 2013, facility delivery rate was 84% and population-based C-section rate was 35% of all deliveries in the service area. Of all C-sections, only 1.4% was conducted for Absolute Maternal Indications (AMIs). Major indications of C-sections included: repeat C-section (24%), fetal distress (21%), prolonged labor (16%), oligohydramnios (14%) and post maturity (13%)
Girum and Wasie (2017)	-to identify correlates of maternal mortality in developing countries	Literature review	-Maternal mortality ratio is very high in developing countries and enormously varies among countries -A significant relationship between the maternal mortality ratio and socio-economic, health care and morbidity indicator variables was observed

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 Bangladesh.

Data Issues

This study is based on annual MMR in Bangladesh 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

ANN Model Summary

Table 1: ANN model summary

Variable	B
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	0.007000
MSE	101.450435
MAE	4.398578

Residual Analysis for the Applied Model

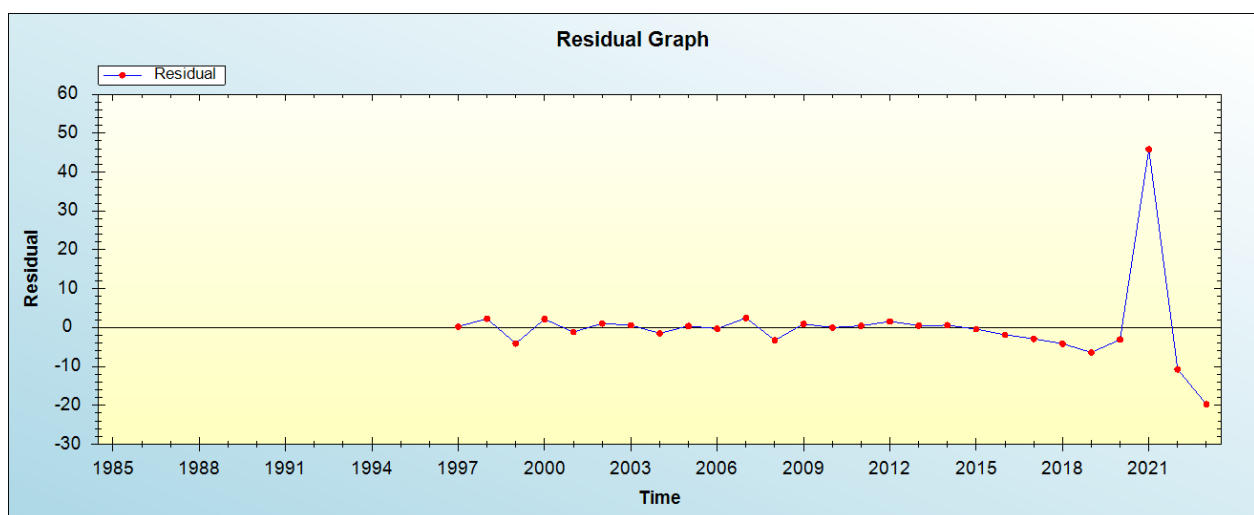


Figure 1: Residual analysis

In-sample Forecast for B

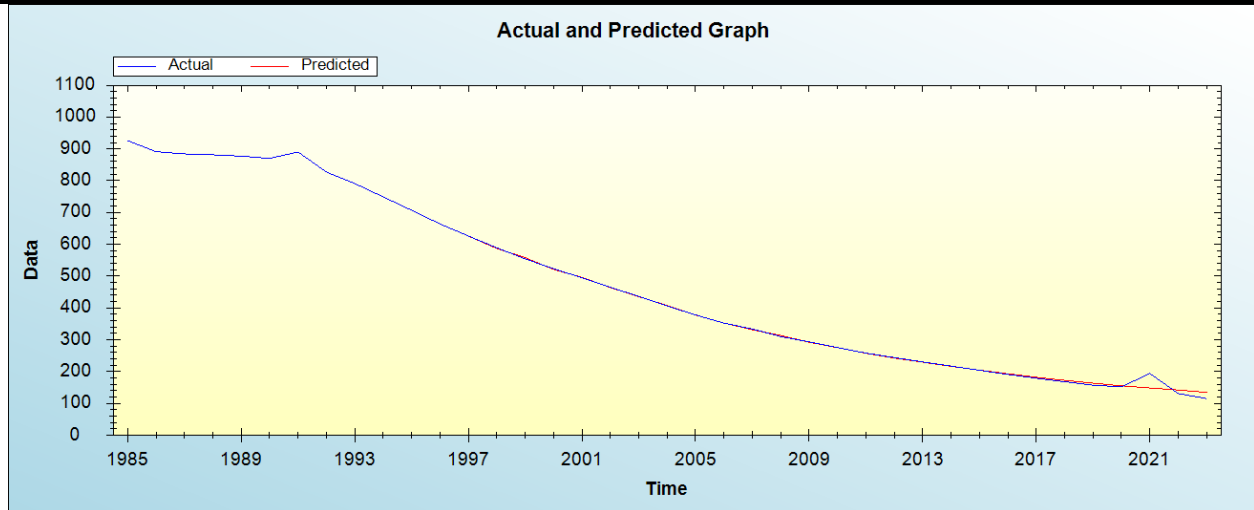


Figure 2: In-sample forecast for the B series

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

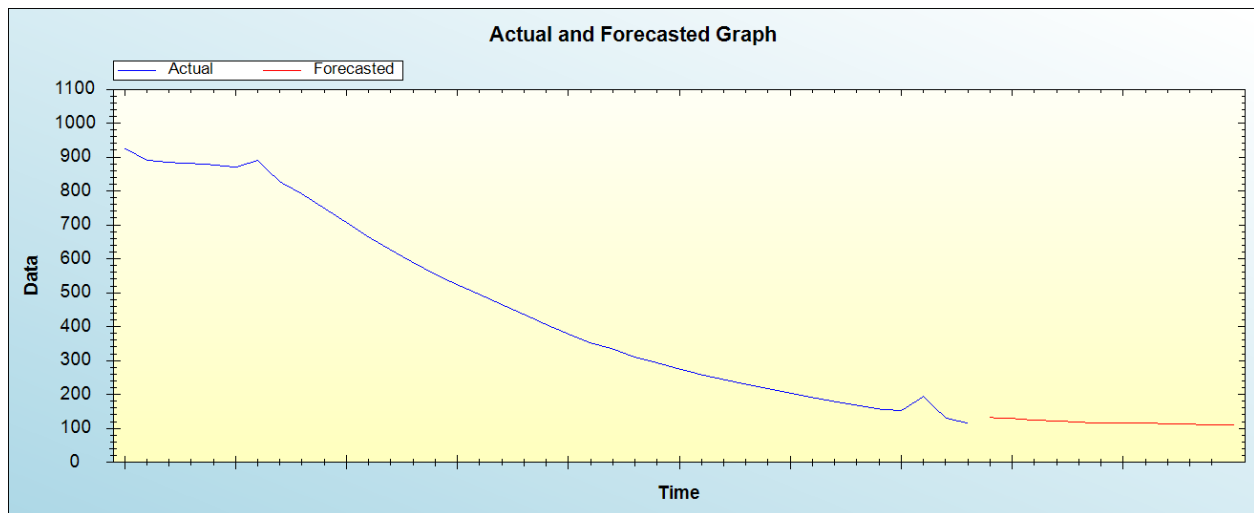


Figure 3: Out-of-sample forecast for B: actual and forecasted graph

Out-of-Sample Forecast for B: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Year	Forecasted MMRs
2024	131.8201
2025	129.3785
2026	123.6804
2027	122.3394
2028	118.0811
2029	115.4901
2030	116.8366

2031	115.7577
2032	113.4571
2033	112.3939
2034	110.0319
2035	109.7810

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 remain high throughout the out of sample period.

Conclusion

Maternal mortality is an important indicator of the quality of maternal health care services in a country. The primary causes of maternal deaths in Bangladesh are post-partum hemorrhage and hypertensive disorders. Factors associated with maternal mortality include maternal age and socio-economic status among others. This paper applied the multilayer perceptron neural network to forecast MMR for Bangladesh. The study results revealed that MMR will over the out of sample period. This paper argues that there is need for health authorities in Bangladesh to adopt the following policy prescription: (1) to promote female education and address bad cultural practices that encourage early childhood marriages so as to reduce adolescent pregnancy, (2) Ensuring availability of adequate medical supplies at all levels of healthcare including marginalized communities, (3) carryout continuous quality improvement initiatives and 4) secondment of obstetricians in all district (first referral level) hospitals across the country.

References

1. Akhter, S., & Alam, A. (2019). Trends and causes of maternal and neonatal mortality in Bangladesh: A South Asian perspective. *Journal of South Asian Healthcare*, 5(2), 112–125.
2. Akhter, S., Alam, A., & Islam, M. (2018). Barriers to achieving MDG 5 targets in Bangladesh: A comprehensive review of literature. *Bangladesh Journal of Public Health*, 12(1), 34–45.
3. Alsharif, A., Ahmed, F., & Almatary, A. M. (2023). Maternal mortality over a seven-year period of conflict at Jiblah referral hospital in Ibb City, Yemen: A retrospective observational study. *Cureus*, 15(6), Article e41044. <https://doi.org/10.7759/cureus.41044>
4. Ara, R., Rahman, M., & Sultana, S. (2025). Sociodemographic profiles and clinical causes of maternal mortality at Rangpur Medical College Hospital, Bangladesh. *Bangladesh Medical Journal*, 54(1), 22–30.
5. Begum, T., Rahman, A., Nababan, H., Hoque, D. M. E., Khan, A. F., & Ali, T. (2017). Indications and determinants of caesarean section delivery: Evidence from a population-based study in Matlab, Bangladesh. *PLoS ONE*, 12(11), Article e0188074. <https://doi.org/10.1371/journal.pone.0188074>
6. Feng, X., Zhang, Y., & Liu, C. (2025). Trends (1990–2021) and 30-year projections of maternal mortality ratio in Southeast Asia: A Global Burden of Disease study. *The Lancet Regional Health - Southeast Asia*, 32, Article 100412.
7. Girmu, T., & Wasie, A. (2017). Correlates of maternal mortality in developing countries: An ecological study in 82 countries. *Maternal Health, Neonatology and Perinatology*, 3, Article 19.

- <https://doi.org/10.1186/s40748-017-0059-8>
8. Hossain, M. A., Islam, M. S., & Chowdhury, M. A. K. (2023). Levels, causes, and healthcare-seeking behaviors surrounding maternal mortality in Bangladesh: Evidence from the 2016 BMMS. *BMC Pregnancy and Childbirth*, 23, Article 401.
 9. Jabeen, S., Ahmed, S., & Khan, M. R. (2023). Hemorrhage-related maternal deaths in Bangladesh: Analysis of trends and timing from National Maternal Mortality Surveys. *International Journal of Gynecology & Obstetrics*, 162(2), 512–520.
 10. McCall, S. J., Nair, M., & Knight, M. (2017). Factors associated with maternal mortality at advanced maternal age: A population-based case-control study. *BJOG: An International Journal of Obstetrics & Gynaecology*, 124(8), 1225–1233. <https://doi.org/10.1111/1471-0528.14216>
 11. Mohammed, S., Worku, A., & Girma, E. (2022). Receiving quality antenatal care service increases the chance of maternal use of skilled birth attendants in Ethiopia: Using a longitudinal panel survey. *PLoS ONE*, 17(12), Article e0279495. <https://doi.org/10.1371/journal.pone.0279495>
 12. National Institute of Population Research and Training, Mitra and Associates, & ICF International. (2016). *Bangladesh Demographic and Health Survey 2014*. NIPORT, Mitra and Associates, & ICF International.
 13. Ray, J. G., Park, A. L., & Dzakupasu, S. (2018). Prevalence of severe maternal morbidity and factors associated with maternal mortality in Ontario, Canada. *JAMA Network Open*, 1(7), Article e184571. <https://doi.org/10.1001/jamanetworkopen.2018.4571>
 14. Seifu, B. L., Tebeje, T. M., & Asgedom, Y. S. (2023). Determinants of high-risk fertility behavior among women of reproductive age in Kenya: A multilevel analysis based on 2022 Kenyan Demographic and Health Survey. *BMC Public Health*, 23(1), Article 2516. <https://doi.org/10.1186/s12889-023-17459-w>
 15. Singh, K., & Swain, P. K. (2025). Caesarean delivery on maternal request and its implications on maternal and fetal outcomes: A prospective cohort study. *Journal of Maternal-Fetal & Neonatal Medicine*, 38(1), Article 2301122.
 16. Singh, K., Thomas, P., & Arifeen, S. E. (2022). Measuring maternal mortality: A comparative case study of methodological approaches in Bangladesh, Mozambique, and Bolivia. *Population Health Metrics*, 20, Article 14.
 17. Souza, J. P., Day, L. T., & Rezende-Gomes, A. C. (2024). A global analysis of the determinants of maternal health and transitions in maternal mortality. *The Lancet Global Health*, 12(2), e306–e316. [https://doi.org/10.1016/S2214-109X\(23\)00468-X](https://doi.org/10.1016/S2214-109X(23)00468-X)
 18. Tajvar, M., Hajizadeh, A., & Zalvand, R. (2022). A systematic review of individual and ecological determinants of maternal mortality in the world based on the income level of countries. *BMC Public Health*, 22(1), Article 2354. <https://doi.org/10.1186/s12889-022-14686-5>
 19. Ward, Z. J., Atun, R., & King, G. (2023). Simulation-based estimates and projections of global, regional and country-level maternal mortality by cause, 1990–2050. *Nature Medicine*, 29(5), 1253–1261. <https://doi.org/10.1038/s41591-023-02310-x>
 20. World Health Organization. (2012). *ICD-10: International statistical classification of diseases and related health problems—Application to deaths during pregnancy, childbirth and the puerperium (ICD-MM)*. World Health Organization.
 21. World Health Organization. (2024). *Maternal mortality ratio (per 100 000 live births) – Indicator metadata (SDG 3.1.1)*.

World Health Organization.
[https://cdn.who.int/media/docs/default-source/documents/ddi/gpw14-results-framework outcome-indicators metadata](https://cdn.who.int/media/docs/default-source/documents/ddi/gpw14-results-framework_outcome-indicators_metadata)