



CALCULATING ANNUAL MATERNAL MORTALITY RATE FOR TIMOR-LESTE USING A MACHINE LEARNING APPROACH

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Abstract

This research article employs annual time series data on MMR for Timor Leste 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 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

Ending preventable maternal deaths has proven to be a huge challenge for developing countries who often have limited or constrained resources (Bolan et al. 2021; Frost et al. 2021; Iqbal et al. 2019). The situation becomes more difficult when these problems are combined with political and social conflict (Bowsher et al. 2019; Cabieses & Bird, 2014). Timor-Leste is a post-conflict country situated between South East Asia, Australia and the Pacific; it is the newest nation in Asia. The majority (72%) of Timor Leste's population reside in the rural and remote areas and 42% live below the poverty line (WHO,2018; GDS & ICF, 2018). Independence from Indonesia was obtained in 2002 after years of occupation (Bovensiepen, 2018). The government has made significant progress in the reconstruction of the health care system following Indonesian forces exit from the country, however huge challenges remain to achieve health and well-being for the nation's most vulnerable (Percival et al. 2018). Maternal mortality ratio is



218 deaths per 100 000 live births and infant and under-5 mortality rates are 30 and 41 deaths per 1000 live births, respectively (GDS & ICF, 2018). The aim of this study is to model and forecast MMR for Timor- Leste using a machine learning technique. The results of the study are expected to assist in crafting maternal and child health policies, planning and adequate allocation of resources to the health sector in order to further reduce preventable maternal deaths across the country.

Literature Review

Author(s)	Objective(s)	Methodology	Key finding(s)
Becerra et al. (2026)	to identify and analyze maternal complications associated with adolescent pregnancy, with a particular focus on the Latin American context	qualitative and descriptive approach	adolescent pregnancy in Latin America and the Caribbean entails significant medical risks and negatively affects the integral development of adolescents, a situation that is aggravated by the lack of access to health services, education and by factors such as poverty
Mackin et al. (2026)	to understand how levels of MNH care are organized in different country contexts	Scoping review	Three or four levels of MNH facility care were most commonly reported. Linking maternal and newborn facility care to community connections is an important consideration to ensure equitable access to routine and emergency care
Marks & Castro (2026)	To examine how MWHs have been implemented across Latin America, analyzing their evolution, the specific needs they address in different countries, and their impact on maternal and neonatal health outcomes throughout the region	Systematic review	The evolution of MWHs suggests that they address a spectrum of needs beyond their original purposes, such as providing culturally responsive maternal support and psychosocial and early childhood support



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Tsushima et al. (2026)	To determine the long-term incidence of dysglycemia and dyslipidemia after GDM and evaluated whether postpartum changes in body mass index (BMI) independently predicted these outcomes	Prospective cohort study	postpartum weight change may help identify women at higher risk of subsequent metabolic abnormalities, particularly dysglycemia, in this high-risk population, although causal relationships cannot be inferred from this observational study
Yue et al. (2026)	to perform an umbrella review to summarize the current evidence to provide a reference for clinicians and future research	Systematic literature review	This review offers a thorough overview of the current evidence linking SLE, SS and APS to pregnancy and assisted reproductive outcomes. It identifies existing gaps and proposes future research directions
Cresswell et al. (2025)	To obtain updated evidence on causes of maternal death is needed to accelerate progress	Systematic review	Globally, the most common cause of maternal death was hemorrhage (27%; 80% uncertainty interval 22–32), followed by indirect obstetric deaths (23%, 18–30), and hypertensive disorders (16%, 14–19). The proportion of hemorrhage deaths varied substantially by region and was highest in sub-Saharan Africa and Western Asia and Northern Africa.
Quiroz-Acuña et al. (2025)	To assess maternal mortality trends in LAC women from 1997 to 2019, providing key insights to address this issue.	ecological observational time-series study	Despite overall progress, regional differences in maternal mortality persist across Latin America and the Caribbean. These variations highlight the importance of strengthening maternal health systems, improving access to skilled birth attendance, and ensuring quality prenatal and postnatal care
Silvana et al. (2025)	To describe the factors influencing the reduction of maternal mortality during the	Participatory Action Research (PAR) with a qualitative-quantitative analysis. Twelve	intercultural, comprehensive, and territory-based management of pregnancy and childbirth led to a reduction in



	2022–2024 management period at Tartagal Hospital (HT)	meetings and interviews were conducted with the healthcare team, along with 10 validated surveys administered to obstetric inpatients (10/12/24), and an analysis of hospital databases	maternal mortality beginning in 2022. Teamwork and intersectoral collaboration optimized available resources, consolidating a sustainable and effective model for maternal health. However, the greatest challenge lies in maintaining and increasing funding to ensure the continuity of this policy
Nigenda and Serván-Mori (2024)	To discuss the relationship between the availability of human resources for health and the maternal mortality ratio for the period 1990–2021 in Latin America	used secondary data from a global source to show patterns in the relationship between these two aspects and identify gaps in the Latin American and Caribbean regions	Although variations in maternal mortality rate cannot be explained solely through the provision of health personnel, it is important to consider that it is critical to find new modalities on how human resources for health could integrate and create synergies with other resources to increase systems capacity to deliver care according to conditions in each country
Khorshed et al. (2022)	to map the quality of MNCH services against WHO quality standards on: 1. Provision of care, 2. Experiences of care, and 3. Cross-cutting standards	Scoping review	The findings highlight health workers' limited capacity to provide quality services and referrals. The major reasons for this are: a lack of essential supplies, poor infrastructure and transport, limited opportunities for ongoing learning, and gaps in health information systems
Critto et al. (2022)	To examine the effects of a pandemic influenza virus on cause-specific maternal mortality time series, using Argentinian vital statistics	-conducted a population-based natural experiment from national vital records of maternal deaths between 1980 and 2017 -applied Join-point regression models	Over this 38-year study, the MMR decreased by 58.6% (69.5 to 28.8 deaths/100,000 live births), transitioning from direct obstetric causes (67.0 to 21.1/100,000 live births; 68.4% decrease) to indirect causes (2.6 to 7.7/ 100,000 live births; 196.2% increase)
Matos et al. (2022)	to identify outcome of mother who attend for delivery the baby at the	observational cross sectional (cases series) study with retrospective data	Almost all mothers who attended baby delivery in Dili were successfully going home and only few which were



	four CHC in Dili during 2018	collection and descriptive data analysis to describe the outcome of the mother who attended for delivery baby at four CHC in Dili during 2018	referred to the hospital for various reasons
Pinto et al. (2017)	to determine the relationship between the variables of age, parity, spacing pregnancies, health behavior, and health status of mothers with maternal deaths in Timor Leste	cross-sectional study with a sample of 298 pregnant women in 13 districts throughout Timor-Leste	There was a significant relationship between behavioral maternal health, maternal health, birth spacing with maternal mortality while age and parity are not related

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 Timo Leste.

Data Issues

This study is based on annual MMR in Timo Leste 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	T
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	0.001359
MSE	90.082493
MAE	4.431288

Residual Analysis for the Applied Model

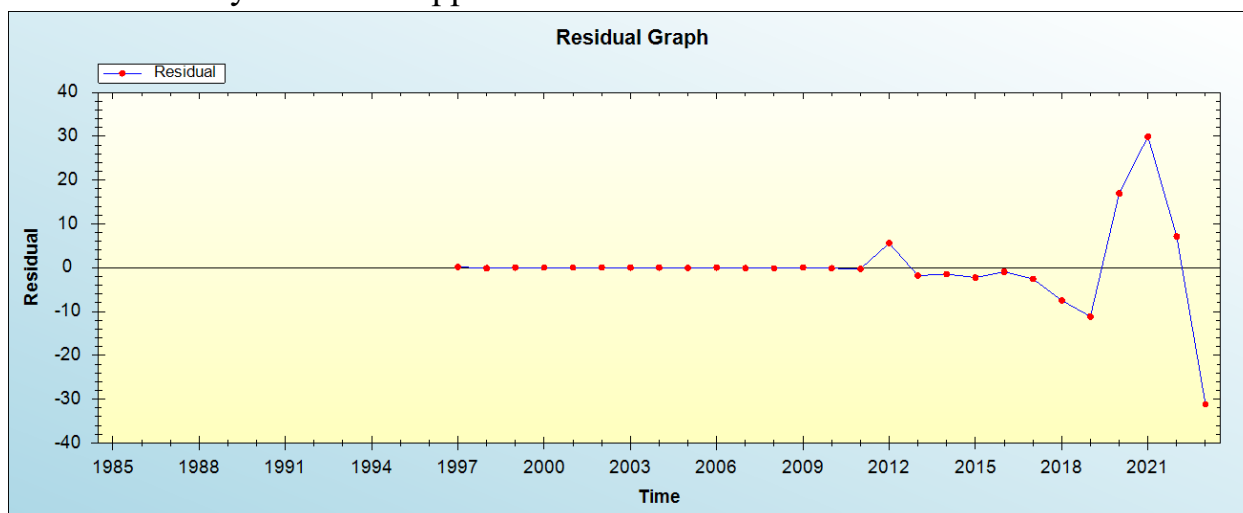


Figure 1: Residual analysis



In-sample Forecast for T

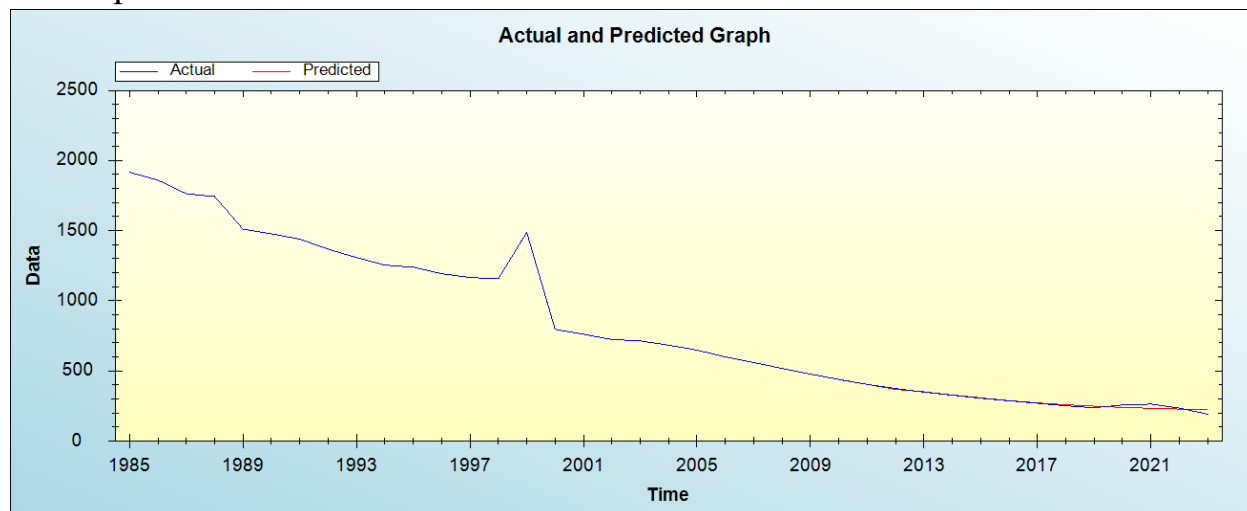


Figure 2: In-sample forecast for the T series

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

Year	Forecasted MMR
2024	219.7480
2025	217.2463
2026	217.3169
2027	215.1930
2028	213.6012
2029	212.4581
2030	212.8227
2031	210.3836
2032	210.0777
2033	209.6726
2034	209.8541
2035	209.6631

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

Out-of-Sample Forecast for T: Forecasts only

Table 2: Tabulated out-of-sample forecasts

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 very high over the out of sample period.



Recommendations & Conclusion

Timor Leste is a post-war country currently faced with a very high burden of maternal mortality. There is a great need to invest in the health sector and other sectors of the economy so that the country can achieve substantial reduction of maternal, under five and neonatal mortality rates. In this study we modelled and forecasted MMR for Timor Leste and findings indicate that MMR will remain very high over the out of sample period. Hence, we implore 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 medical staff in all medical facilities and (5) create posts for obstetricians at government 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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