

ESTIMATION OF EXPECTED FUTURE VALUES OF MATERNAL MORTALITY RATE FOR MALTA USING A MACHINE LEARNING MODEL

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ABSTRACT

This research article employs annual time series data on MMR for Malta 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 low throughout the out of sample period. Therefore, we encourage the government to relentlessly address local drivers of maternal mortality and continue routine surveillance of severe maternal morbidity.

Keywords: ANN, Forecasting, Maternal Mortality Ratio

INTRODUCTION

Maternal mortality is a global public health problem. Nearly 800 women die each day from preventable causes related to pregnancy or childbirth (WHO, 2023). Hemorrhage, hypertensive disorders, and sepsis are responsible for over 50% of maternal deaths worldwide (Khan et al. 2006). In Sub-Saharan Africa, 65% of maternal deaths from hemorrhage occur following delivery (Campbell et al. 2006; Li et al, 1996). Maternal mortality affects low-middle countries more than the developed countries. According to the WHO, at the global level, the maternal mortality ratio in 2020 was estimated at 233 per 100,000 live births (WHO, 2020). However, during the recent years, a significant decline of maternal mortality ratio at the global level was noted, with a reduction 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 the Malta Country Health Profile 2021, in 2020 Malta had an estimated population size of 514 564 inhabitants and in 2019 the overall fertility rate was 1.1 births per woman. The country's gross domestic product in 2020 was revealed to be 28 746 Euros per capita. In the same year, unemployment rate stood at 4.3 percent. Mortality from preventable causes in Malta is among the lowest in the EU. Deaths from treatable causes have dropped in recent years, and are now equal to the EU average. More deaths from cardiovascular diseases, cancers and diabetes could be prevented through more timely and effective diagnosis and treatment. The purpose of this paper is to model and forecast MMR for Malta using a machine learning technique. The results of this paper will highlight future trends of MMR for Malta. This will guide policy, planning and allocation of resources to the health sector in order to eliminate preventable maternal deaths in the country.

LITERATURE REVIEW

Author(s)	Objective(s)	Methodology	Main finding(s)
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 BMI increase was independently associated with new-onset dysglycemia. No independent predictor of T2DM progression was identified. Dyslipidemia was independently associated with higher pre-pregnancy BMI and multiparity, whereas postpartum BMI change was not independently associated after multivariable adjustment
Yue et al. (2026)	to perform an umbrella review to summarize the current evidence to provide a reference for clinicians and future research	Systematic review	Positive aPLs significantly increased the risk of miscarriage rate in assisted reproductive technology (ART) and were also associated with total fetal loss, PE, intrauterine growth retardation and placental abruption
Nunn et al. (2025)	To explore whether changes in key characteristics among Victorian Aboriginal and/or Torres Strait Islander women contributed to reduced perinatal death rates	Retrospective population-based cohort study of all births in Victoria from 2000–2019	Changes in key maternal characteristics may have contributed to improved perinatal death rates among babies of Victorian Aboriginal and/or Torres Strait Islander women
Haninger-Vacariu et al. (2024)	To describe pregnancy and delivery outcomes in women with Fabry disease	Retrospective cohort-study of women with Fabry disease in Austria using a specific questionnaire and the Austrian Mother–Child Health Passport	The cohort-study in women with Fabry disease showed an increase of pain burden during pregnancies and clearly points to an increased risk for preeclampsia, prematurity, and neonates small for gestational age. With a substantial number of high-risk pregnancies, neonatal outcomes are somewhat worse in Fabry disease than in the general public
Kornyicki & Fedor (2024)	to publish findings on the lifestyle factors of pregnant women in Hungary and their impact on early childhood health status by examining changes over time and regional/geographical disparities	Secondary analysis of raw indicators reported by health visitors as per mandatory annual report data for the period of 1997–2019 in Hungary	Interventions to improve early childhood health in some counties of Hungary are urgently needed to reduce regional disparities

Wilhelm et al. (2024)	To describe the contribution of CA to NMR in Malta, investigating possible associations with known maternal risk factors of maternal age, nationality, and education	-Anonymous data for births and neonatal deaths were obtained for 2006-2020 from the National Obstetrics Information System (NOIS) in Malta -applied regression analysis	Between 2006 and 2020, Malta's NMR remained stable. Maternal Nationality, from non-EU low-income countries, was associated with higher neonatal mortality
Diguisto et al. (2022)	To compare maternal mortality in eight countries with enhanced surveillance systems	Descriptive multi-country population-based study	Variations in maternal mortality ratios exist between high income European countries with enhanced surveillance systems
Wami et al. (2022)	To explore both real maternal and fetal-neonatal characteristics associated with Hungarian homebirths	Retrospective cohort study	Aggregated maternal complications (primary uterine inertia, prolonged second stage labor, and third stage hemorrhage) were prevalent among homebirth cases (1.29% vs. 0.72%, $p < 0.05$) and were associated with an average of 11.77% rate of transfer to a health care institution. On the other hand, the rate of operative (vaginal or caesarean) delivery was 26.31% among institutionalized births
Schildberger et al. (2017)	-To investigate the personal meanings and experiences of women with disabilities in regard to pregnancy, childbirth and the puerperium	Conducted semi-structured interviews	Participants reported limited acceptance of their life decisions and experienced an environment of discriminatory attitudes. They experienced a lack of support and lack of confidence in their parenting abilities, which negatively influenced their self-efficacy and self-awareness. Violations of personal borders and a feeling of being watched and controlled were reported

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 Malta.

Data Issues

This study is based on annual MMR in Malta 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	R
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	0.023804
MSE	0.095637
MAE	0.178655

Residual Analysis for the Applied Model

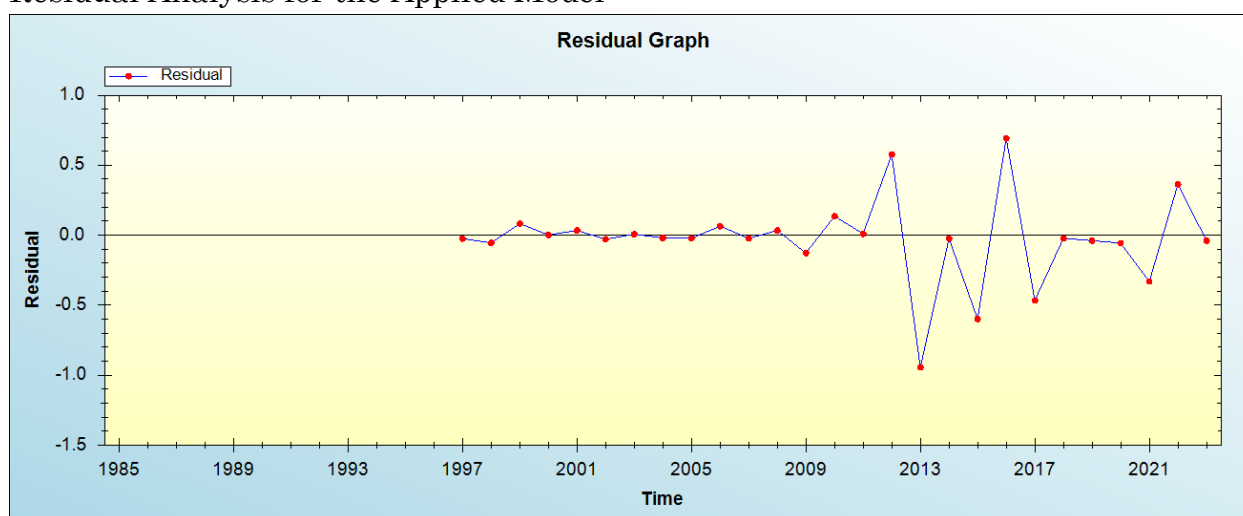


Figure 1: Residual analysis

In-sample Forecast for R

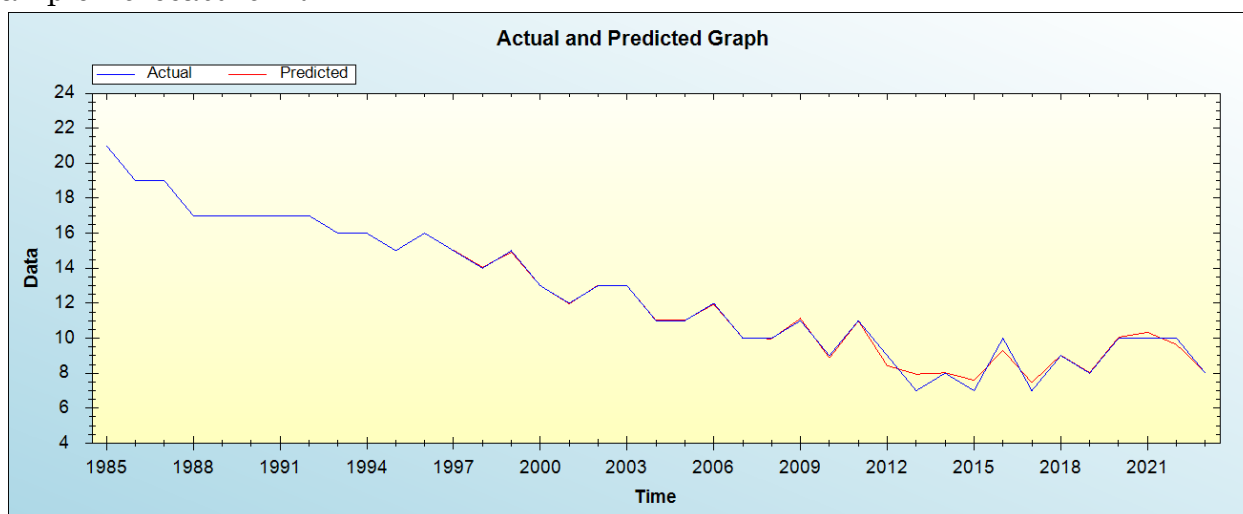


Figure 2: In-sample forecast for the R series

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

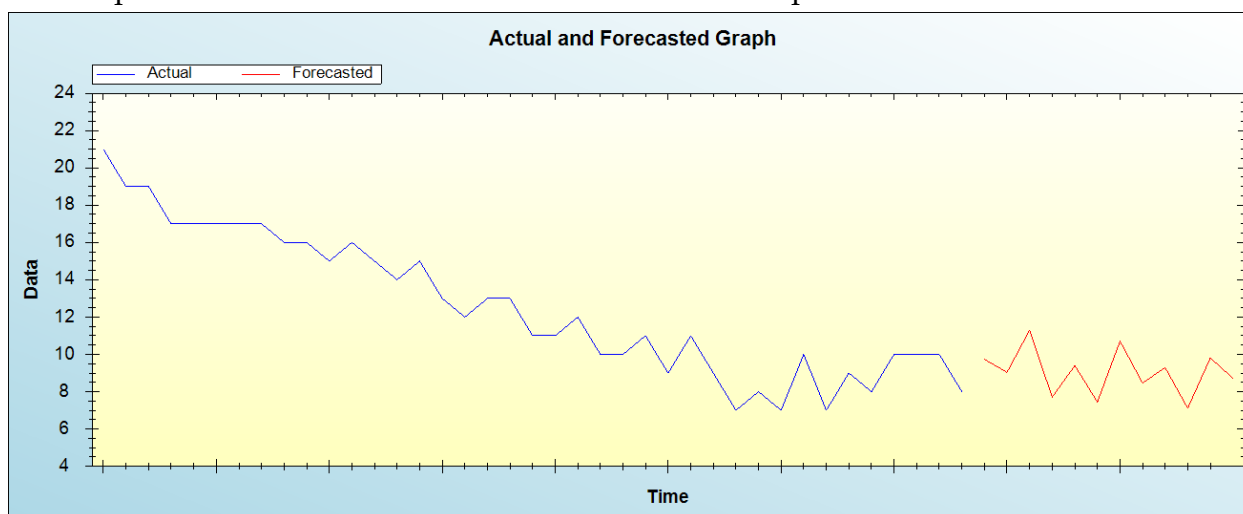


Figure 3: Out-of-sample forecast for R: actual and forecasted graph

Out-of-Sample Forecast for R: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Year	Forecasted MMR
2024	9.7363
2025	9.0326
2026	11.2960
2027	7.7090
2028	9.3978
2029	7.4493
2030	10.7070
2031	8.4598
2032	9.2993
2033	7.1103
2034	9.8043
2035	8.7230

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 low over the out of sample period.

RECOMMENDATIONS & CONCLUSION

Maternal mortality is generally low in Malta and the few cases of maternal deaths are due to indirect causes such as non-communicable diseases. This paper applies a machine learning method to forecast MMR for Malta and findings indicate that MMR will remain very low in the out of sample period. Therefore, we implore authorities to address local causes of maternal deaths and continue reporting of severe maternal morbidities.

REFERENCES

1. Campbell O.M., Graham W.J and Lancet Maternal Survival Series steering group (2006). Strategies for reducing maternal mortality: getting on with what works. The lancet, 368(9543), pp.1284-1299.
2. Khan K.S., Wojdyla D., Say L., Gülmezoglu A.M. and Van Look P.F (2006). WHO analysis of causes of maternal death: a systematic review. The lancet, 367(9516), pp.1066-1074.
3. Li X.F., Fortney J.A., Kotelchuck M. and Glover, L.H (1996). The postpartum period: the key to maternal mortality. International Journal of Gynecology & Obstetrics, 54(1), pp.1-10.
4. Malta Country Health Profile 2021.
5. WBG (2023). Maternal mortality ratio (modeled estimate, per 100,000 live births) 2023. World Bank Open Data. Available: <https://data.worldbank.org>
6. WHO (2020). Maternal Mortality. Available: <https://www.who.int/news-room/fact-sheets/detail/Maternal-mortality>.
7. WHO (2023). Trends in maternal mortality 2000 to 2020: estimates by Who, UNICEF, Unfpa, World Bank Group and UNDESA/Population Division. Geneva: World Health Organization; 2023. Licence: CCBY-NC SA3.0IGO.