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CALCULATION OF ANNUAL MATERNAL MORTALITY RATE FOR THE STATE OF ISRAEL USING A MACHINE LEARNING TECHNIQUE

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Abstract
This research article employs annual time series data on MMR for the State of Israel 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 around 3 deaths per 100 000 live births throughout the out of sample period. Therefore, we encourage the government to address local causes of maternal deaths and continue routine surveillance of severe maternal morbidity.

Keyword(s): - 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). This scourge affects low-middle countries more. 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 World Bank data maternal mortality in the state of Israel has substantially declined over the years as a result of improvements in the quality and accessibility of maternal healthcare services. The purpose of this paper is to model and forecast MMR for the State of Israel using a machine learning technique. The findings of this paper are expected to stimulate an appropriate national response in order to keep maternal deaths under control.

Literature Review

Author(s)	Objective(s)	Methodology	Main finding(s)
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

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			care to community connections is an important consideration to ensure equitable access to routine and emergency care.
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	Retrospective population-based	Changes in key maternal

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	characteristics among Victorian Aboriginal and/or Torres Strait Islander women contributed to reduced perinatal death rates	cohort study of all births in Victoria from 2000–2019	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
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
Pinchas-Mizrachi et al. (2022)	To examine the disparities in breast cancer-related mortality rates among women from urban areas compared to rural areas in Israel	This was a retrospective, follow-up study on mortality from breast cancer among 894,608 Israeli women born between the years of 1940 and 1960	A higher incidence of mortality from breast cancer in Israel was found among urban women compared to rural women (1047.8/100,000 compared to

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			837/100,000, respectively)
Rottenstreich et al. (2020)	To determine the prevalence of obstetric ICU admissions in one medical center in Israel and to characterize this population	In this retrospective study the files of women coded for pregnancy, birth, or the perinatal period and admission to the ICU were pulled for data extraction (2005–2013)	Most pregnancies (71.2%) were uneventful prior to admission. ICU admissions were divided equally between direct (usually hemorrhage) and indirect (usually cardiac disease) obstetric causes
Morong et al. (2017)	This study was a retrospective cohort study of cases of in-hospital maternal deaths in the Ochsner Health System (Louisiana, United States) and the Queensland Health System (Australia) from 1995 to 2013	-to determine if American and Australian women have a similar rate of preventable maternal death and if the deaths were attributable to the same factors	Women from Louisiana, United States and Queensland, Australia have similar rates of preventable maternal death. No statistically significant factors explained trends in Australian maternal death; American maternal mortality was significantly associated with point of entry into prenatal care, likely influenced by insurance status
Nahidi & Hajifoghaha (2017)	To provide the current situation and trend of MMR in the Eastern Mediterranean region between 1990 and 2015	Systematic review	Based on the collected data, 36 out of 66 studies met the required criteria and were chosen for analysis. All countries of this region showed a downward trend between 1990 and

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			2015, and this change varied from 16.30% in Yemen to 76.56% in Lebanon. The maternal mortality reduction was 69.88% in Iran in the same time
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
Bouvier-Colle et al. (2012)	To assess capacity to develop routine monitoring of maternal health in the European Union using indicators of maternal mortality and severe morbidity	Analysis of aggregate data from routine statistical systems compiled by the EURO-PERISTAT project and comparison with data from national enquiries	Currently available data on maternal mortality and morbidity are insufficient for monitoring trends over time in Europe and for comparison between countries

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

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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 the State of Israel.

Data Issues

This study is based on annual MMR in the State of Israel 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	0.003885
MSE	0.099611
MAE	0.172036

Residual Analysis for the Applied Model

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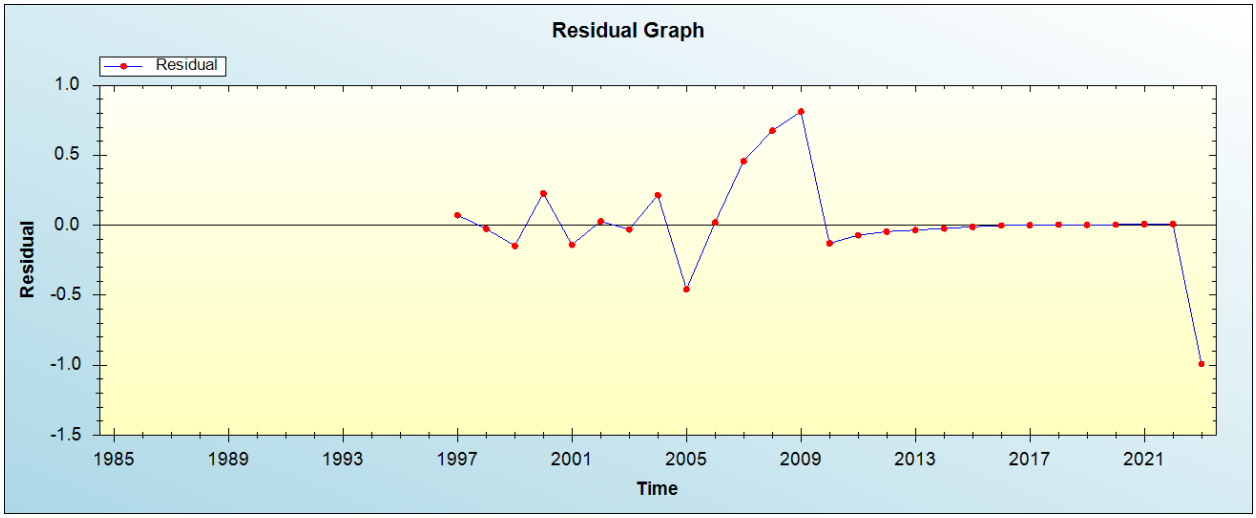


Figure 1: Residual analysis

In-sample Forecast for R

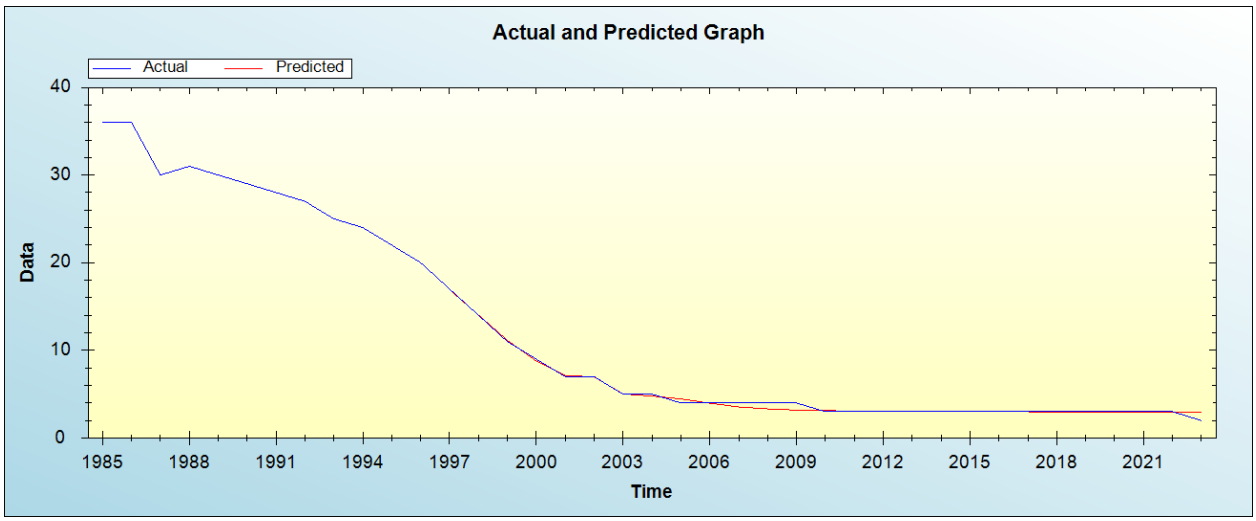


Figure 2: In-sample forecast for the R series

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

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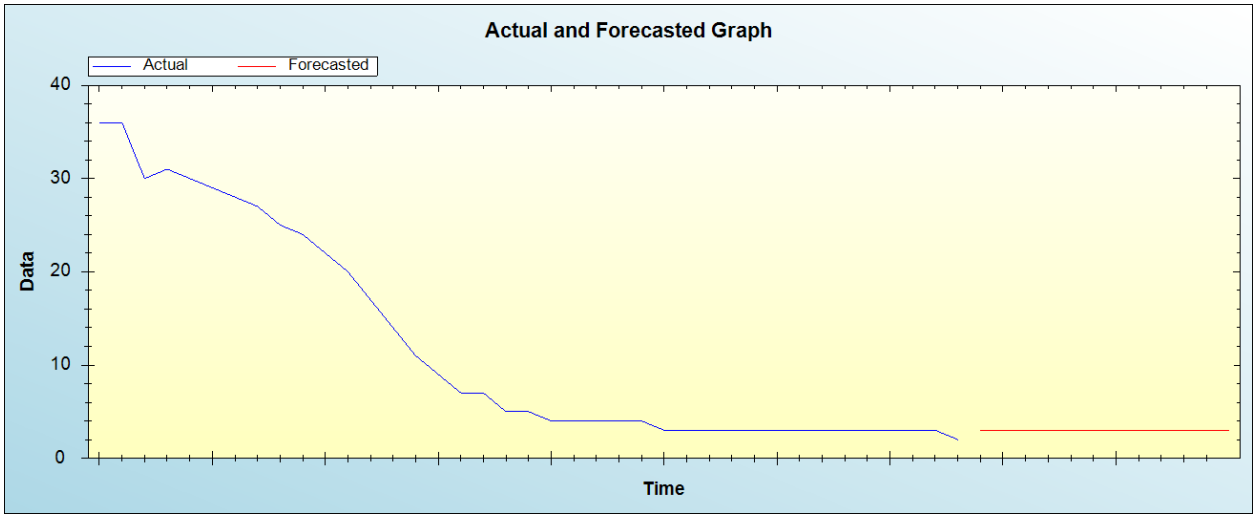


Figure 3: Out-of-sample forecast for R: actual and forecasted graph

Out-of-Sample Forecast for R: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Year	Forecasted MMR
2024	2.9859
2025	2.9826
2026	2.9919
2027	2.9887
2028	2.9846
2029	2.9858
2030	2.9903
2031	2.9869
2032	2.9922
2033	2.9898
2034	2.9870
2035	2.9897

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.

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It is projected that annual MMR will remain around 3 deaths per 100 000 live births throughout the out of sample period.

Conclusion

This study applied the double exponential smoothing method to project MMR for the state of Israel and findings indicate that MMR will remain around 3 deaths per 100 000 live births throughout the forecast period. Therefore, we encourage Israeli authorities to continuously attend to local causes of maternal deaths and continue routine surveillance of severe maternal morbidities.

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