



ANNUAL MATERNAL MORTALITY RATE APPROXIMATION FOR VIETNAM USING HOLT'S LINEAR APPROACH

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Abstract

This study uses annual time series data on MMR for Vietnam from 1985 to 2023 to predict future trends of MMR over the period 2024 to 2035. The study utilizes Holt's double exponential smoothing model. The optimal values of smoothing constants α and β are 0.9 and 0.1 respectively based on minimum MSE. The results of the study indicate that MMR will continue to fall and reach levels around 29 deaths per 100 000 live births by 2030. Therefore, we encourage authorities relentlessly address local causes of maternal deaths across the country.

Keywords: Exponential smoothing, Forecasting, Maternal Mortality Ratio

Introduction

Maternal health is one of the top priorities in Vietnam as highlighted in the National Strategy on Reproductive Health 2001-2010 (MOH, 2000). Maternal mortality ratio (MMR) stood at 165/100 000 live births in 2001 and much higher in remote and mountainous regions hovering around 411/100 000 live births (WHO, 2005; MOH, 2002). The Vietnamese government has made significant progress in the reduction of maternal mortality across the country by implementing several strategies which yielded positive results (MOH, 2012; MOH, 2003). The objective of this paper is to model and forecast MMR for Vietnam using the double exponential smoothing technique. The findings of this paper are expected to highlight likely future trends of MMR. This will inform policy, planning and allocation of adequate resources to the health sector with a view of controlling preventable maternal deaths.



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
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.
Dinh et al. (2025)	to assess the prevalence of PPD and identify associated risk factors among postpartum women in central Vietnam	A cross-sectional study was conducted on 906 women who delivered at Hue Central Hospital from May 2022 to May 2023	Nearly one in six women in this Vietnamese cohort experienced PPD. Key risk factors were social and reproductive, highlighting the importance of addressing marital



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			status, pregnancy planning, partner violence, and familial support
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 2022–2024 management period at Tartagal Hospital (HT)	Participatory Action Research (PAR) with a qualitative-quantitative analysis. Twelve 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	intercultural, comprehensive, and territory-based management of pregnancy and childbirth led to a reduction in 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
Win et al. (2024)	to summarize all possible factors influencing maternal mortality in CLMV countries	Systematic review	Low utilization rates were due to several supply-side constraints
Nguyen et al. (2023)	to analyze and synthesize the findings of studies on PPD examining the symptoms, consequences, and management strategies among Vietnamese women	Scoping review	PPD in Vietnam has not been sufficiently managed; mothers tend to seek help from ‘fortune-tellers’ or ‘word-of-mouth’ practices rather than from evidence-based modern medicine
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)
Romero et al. (2021)	To describe epidemiological and clinical characteristics of pregnant women with malaria in southern Venezuela	A retrospective study in pregnant women attending at the “Ruíz y Páez” University Hospital Complex, Bolívar state, Venezuela, was carried out between February and	A high prevalence of maternal–fetal complications was found in the studied population



		October, 2019. Epidemiological, clinical, and laboratory information was analyzed	
Do et al. (2018)	to identify the prevalence of PPD and the risk factors contributing to PPD in Vietnam	Cross-sectional study	Level of education, diseases during pregnancy, being the first-time mothers, dissatisfaction about family, and limited communication and interaction with others were significant predictors of PPD.

Methodology

This study utilizes an exponential smoothing technique to model and forecast future trends of MMR for Vietnam. In exponential smoothing forecasts are generated from the smoothed original series with the most recent historical values having more influence than those in the more distant past as more recent values are allocated more weights than those in the distant past. This study uses the Holt's linear method (Double exponential smoothing) because it is an appropriate technique for modeling linear data.

Holt's linear method is specified as follows:

Model equation

$$V_t = \mu_t + \rho_t t + \varepsilon_t$$

Smoothing equation

$$S_t = \alpha V_t + (1-\alpha) (S_{t-1} + b_{t-1})$$

$$0 < \alpha < 1$$

Trend estimation equation

$$b_t = \beta (S_t - S_{t-1}) + (1-\beta) b_{t-1}$$

$$0 < \beta < 1$$

Forecasting equation

$$f_{t+h} = S_t + h b_t$$

V_t is the actual value of MMR at time t

ε_t is the time varying **error term**

μ_t is the time varying mean (**level**) term

ρ_t is the time varying **slope term**

t is the trend component of the time series

S_t is the exponentially smoothed value of MMR at time t



α is the exponential smoothing constant for the data

β is the smoothing constant for trend

f_{t+h} is the h step ahead forecast

b_t is the trend estimate (slope of the trend) at time t

b_{t-1} is the trend estimate at time t-1

Data Issues

This study is based on annual MMR in Vietnam 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

Exponential smoothing Model Summary

Table 1: ES model summary

Variable	V
Included Observations	39
Smoothing constants	
Alpha (α) for data	0.900
Beta (β) for trend	0.100
Forecast performance measures	
Mean Absolute Error (MAE)	3.492323
Sum Square Error (SSE)	1527.386592
Mean Square Error (MSE)	39.163759
Mean Percentage Error (MPE)	1.095259
Mean Absolute Percentage Error (MAPE)	3.472525



Residual Analysis for the Applied Model

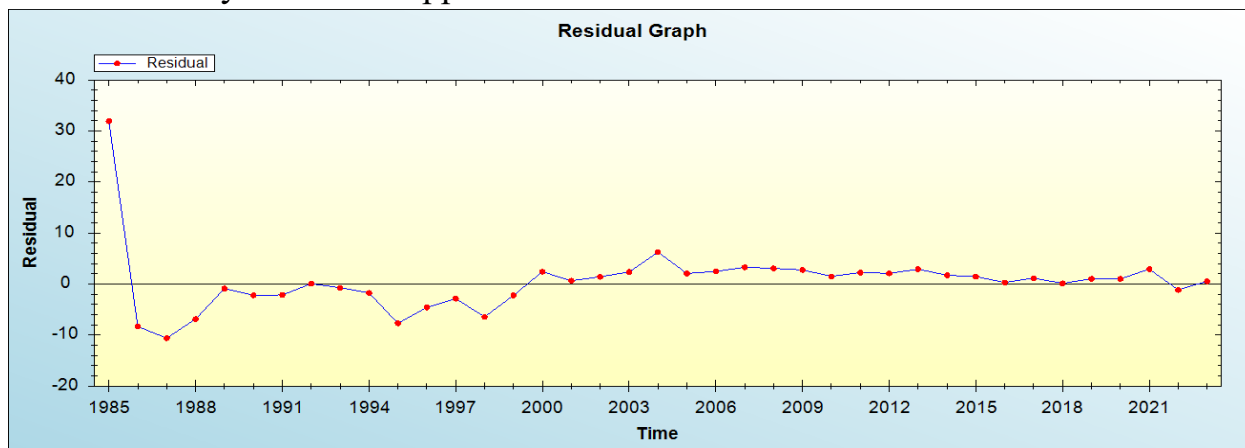


Figure 1: Residual analysis

In-sample Forecast for V

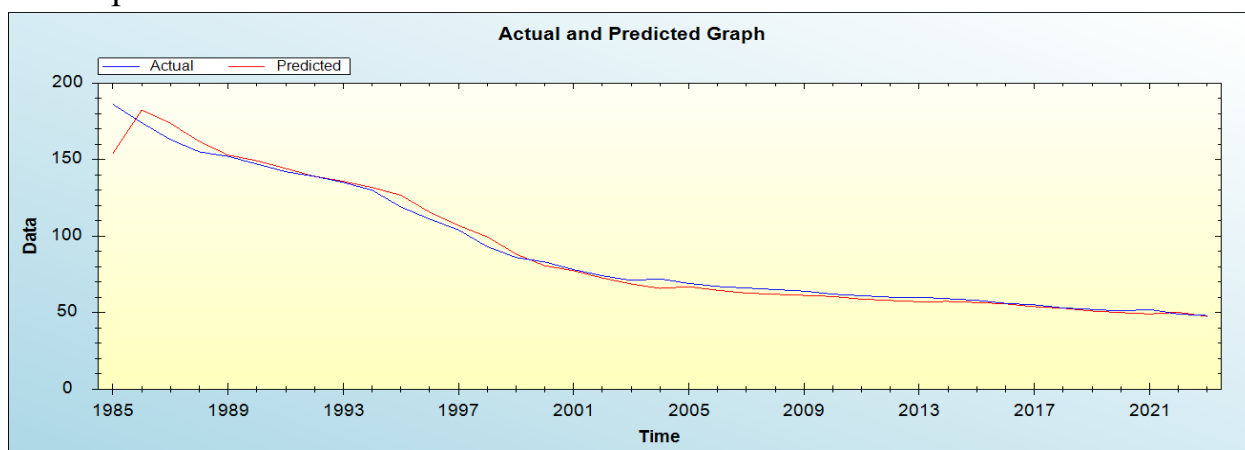


Figure 2: In-sample forecast for the V series

Actual and Smoothed graph for V series

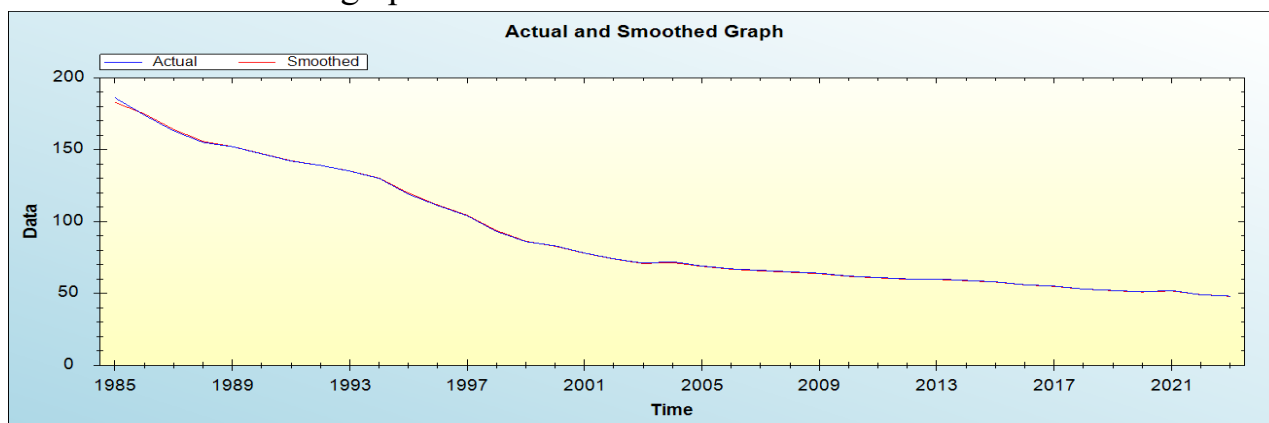


Figure 3: Actual and smoothed graph for V series



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

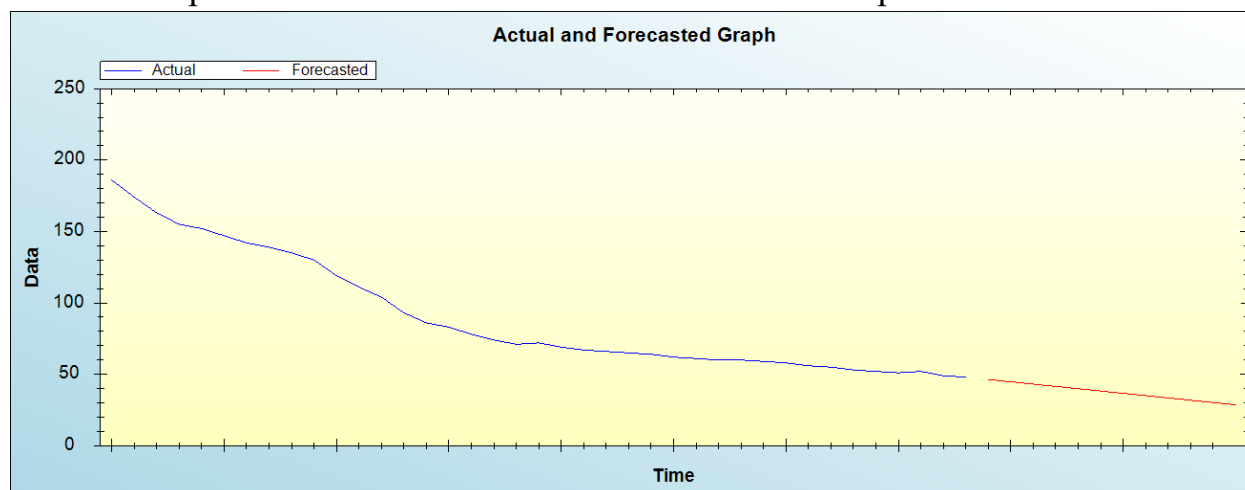


Figure 4: Out-of-sample forecast for V: actual and forecasted graph

Out-of-Sample Forecast for V: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Year	Forecasted MMR
2024	46.3321
2025	44.7189
2026	43.1057
2027	41.4926
2028	39.8794
2029	38.2662
2030	36.6530
2031	35.0399
2032	33.4267
2033	31.8135
2034	30.2004
2035	28.5872

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 continue to fall and reach around 29 deaths per 100 000 live births by 2035. **Conclusion**



In this paper, the double exponential smoothing technique was applied to model and forecast MMR for Vietnam and findings indicate that MMR will continue to fall and reach levels around 29 deaths per 100 000 live births by 2035. Hence, we encouraged health authorities in this country to relentlessly address local drivers of maternal deaths.

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