



ANNUAL MATERNAL MORTALITY RATE FORECASTING FOR THAILAND USING THE HOLT'S LINEAR METHOD

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Abstract

This study uses annual time series data on MMR for Thailand 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 0.2 and 0.2 respectively based on minimum MSE. The results of the study indicate that MMR is expected to increase from around 52 in 2024 to about 79 deaths per 100 000 live births in 2035. Therefore, we encourage authorities to attend to local causes of maternal deaths and channel more resources towards the implementation of quality improvement activities.

Keywords: Exponential smoothing, Forecasting, Maternal Mortality Ratio.

Introduction

Maternal death refers to the demise of a woman whilst pregnant or within 42 days of termination of pregnancy, regardless of the duration and the site of the pregnancy, from any causes related to or aggravated by the pregnancy or its management but not from accidental or incidental causes according to the World Health Organization (WHO, 2015). Most maternal deaths are reported in low-middle countries. Nearly 830 women die per day worldwide due to pregnancy-related causes, which can be avoided. Direct obstetric causes include hemorrhage, sepsis and obstructed labor, while indirect causes encompass conditions like pregnancy-associated heart disease (WHO, 2012). The global maternal mortality ratios (MMR) vary significantly due to factors such as individual behavioral traits, obstetric service accessibility/quality, socioeconomic/cultural contexts, and



external environments (Mc Call et al. 2017). The World Health Organization estimated that 303,000 women worldwide will have died by the end of 2015 during and following pregnancy and childbirth. A recent World Health Organization report highlighted that maternal mortality has declined by 43% worldwide; however, maternal death is still high in sub-Saharan Africa and South Asia (WHO, 2023). Southeast Asia had an MMR of 134 per 100,000 live births in 2020, but internal disparities still exist. Countries like Indonesia, Myanmar, and Laos have persistently high regional MMR; Indonesia, for example, recorded an MMR of 249 per 100,000 live births in 2020 (Syairaji et al. 2024; Sysavanh et al. 2019; WHO, 2015). In 2023, roughly 260,000 maternal deaths were reported worldwide, with Southeast Asia contributing 20% (Lancet Reg Health Southeast Asia, 2023). The aim of this paper is to model and forecast MMR for Thailand using Holt's linear method. The study findings will facilitate crafting of regional policies and effective strategies that will further reduce preventable maternal deaths.

Literature Review

Author(s)	Objective(s)	Methodology	Key finding(s)
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, 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. Analysis: 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	Regional Trends: The ASMR in Southeast Asia fell by 59%, dropping from 255.88 in 1990 to 104.56 per 100,000 live births by 2021
Soni et al. (2025)	to explore the prevalence of institutional delivery and its determinants in five South Asian countries	Data were extracted from five South Asian countries latest demographic and health survey data, including Afghanistan (2015), Bangladesh (2017–18), Nepal (2016), Myanmar (2015–16), and Pakistan (2017–18)	Women who didn't take any health care decision by-self had 16% lower chance of getting institutional delivery facility than others. Most importantly, rural area in south Asian countries presented lower odds of receiving healthy facility during delivery (OR 0.63, [0.59, 0.68])



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Rahman et al. (2024)	to assess socioeconomic disparities in the utilization of health care services by mothers and to determine the factors influencing this utilization among women aged 15 to 49 in five South Asian countries	Applied logistic regression	Several socioeconomic and sociodemographic variables of the individual population, as well as policy issues, all have an impact on maternal mortality
Baig et al. (2023)	to examine and critically evaluate existing literature on perceptions and investigations regarding maternal mortality in Southeast Asia, Europe and Africa, utilizing the three delays model approach as a categorization framework	Systematic review	primary cause of maternal mortality is the first delay, which refers to the lack of awareness in seeking medical care. On the other hand, in Africa and other European countries, the second and third delays are more prominently associated with maternal mortality
Aziz et al. (2021)	To explore the relationship between health expenditure and maternal mortality by using data set consisting of 18 years from 2000 to 2017	Fully modified ordinary least squares (FMOLS) and dynamic ordinary least squares (DOLS) models were employed for the empirical analysis	The findings revealed that population growth has a significant long-term effect on maternal mortality—an increase of 40% in the case of FMOLS and 10% in the case of DOLS—and infers that an increase in population growth has also dampened efforts towards reducing maternal mortality in the South Asian panel
Liabsuetrakul et al. (2019)	To estimate the trend and projection of cesarean section rates (CSRs) and explore correlations between CSRs with adverse maternal and perinatal outcomes, namely maternal mortality	A secondary analysis of the hospital-based database of pregnant women and newborns under the Thai Universal Coverage Scheme between January 2009 and December 2017 was conducted	CSRs in Thailand continuously increased and were correlated with adverse maternal and perinatal outcomes



	ratios (MMRs), rates of postpartum hemorrhage (PPH), neonatal mortality rates (NMRs), and birth asphyxia per 1,000 live births across all regions of Thailand		
Sharma et al. (2018)	This was a systematic review on the effectiveness of community interventions in improving maternal health care outcomes in South Asia	Systematic review	Women's education interventions may improve the number of women seeking birth at a health care facility, but the evidence is of low quality
Girum and Wasie (2017)	to identify correlates of maternal mortality in developing countries	Scoping review	Maternal mortality is correlated with multiples of socio-economic factors, health care system associated factors, disease burden and their complex interactions
Chandoevrit et al. (2016)	to systematically measure maternal mortality in Thailand and show disparity between age groups and regions	Secondary data analysis	using multiple administrative data sources in the two-stage method was an efficient method that provided systematic measurement and timely reporting on the maternal mortality ratio
Bhandari (2012)	to assess the maternal and child health status in South East Asia Region	Systematic review	In the South East Asia, there is wide divergence in socio-economic and health status among the countries. More than one-third of maternal and child deaths of global mortality occurs in this region. Many countries in this region are unlikely to achieve the Millennium Development Goals 4 and 5 even if maternal child health is made the priority agenda of all the countries

Methodology

This study utilizes an exponential smoothing technique to model and forecast future trends of MMR for Thailand. 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 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

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

Smoothing equation

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

$$0 < \alpha < 1$$

Trend estimation equation

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

$$0 < \beta < 1$$

Forecasting equation

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

A_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 Thailand 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	A
Included Observations	39
Smoothing constants	
Alpha (α) for data	0.200
Beta (β) for trend	0.200
Forecast performance measures	
Mean Absolute Error (MAE)	6.582118
Sum Square Error (SSE)	7790.573754
Mean Square Error (MSE)	199.758301
Mean Percentage Error (MPE)	2.063029
Mean Absolute Percentage Error (MAPE)	11.136224

Residual Analysis for the Applied Model

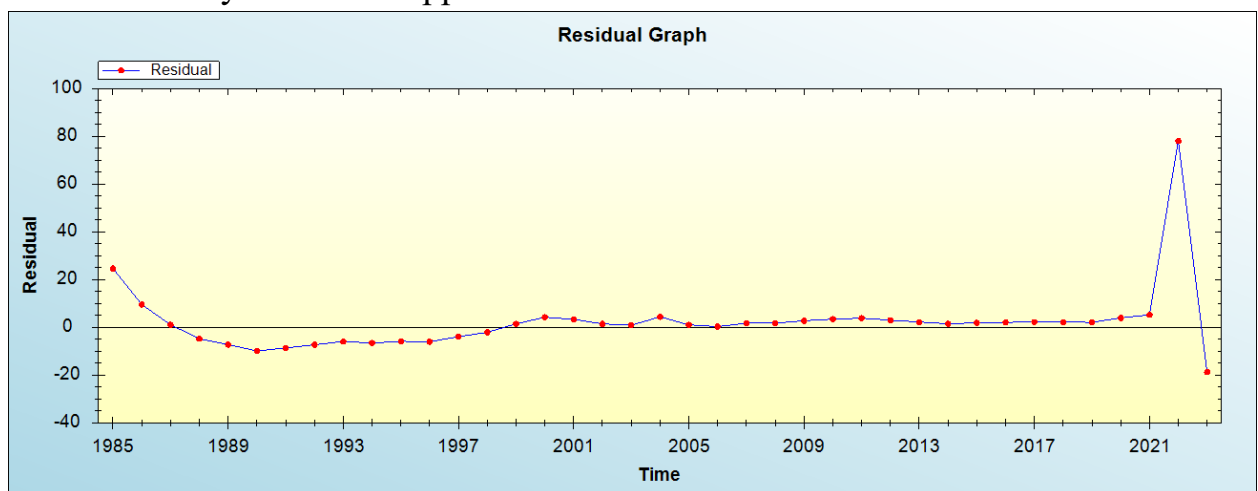


Figure 1: Residual analysis



In-sample Forecast for A

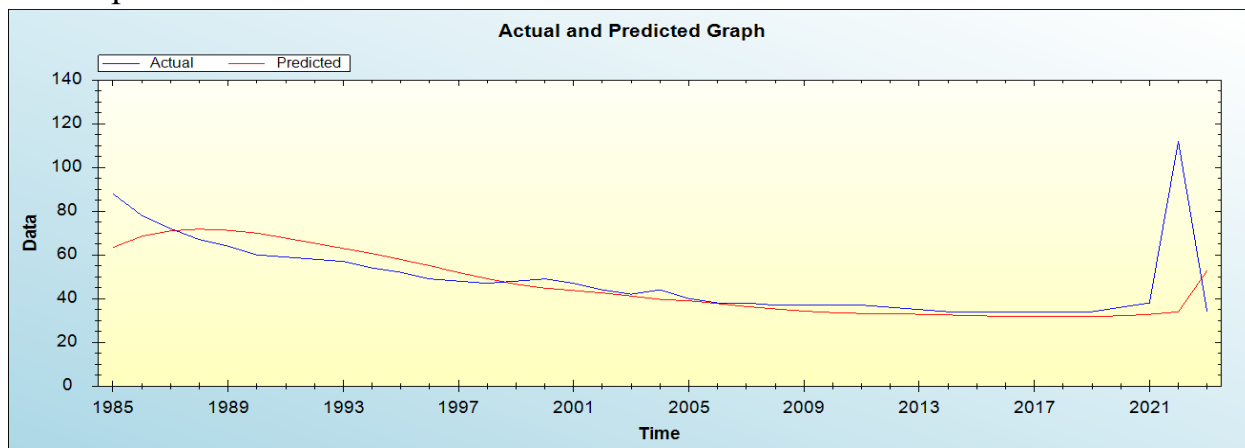


Figure 2: In-sample forecast for the A series

Actual and Smoothed graph for A series

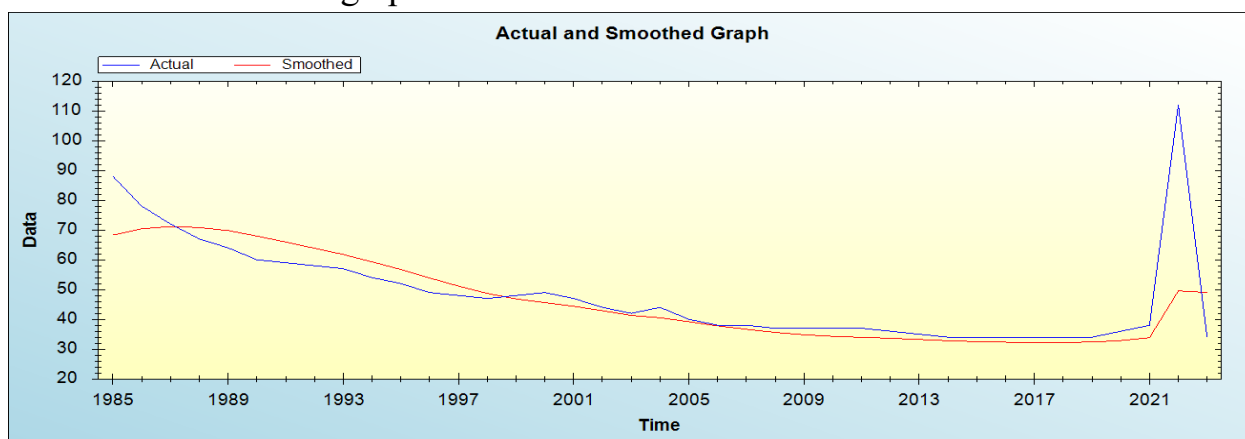


Figure 3: Actual and smoothed graph for A series

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

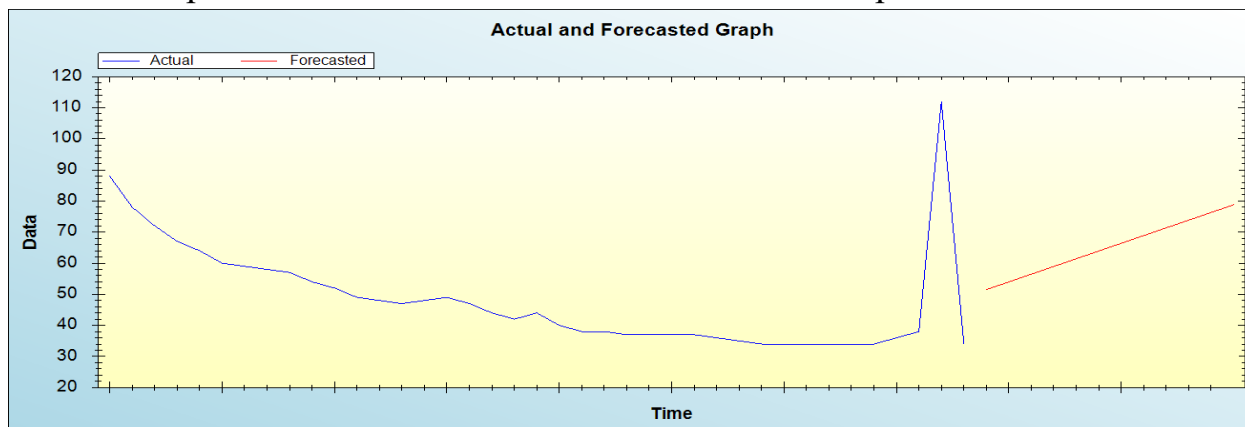


Figure 4: Out-of-sample forecast for A: actual and forecasted graph



Out-of-Sample Forecast for A: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Year	Forecasted MMR
2024	51.5070
2025	53.9885
2026	56.4701
2027	58.9516
2028	61.4332
2029	63.9147
2030	66.3963
2031	68.8778
2032	71.3594
2033	73.8409
2034	76.3224
2035	78.8040

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 is expected to increase from around 52 in 2024 to about 79 deaths per 100 000 live births in 2035.

Recommendations & Conclusion

This paper used the technique to model and forecast MMR for Thailand and results indicate that MMR is expected to increase from around 52 in 2024 to about 79 deaths per 100 000 live births in 2035. Hence, we implore health authorities to direct its effort towards addressing local causes of maternal deaths and implementation of quality improvement strategies.



References

1. McCall S.J., Nair M., and Knight M (2017). Factors associated with maternal mortality at advanced maternal age: a population-based case-control study. BJOG. 2017;124(8):1225–33.
2. Syairaji M., Detty Siti Nurdiati., and Bayu Satria Wiratama (2024). Trends and causes of maternal mortality in Indonesia: a systematic review. BMC pregnancy and childbirth.
3. Sysavanh Phommachanh., Dirk Essink., and Maaïke Jansen (2019). Improvement of quality of antenatal care (ANC) service provision at the public health facilities in Lao PDR: perspective and experiences of supply and demand Sides. BMC pregnancy and childbirth.
4. The Lancet Regional Health-Southeast Asia. Life-course approach for maternal and child health: much to do. Lancet Reg Health Southeast Asia. 2023; 15:100263.
5. WHO (2015). Health in 2015 from MDGs to SDGs. Geneva.
6. WHO (2023). The Global Health Observatory Explore a world of health data [Internet]
7. 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). Geneva
8. World Health Organization (2015). (WHO) Factsheet/maternal health topic.