

PREDICTION OF MATERNAL MORTALITY FOR MYANMAR USING THE DOUBLE EXPONENTIAL SMOOTHING MODEL

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ABSTRACT

This study uses annual time series data on MMR for Myanmar 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 but remain relatively high throughout the out of sample period. Therefore, we encourage authorities to adopt the suggested 5-fold policy prescription.

Keywords: Exponential smoothing, Forecasting, Maternal Mortality Ratio.

INTRODUCTION

Maternal mortality remains a huge global health issue because of the negative impact it has on the family and community (Geetika et al. 2015). Approximately 80% are as a result of causes directly related to pregnancy (Kwale et al. 2005). The World Health Organization (WHO) data indicates that more than a quarter million women die worldwide because of complications during childbirth or pregnancy (WHO, 2014), with the majority of these deaths occurring in developing countries. For every woman who dies from obstetric complications, many more face injuries, disabilities and infections (WHO, 2010). Most of these deaths and complications could be prevented if all women gave birth with the assistance of skilled midwives (Khanal et al. 2015). The purpose of antenatal care is to improve and monitor the welfare of both mother and fetus, identify potential problems, prepare women for childbirth and child rearing and respond to their complaints (WHO, 2009). Myanmar continues to face several challenges in improving maternal and child health outcomes. Current data shows that the maternal mortality ratio in Myanmar is around 250 deaths per 100,000 live births, whereas the under-five mortality rate is 46 per 1,000 live births (Syairaji et al. 2024). These figures are higher in rural areas, where healthcare infrastructure is lacking and access to essential maternal and child health services is limited (Benner et al. 2024). The disparity in healthcare services between urban and rural areas of Myanmar exacerbates the situation. In urban regions, healthcare facilities are more readily available, staffed by trained professionals, and equipped with modern medical technology. However, rural regions, where 70% of Myanmar's population lives, encounter a severe shortage of healthcare workers, limited medical supplies, and inadequate transportation infrastructure (Moon et al. 2023). This urban-rural divide is a major factor that drives higher mortality rates observed in rural populations (Kim et al. 2023). The objective of this paper is to model and forecast MMR for Myanmar using the double exponential smoothing technique. The findings of this study will

guide policy, planning and allocation of resources to the health sector. This will help in further reducing preventable maternal deaths.

LITERATURE REVIEW

Author(s)	Objective(s)	Methodology	Main 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 and 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 -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	The ASMR in Southeast Asia fell by 59%, dropping from 255.88 in 1990 to 104.56 per 100,000 live births by 2021. This decline was primarily driven by reduced rates of maternal hemorrhage and hypertensive disorders. Progress slowed during the 1997 Asian financial crisis yet picked up pace after 2000
Singh & Swain (2025)	to explore the factors influencing CDMR and its effect on maternal and fetal outcomes	Prospective cohort study	The prevalence of CDMR was 21.35%, which was relatively higher than the World Health Organization's recommended guidelines
Kwee et al. (2024)	To evaluate the impact of healthcare access on maternal and child mortality rates in the rural region of Kayin State, Myanmar, where disparities in healthcare services significantly affect vulnerable populations	cross-sectional study design	The findings reveal alarming maternal mortality rates of 250 per 100,000 live births and child mortality rates of 80 per 1,000 live births in rural areas, compared to urban counterparts. Major barriers identified include geographic isolation, economic challenges, and cultural factors limiting healthcare utilization
Phan et al. (2024)	To examine the association between health insurance coverage and antenatal care (ANC) visits during pregnancy	The study 19 utilized data from the 2021-22 Cambodia Demographic and Health Surveys (CDHS). A total of 20 3,162 weighted women who gave birth within two years were included in the analysis. Multiple logistic regression analysis assessed the association between health insurance coverage and pregnant women who attended at least four antenatal care visits during pregnancy	Having health insurance coverage was significantly associated with four or more 31 ANC visits
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
Hossain et al. (2023)	To report the current level and major causes of maternal deaths in Bangladesh, focusing on care-seeking practices, timing, and place of deaths	-analyzed data from the 2016 Bangladesh Maternal Mortality and Health Care Survey (BMMS), conducted with nationally representative sample of 298 284 households -adapted the World Health Organization's 2014 verbal	Nineteen per cent of the maternal deaths occurred at home, another 19% in-transit, almost half (49%) in a public facility, and 13% in a private hospital. Hemorrhage contributed to 31% and eclampsia to 23% of the maternal deaths. Twenty-one

		autopsy (VA) questionnaire. Trained physicians reviewed the responses and assigned the cause of death based on the International Classification of Diseases (ICD-10)	per cent of the maternal deaths occurred due to indirect causes
Jabeen et al. (2023)	To examine the current levels, trends, time of death, and care-seeking practices for hemorrhage-related maternal deaths in Bangladesh	-conducted a secondary analysis with data from the nationally representative 2001, 2010, and 2016 Bangladesh Maternal Mortality Surveys (BMMS) -The cause of death information was collected through verbal autopsy (VA) interviews using a country-adapted version of the standard World Health Organization VA questionnaire	Postpartum hemorrhage remains the primary cause of maternal mortality in Bangladesh
Win et al. (2023)	to summarize all possible factors influencing maternal mortality in CLMV countries	Systematic review	Poor family income, illiteracy, low education levels, living in poor households, and agricultural and unskilled manual job types of mothers contributed to insufficient antenatal care
Lwin et al. (2022)	To examine factors influencing institutional maternity service utilization and identified the need for improved maternal health outcomes	cross-sectional study design	A greater number of ANC visits and level of the couple's education had a positive association with institutional delivery
Singh et al. (2022)	to inform on potential options for measuring maternal mortality	Applied a case study approach to compare methodologies and estimates of pregnancy-related mortality ratio (PRMR)/maternal mortality ratio (MMR) obtained from four different data sources from similar time periods in Bangladesh, Mozambique, and Bolivia—national population census; post-census mortality survey; household sample survey; and sample vital registration system (SVRS)	For Bangladesh, PRMR from the 2011 census falls closely in line with the 2010 household survey and SVRS estimates, while SVRS' MMR estimates are closer to the PRMR estimates obtained from the household survey. Mozambique's PRMR from household survey method is comparable and shows an upward trend between 1994 and 2011, whereas the post-census mortality survey estimated a higher MMR for 2007. Bolivia's DHS and post-census mortality survey also estimated comparable MMR during 1998–2003
Chham et al. (2021)	to explore the coverage level of the Optimal CoC by (1) measuring the continuity of optimal antenatal care (ANC), skilled birth attendance (SBA) and optimal post-natal care (PNC), (2) identifying the determinants of dropping out from one service to another and (3) of not	The study employed data from the Cambodia Demographic Health Survey 2014. We restricted our analysis to married women who had a live birth in the five years preceding the survey (n = 5678). Bi-variate and multivariate logistic regression were performed using STATA version 14	Household wealth was found to be the most influential factor, yet the study discovered also other barriers to optimal maternal health care which need to be addressed

	achieving the complete CoC		
Akhter, & Alam. (2019)	-to present the trends of maternal and neonatal mortality - to explain the maternal and neonatal mortality rate by background characteristics and the causes of maternal and neonatal deaths in Bangladesh on the basis of South Asian perspective	The main source of data collection and analysis was the secondary sources, from different journals and project reports published between the years 2001 to May 2018	In Bangladesh, 35% maternal deaths occurred as indirect causes and 9% causes of deaths are still remaining unidentified. hemorrhage (31%) and pre-eclampsia-eclampsia (20%) are found two vital causes of maternal deaths with two more causes which are due to obstructed labor (7%), and termination of pregnancy (1%)
Akhter et al. (2018)	to present, analyze and interrelate recent data to find barriers to achieving set MDG 5 targets by 2015	literature review has been done as a main method of data collection from Elsevier, Lancet, WHO, UNICEF, BBMS, NIPORT published from 2001 to May 2018	approximately 80% of maternal deaths could be averted if women had access to essential maternity and basic health care services
Kabir et al. (2018)	to identify the relationship between socio-demographic characteristics of Myanmar women and utilization of antenatal care services	This was a descriptive cross-sectional study utilizing the Myanmar Demographic and Health Survey Data 2015-16. A total of 13,454 women aged between 15-49 years were surveyed. This study sampled married women only (n=7870).	The study found that women with no education, poorer socioeconomic status, less access to mass media, living in rural areas and with more children were not utilizing ANC services adequately
Begum et al. (2017)	To identify indications and determinants of C-sections	Retrospective study	During 2013, facility delivery rate was 84% and population-based C-section rate was 35% of all deliveries in icddr,b service area. Of all C-sections, only 1.4% was conducted for Absolute Maternal Indications (AMIs). Major indications of C-sections included: repeat C-section (24%), fetal distress (21%), prolonged labor (16%), oligohydramnios (14%) and post maturity (13%)
Girum and Wasie (2017)	-to identify correlates of maternal mortality in developing countries	Literature review	-Maternal mortality ratio is very high in developing countries and enormously varies among countries -A significant relationship between the maternal mortality ratio and socio-economic, health care and morbidity indicator variables was observed

METHODOLOGY

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

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

Smoothing equation

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

$$0 < \alpha < 1$$

Trend estimation equation

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

$$0 < \beta < 1$$

Forecasting equation

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

M_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 Myanmar 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	M
Included Observations	39
Smoothing constants	
Alpha (α) for data	0.900
Beta (β) for trend	0.100
Forecast performance measures	
Mean Absolute Error (MAE)	9.634432
Sum Square Error (SSE)	8553.028922
Mean Square Error (MSE)	219.308434
Mean Percentage Error (MPE)	0.770359
Mean Absolute Percentage Error (MAPE)	2.904474

Residual Analysis for the Applied Model

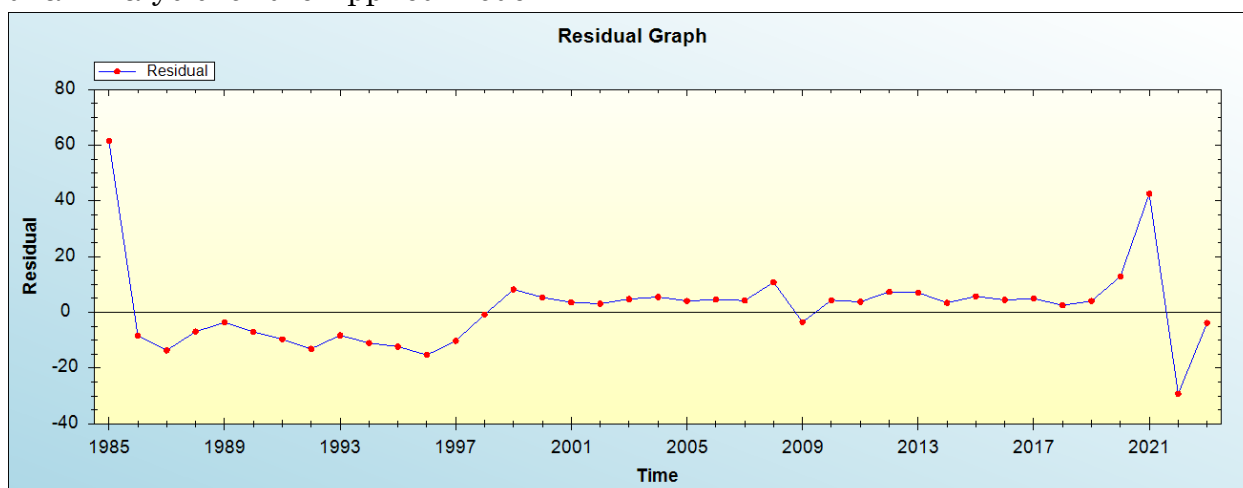


Figure 1: Residual analysis

In-sample Forecast for M

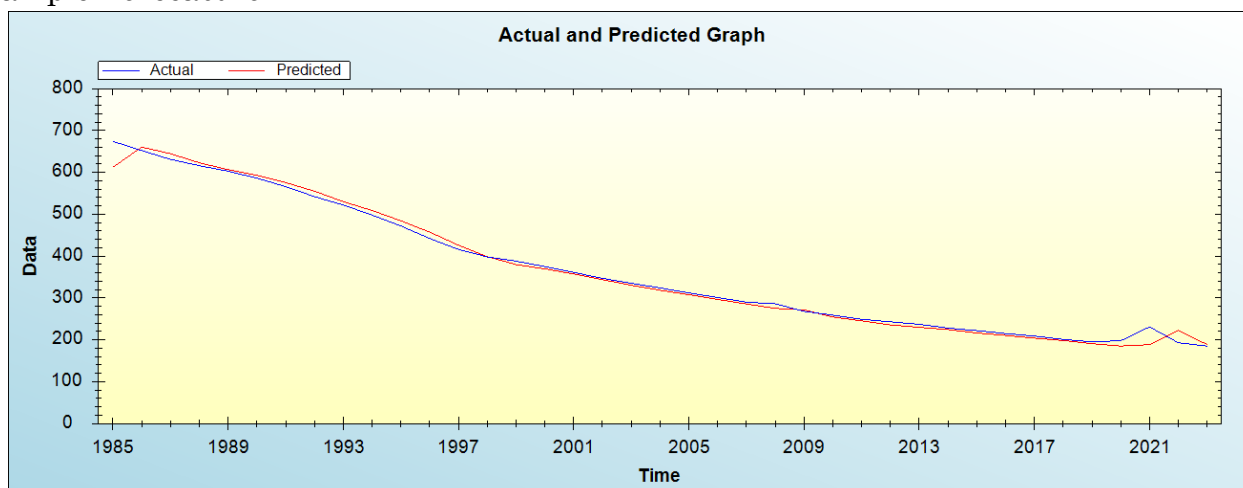


Figure 2: In-sample forecast for the M series

Actual and Smoothed graph for M series

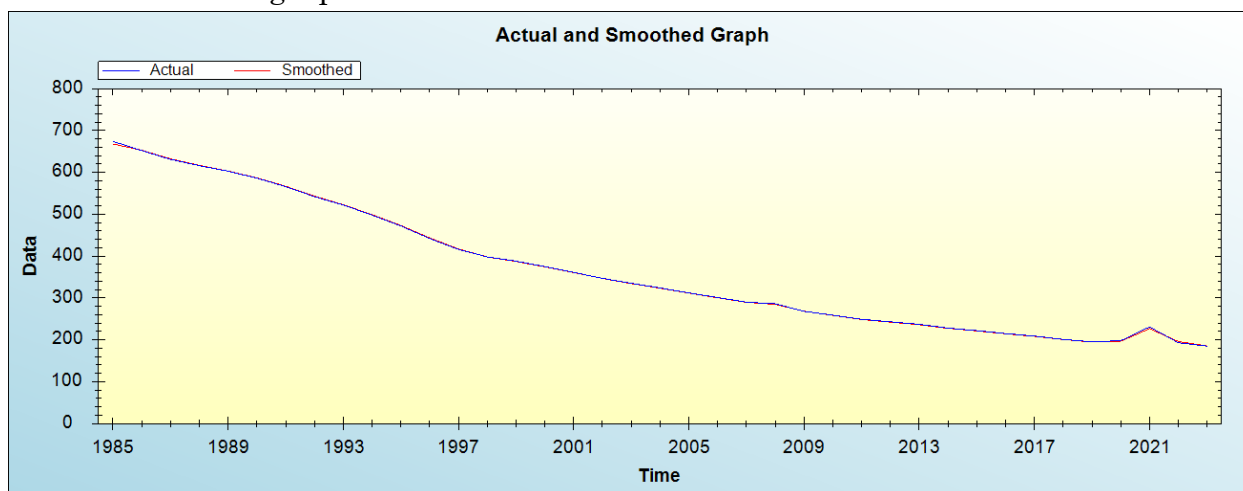


Figure 3: Actual and smoothed graph for M series

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

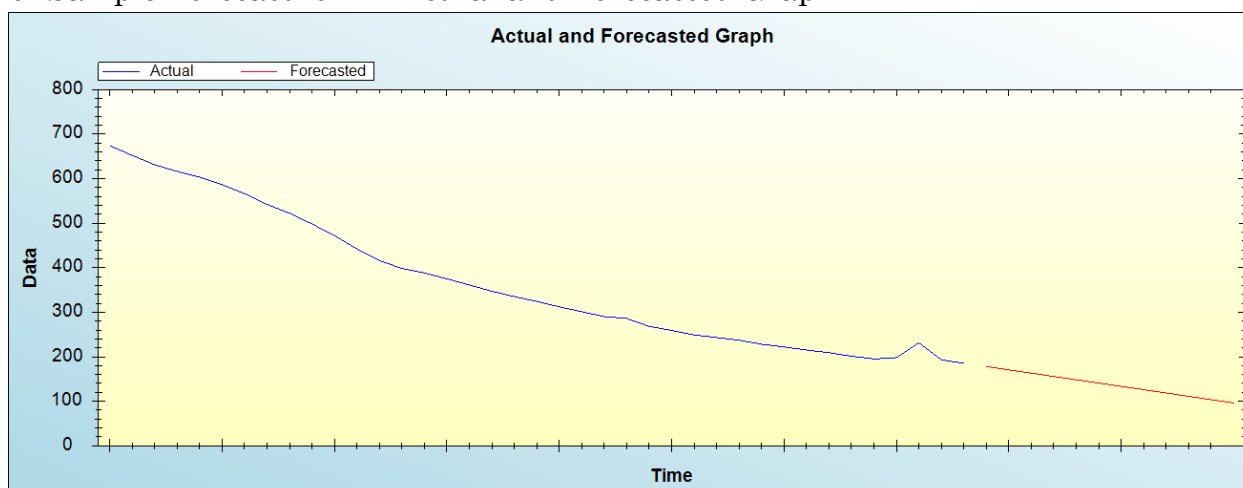


Figure 4: Out-of-sample forecast for M: actual and forecasted graph

Out-of-Sample Forecast for M: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Year	Forecasted MMR
2024	177.9531
2025	170.5217
2026	163.0903
2027	155.6590
2028	148.2276
2029	140.7963
2030	133.3649
2031	125.9336
2032	118.5022
2033	111.0708
2034	103.6395
2035	96.2081

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 but still remain relatively high over the out of sample period.

RECOMMENDATIONS & CONCLUSION

Myanmar has a high burden of maternal mortality reflecting numerous challenges being encountered by pregnant mothers. These high maternal mortality rates are an urgent call for a quick and appropriate national response to curb maternal deaths especially in the rural areas where access to healthcare services is a challenge. Rural areas tend to have shortage of medical supplies, commodities and medical staff. This paper applies the double exponential smoothing approach to model and forecast MMR for Myanmar and findings indicate that MMR is expected to continue to fall but remain relatively 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) carryout routine quality improvement activities (4) ensure availability of adequate medical supplies and medical staff in all medical facilities and (5) creating posts for obstetricians at government general or 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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