

CALCULATION OF FUTURE VALUES OF MATERNAL MORTALITY RATE FOR HONDURAS USING THE DOUBLE EXPONENTIAL SMOOTHING TECHNIQUE

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ABSTRACT

This study uses annual time series data on MMR for Honduras 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 0.8 and 0.1 respectively based on minimum MSE. The results of the study indicate that MMR will drop from around 46.2 in 2024 to about 23.6 deaths per 100 000 live births in 2035. Therefore, we encourage authorities to address local causes of preventable maternal deaths.

Keywords: Exponential smoothing, Forecasting, Maternal Mortality Ratio

INTRODUCTION

The demise of a woman whilst pregnant, during child birth and within 6 weeks post-delivery as a result of complications related to pregnancy, child birth or post-delivery period irrespective of the duration and site of the pregnancy, from any cause related to or aggravated by the pregnancy or its management, but not from accidental or incidental causes is known as maternal mortality (Der et al. 2013). Nearly 800 women die every day from preventable causes related to pregnancy or childbirth (WHO, 2023). This problem affects low-middle countries more than the developed world (Agyei & Kumah, 2024; Bobo et al. 2023; Kyei-Nimakoh et al. 2017). Direct causes of maternal mortality include obstetric bleeding, hypertensive disorders, infection and unsafe abortion (Onambebe et al., 2022; Diallo et al., 2020). Indirect causes include cardiovascular disorders and infection like Tuberculosis and malaria. 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 Honduras policy country profile 2018, maternal mortality ratio stood at 71.8 deaths per 100 000 live births in 2020, and neonatal mortality in 2022 was reported to be at 9.1 deaths per 1000 live births. These figures indicate that Honduras needs to put more effort to control preventable maternal mortality. The objective of this paper is to model and forecast MMR for Honduras using the double exponential smoothing technique. The study findings are anticipated to inform policy and allocation of resources to the health sector in order to further reduce maternal mortality to less than 30 per 100 000 live births.

LITERATURE REVIEW

Author(s)	Objective(s)	Methodology	Key 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 care to community connections is an important consideration to ensure equitable access to routine and emergency care
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.
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	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

		analysis of hospital databases	
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
Silva et al. (2024)	To assess maternal mortality (MM) in Brazilian Black, Pardo, and White women	evaluated the maternal mortality rate (MMR) using data from the Brazilian Ministry of Health public databases from 2017 to 2022. We compared MMR among Black, Pardo, and White women according to the region of the country, age, and cause. For statistical analysis, the Q2 test prevalence ratio (PR) and confidence interval (CI) were calculated	Black women presented higher MMR in all years, in all geographic regions, age groups, and causes. In Brazil, Black skin color is a key MM determinant
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)
Oles et al. (2022)	To assess the efficacy of a sustained educational intervention to affect diverse outcomes across the pregnancy and infancy timeline	A multi-arm cluster-randomized controlled trial in 99 villages in Honduras' Copán region, involving 16 301 people in 5633 households from October 2015 to December 2019	A sustained counselling intervention delivered in the home setting by community health workers can meaningfully change practices, knowledge and attitudes related to proper newborn care following birth, including professional care-seeking, umbilical cord care and breast feeding

Yoon & Kim (2020)	To demonstrate the effectiveness of the health policy in reducing MMR	Quantitative approach	El Salvador could reduce maternal mortality ratio through the improvement of health factors, such as fertility rate, skilled birth attendance, and non-health factors, such as GDP per capita and woman empowerment
Contreras et al. (2020)	To compare maternal and perinatal outcomes between Chilean and Peruvian pregnant women in Santiago, Chile, between January and July 2017	Analytical cross-sectional study	The healthy immigrant effect was observed in pregnant Peruvian immigrants, mainly regarding the perinatal outcomes
Berti et al. (2015)	To determine the impact that a 6-year maternal and child health project in rural Honduras had on maternal health services and outcomes, and to test the effect of level of father involvement on maternal health	Program evaluation	Rather than the father's involvement being key, changes in the mothers may have led to increased institutional births. The project may have empowered women through early identification of pregnancy and stronger social connections encouraged by home visits and pregnancy clubs

METHODOLOGY

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

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

Smoothing equation

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

$$0 < \alpha < 1$$

Trend estimation equation

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

$$0 < \beta < 1$$

Forecasting equation

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

H_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 Honduras 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	H
Included Observations	39
Smoothing constants	
Alpha (α) for data	0.800
Beta (β) for trend	0.100
Forecast performance measures	
Mean Absolute Error (MAE)	6.370510
Sum Square Error (SSE)	4761.208856
Mean Square Error (MSE)	122.082278
Mean Percentage Error (MPE)	0.132040
Mean Absolute Percentage Error (MAPE)	7.290787

Residual Analysis for the Applied Model

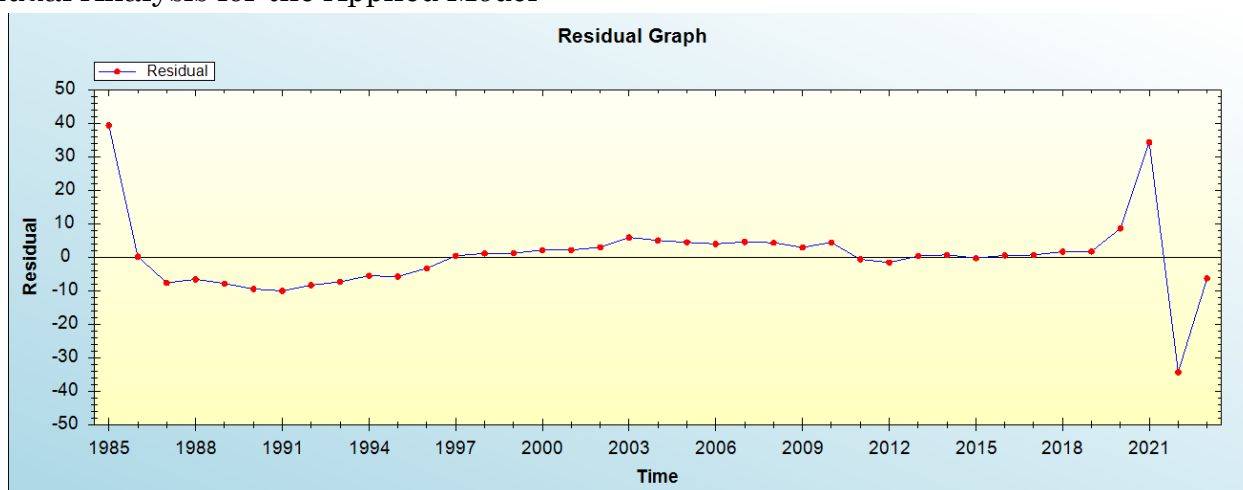


Figure 1: Residual analysis

In-sample Forecast for H

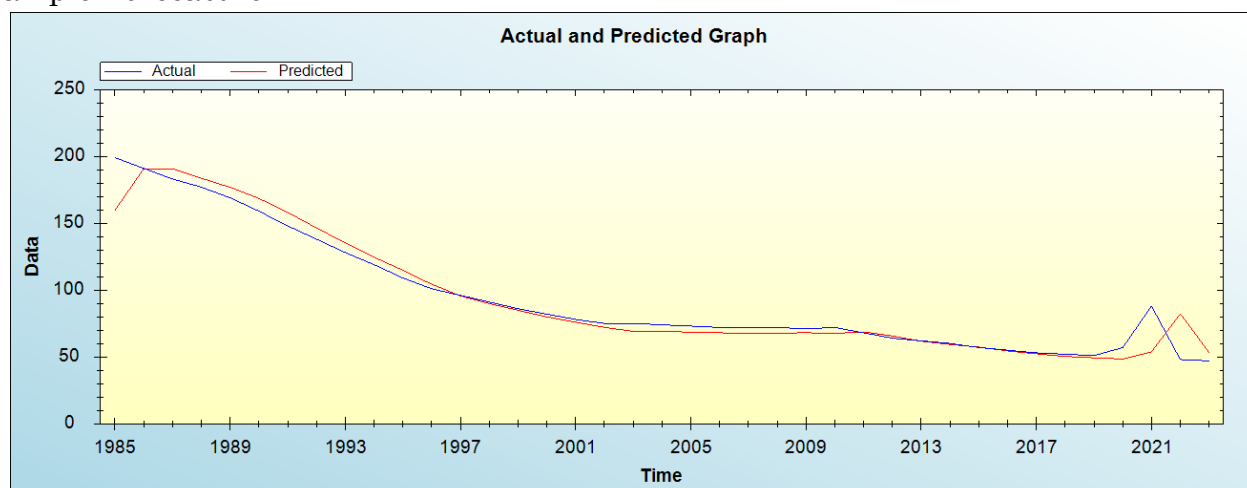


Figure 2: In-sample forecast for the H series

Actual and Smoothed graph for H series

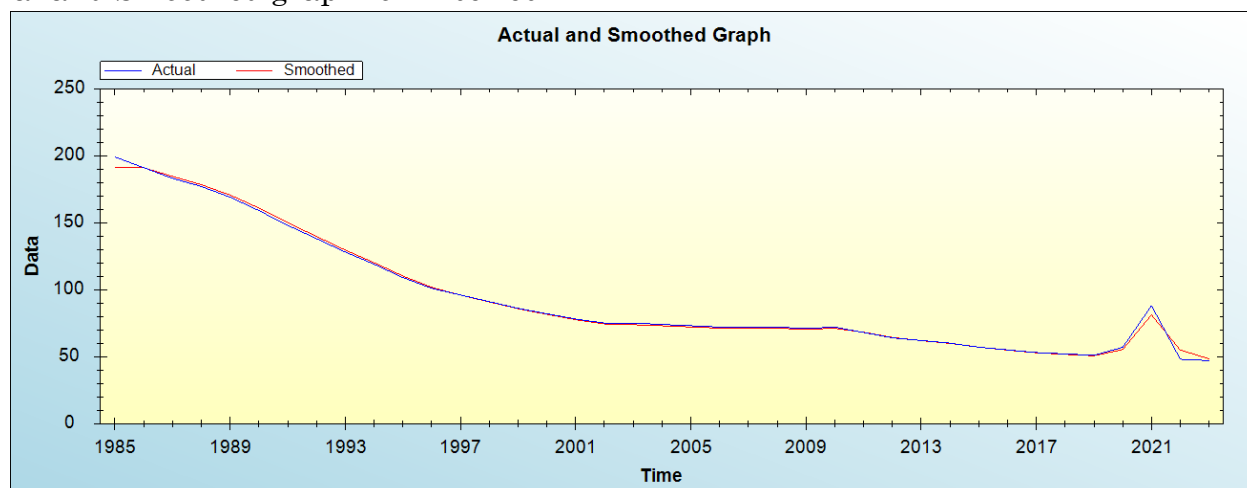


Figure 3: Actual and smoothed graph for H series

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

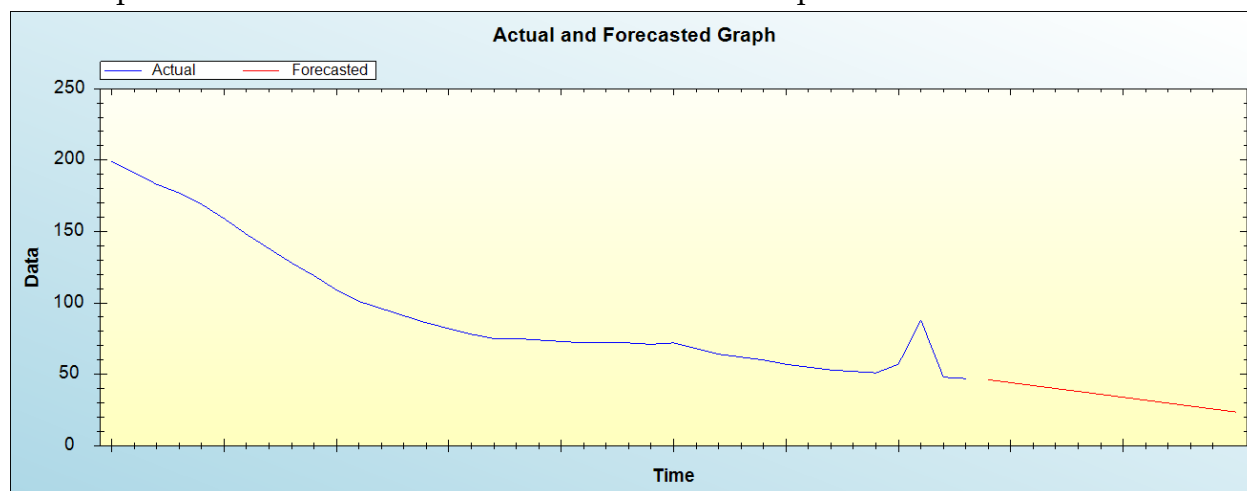


Figure 4: Out-of-sample forecast for H: actual and forecasted graph

Out-of-Sample Forecast for H: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Year	Forecasted MMR
2024	46.2093
2025	44.1545
2026	42.0997
2027	40.0448
2028	37.9900
2029	35.9352
2030	33.8804
2031	31.8256
2032	29.7708
2033	27.7160
2034	25.6612
2035	23.6064

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 drop from around 46.2 in 2024 to about 23.6 deaths per 100 000 live births in 2035.

RECOMMENDATIONS & CONCLUSION

In this study, we applied the double exponential smoothing model to forecast MMR for Honduras and findings suggest that MMR is anticipated to drop from around 46.2 in 2024 to about 23.6 deaths per 100 000 live births in 2035. Hence, authorities should address local causes of maternal deaths.

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