



Analyzing Future Trends Of Maternal Mortality For Antigua And Barbuda Using The Double Exponential Smoothing Technique

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ABSTRACT

This study uses annual time series data on MMR for Antigua and Barbuda 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 0.6 and 0.1 respectively based on minimum MSE. The results of the study indicate that MMR is likely going to increase slightly in the out of sample period. Therefore, we encourage authorities to address major causes of maternal deaths and direct resources towards quality improvement activities across the country.

Keywords:

Exponential smoothing, Forecasting, Maternal Mortality Ratio

Introduction

According to the National strategic plan for health 2016-2020, Antigua and Barbuda is a Commonwealth Caribbean nation that comprises Antigua, Barbuda and the uninhabited Redonda. It is ranked as an upper middle-income country with a high development index. UNDP's Human Development Index (HDI) Report, 2014 positioned Antigua and Barbuda at 61st out of 187 countries and territories world-wide. The country has one of the lowest unemployment rates in the Caribbean region. High levels of employment exist among heads of households, with only 2.2 percent of male heads and 3.3 percent of female heads of households reported as 2.7 percent. An estimated 18.3 percent of the

population lives at or below the poverty line (Caribbean development Bank, 2007). Antigua and Barbuda's maternal and child health program has reported huge gains in key health indicators. Antenatal services are accessed routinely by pregnant women and all births are attended by trained health personnel. Maternal deaths have virtually disappeared from the health statistics although two deaths were recorded in 2015 following zero incidences for two consecutive years (National strategic plan for health 2016-2020). The objective of this study is to model and forecast maternal mortality ratio using the double exponential smoothing technique. The study findings will guide policy and allocation of resources to the health sector.

Literature Review

Author(s)	Objective(s)	Methodology	Key result(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 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
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 change was independently associated with dysglycaemia in women with history of GDM
Nunn et al. (2025)	To explore whether changes in key characteristics among Victorian Aboriginal and/or Torres Strait Islander women contributed to reduced perinatal death rates	Retrospective population-based cohort study	Changes in key maternal characteristics may have contributed to improved perinatal death rates among babies of Victorian Aboriginal and/or Torres Strait Islander women. However, these are unlikely to fully explain observed improvements and several stagnant/increasing risk factors may have hindered

			further improvements
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
Nahidi & Hajifoghaha (2020)	To provide the current situation and trend of MMR in the Eastern Mediterranean region between 1990 and 2015	Systematic literature review	Although all countries of the Eastern Mediterranean Region demonstrated a downward trend in MMR, this trend was not the same in all countries
Morong et al. (2017)	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	A multidisciplinary team assessed medical records to determine preventability	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
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. Confidential enquiries into

			maternal deaths are recommended
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Methodology

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

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

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 Antigua and Barbuda 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	0.600
Beta (β) for trend	0.100
Forecast performance measures	
Mean Absolute Error (MAE)	1.353635
Sum Square Error (SSE)	110.312254
Mean Square Error (MSE)	2.828519
Mean Percentage Error (MPE)	0.528528
Mean Absolute Percentage Error (MAPE)	3.897016

Residual Analysis for the Applied Model

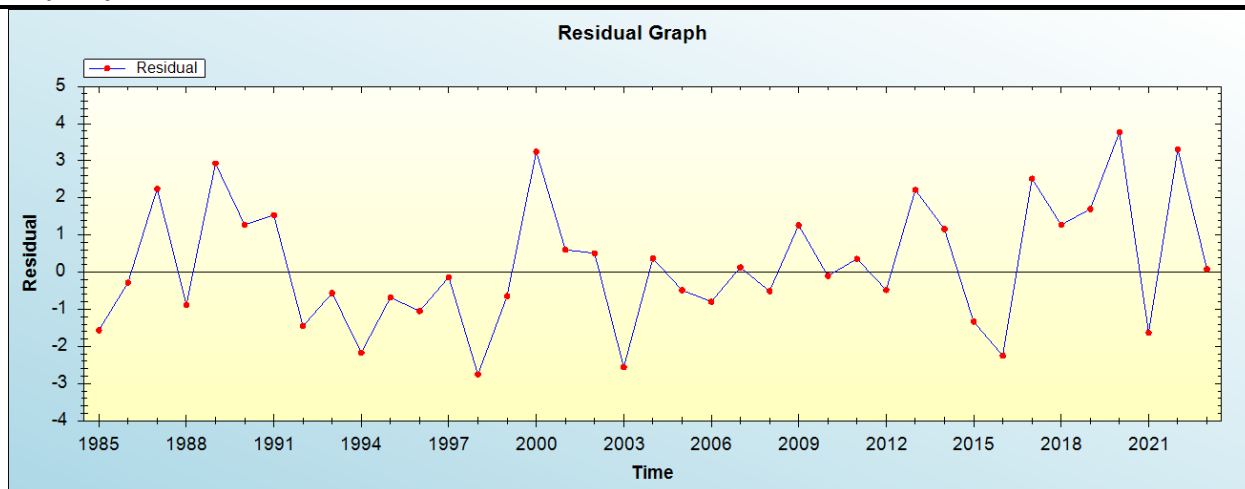


Figure 1: Residual analysis
In-sample Forecast for A

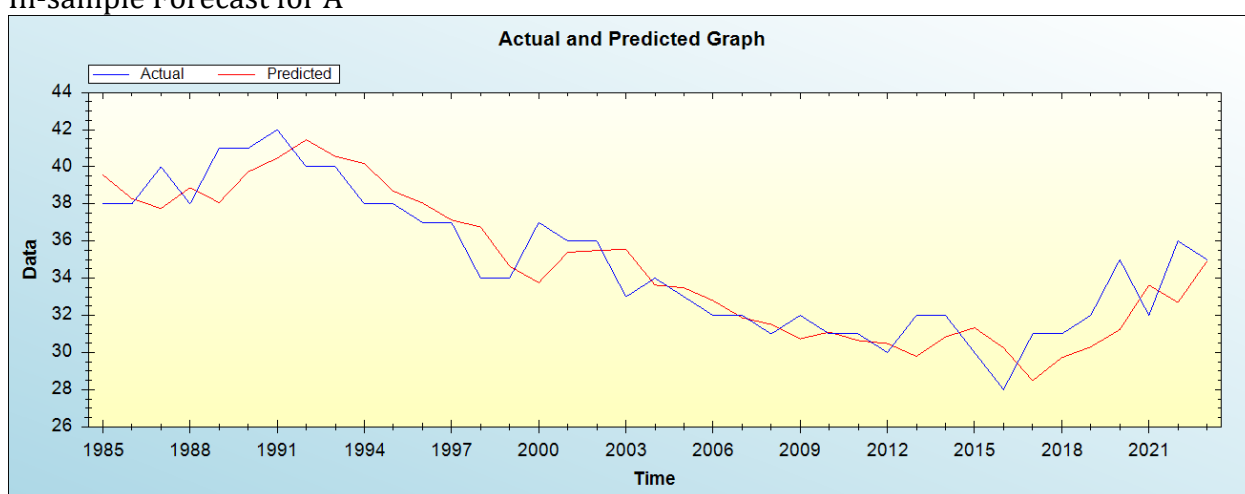


Figure 2: In-sample forecast for the A series
Actual and Smoothed graph for A series

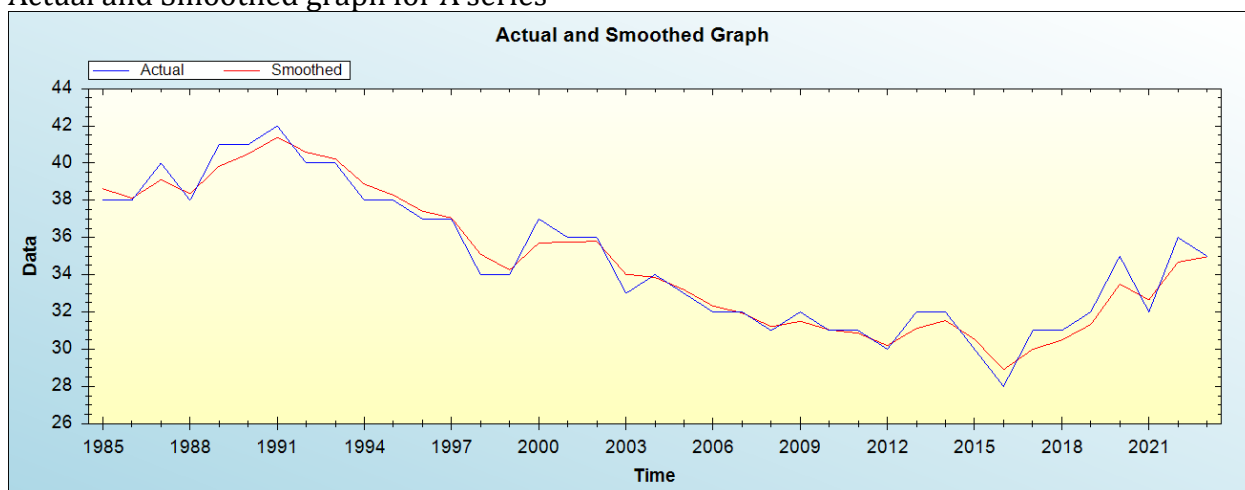


Figure 3: Actual and smoothed graph for A series
Out-of-Sample Forecast for A: Actual and Forecasted Graph

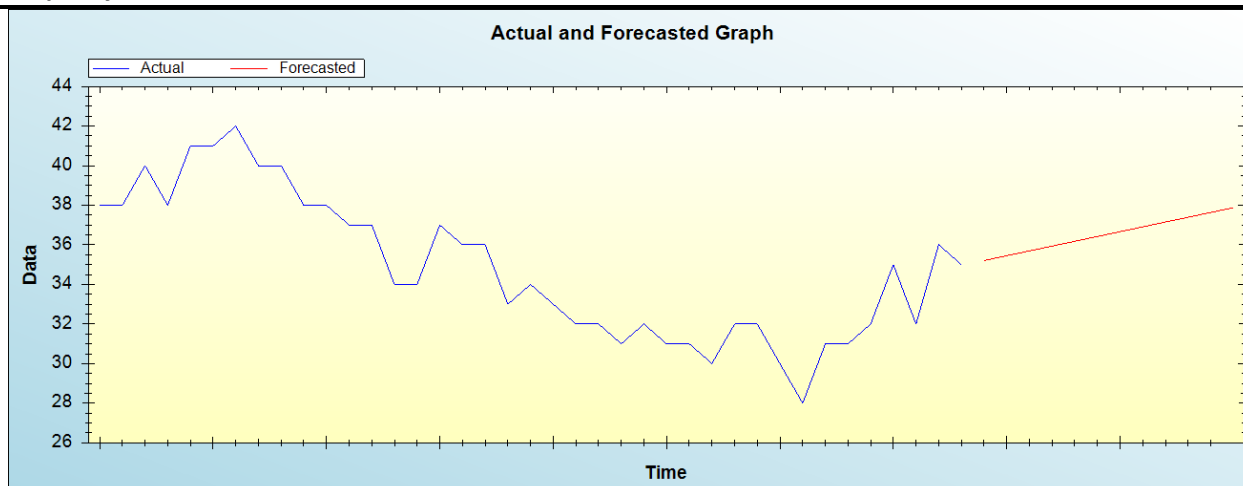


Figure 4: Out-of-sample forecast for A: actual and forecasted graph

Out-of-Sample Forecast for A: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Year	Forecasted MMR
2024	35.2086
2025	35.4516
2026	35.6946
2027	35.9376
2028	36.1805
2029	36.4235
2030	36.6665
2031	36.9094
2032	37.1524
2033	37.3954
2034	37.6383
2035	37.8813

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 likely to increase slightly over the out of sample period.

Conclusion

In this paper we applied double exponential smoothing technique to model and forecast annual MMR for Antigua and Barbuda and results indicate that MMR is likely going to increase slightly throughout the out of sample period. Hence, authorities are implored to address major causes of maternal deaths and direct resources towards quality improvement activities across the country.

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