



Use Of Double Exponential Smoothing Forecasts To Inform The Maternal And Child Health Program In Barbados

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ABSTRACT

This study uses annual time series data on MMR for Barbados 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 drop and reach levels around 30 deaths per 100 000 live births by 2035. Therefore, we encourage authorities to relentlessly support the maternal and child health program and direct more effort towards surveillance of severe maternal morbidity across the country.

Keywords:

Exponential smoothing, Forecasting, Maternal Mortality Ratio

Introduction

According to the Barbados Health Report 2020, Barbados is categorized as a high-income country whose economy is largely driven by the tourism industry. Per capita GDP in 2020 was BBD \$28, 658.4. Expenditure on health, as a percentage of all country spending rose from seven percent in 2019 to ten percent in 2020 as a result of funding which was allocated to the COVID19 pandemic programs and activities. In 2020, Barbados reported a total population estimate of around 271,418, females representing 51.7 percent of the total population in 2019 and male 48.3 percent. The population younger than 15 years accounted for 19.72 percent of the total population. In 2020, the birth rate was 8.8 per 1,000 and the crude

death rate, 9.8 per 1,000. In addition, women of childbearing age (15–44 years old) represented 41.6 percent of the total female population, with a total fertility rate of 1.4 children per woman. Barbados' maternal mortality rate in 2020 stood at 0.8 deaths per 100 000 live births, and neonatal mortality stood at 7.5 deaths per 1000 live births which shows that the government of Barbados has managed to implement a successful maternal and child health (MNCH) program. The aim of this paper is to model and forecast MMR for Barbados using double exponential smoothing technique. The findings of this paper will detect likely future trends of MMR, with the goal of further reducing maternal mortality across the country.

Literature Review

Author(s)	Objective(s)	Methodology	Main finding(s)
Mackin et al. (2026)	to understand how levels of MNH care are organized in	Scoping review	Three or four levels of MNH facility care were most

	different country contexts		commonly reported. Linking maternal and newborn facility care to community connections is an important consideration to ensure equitable access to routine and emergency care.
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 increase was independently associated with new-onset dysglycemia. No independent predictor of T2DM progression was identified. Dyslipidemia was independently associated with higher pre-pregnancy BMI and multiparity, whereas postpartum BMI change was not independently associated after multivariable adjustment
Yue et al. (2026)	to perform an umbrella review to summarize the current evidence to provide a reference for clinicians and future research	Systematic review	Positive aPLs significantly increased the risk of miscarriage rate in assisted reproductive technology (ART) and were also associated with total fetal loss, PE, intrauterine growth retardation and placental abruption
Nunn et al. (2025)	To explore whether changes in key characteristics among Victorian Aboriginal and/or	Retrospective population-based cohort study of all births in Victoria from 2000–2019	Changes in key maternal characteristics may have contributed to improved perinatal

	Torres Strait Islander women contributed to reduced perinatal death rates		death rates among babies of Victorian Aboriginal and/or Torres Strait Islander women
Haninger-Vacariu et al. (2024)	To describe pregnancy and delivery outcomes in women with Fabry disease	Retrospective cohort-study of women with Fabry disease in Austria using a specific questionnaire and the Austrian Mother-Child Health Passport	The cohort-study in women with Fabry disease showed an increase of pain burden during pregnancies and clearly points to an increased risk for preeclampsia, prematurity, and neonates small for gestational age. With a substantial number of high-risk pregnancies, neonatal outcomes are somewhat worse in Fabry disease than in the general public
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
Morong et al. (2017)	This study was a retrospective cohort study of cases of in-hospital maternal deaths in the Ochsner Health System (Louisiana, United States) and the Queensland Health System (Australia) from 1995 to 2013	-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	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
Nahidi & Hajifoghaha (2017)	To provide the current situation and trend of MMR in the Eastern Mediterranean region between 1990 and 2015	Systematic review	Based on the collected data, 36 out of 66 studies met the required criteria and were chosen for analysis. All countries of this region showed a downward trend between 1990 and 2015, and this change varied from 16.30% in Yemen to 76.56% in Lebanon. The maternal mortality reduction was 69.88% in Iran in the same time
Schildberger et al. (2017)	-To investigate the personal meanings and experiences of women with disabilities in regard to pregnancy, childbirth and the puerperium	Conducted semi-structured interviews	Participants reported limited acceptance of their life decisions and experienced an environment of discriminatory attitudes. They experienced a lack of support and lack of confidence in their parenting abilities, which negatively influenced their self-efficacy and self-awareness. Violations of personal borders and a feeling of being watched and controlled were reported
Bouvier-Colle et al. (2012)	To assess capacity to develop routine monitoring of maternal health in the European Union using indicators of maternal mortality	Analysis of aggregate data from routine statistical systems compiled by the EURO-PERISTAT project and comparison with	Currently available data on maternal mortality and morbidity are insufficient for monitoring trends over time in Europe

	and severe morbidity	data from national enquiries	and for comparison between countries
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Methodology

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

$$Z_t = \mu_t + \rho_t \mathbf{t} + \varepsilon_t$$

Smoothing equation

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

$$0 < \alpha < 1$$

Trend estimation equation

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

$$0 < \beta < 1$$

Forecasting equation

Findings

Exponential smoothing Model Summary

Table 1: ES model summary

Variable	Z
Included Observations	39
Smoothing constants	
Alpha (α) for data	0.900
Beta (β) for trend	0.100
Forecast performance measures	
Mean Absolute Error (MAE)	1.595624
Sum Square Error (SSE)	165.879811
Mean Square Error (MSE)	4.253328
Mean Percentage Error (MPE)	0.024226
Mean Absolute Percentage Error (MAPE)	3.441485

Residual Analysis for the Applied Model

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

Z_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**

$\mathbf{t}$ 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 Barbados 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.

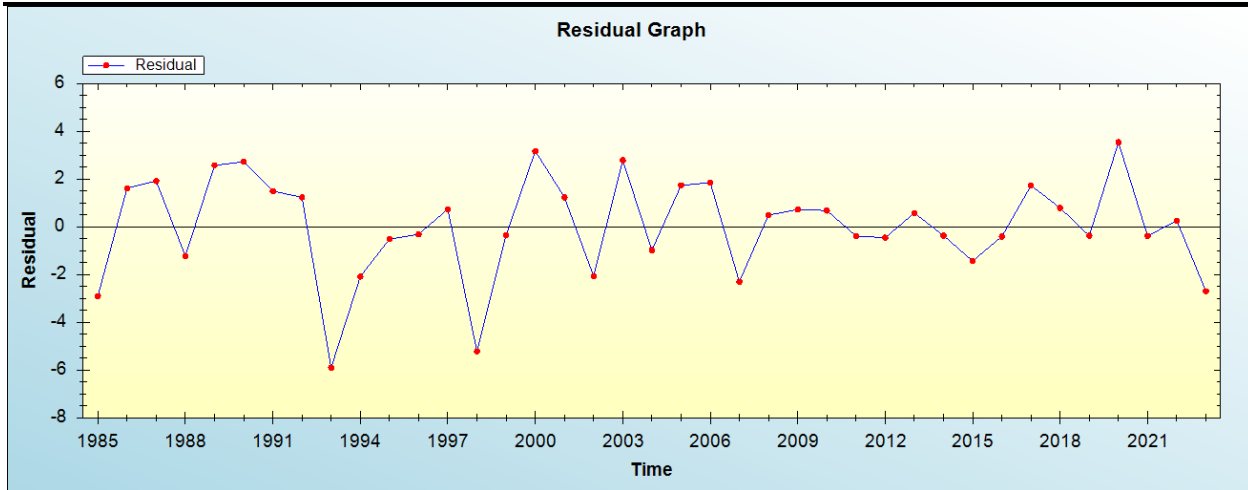


Figure 1: Residual analysis

In-sample Forecast for Z

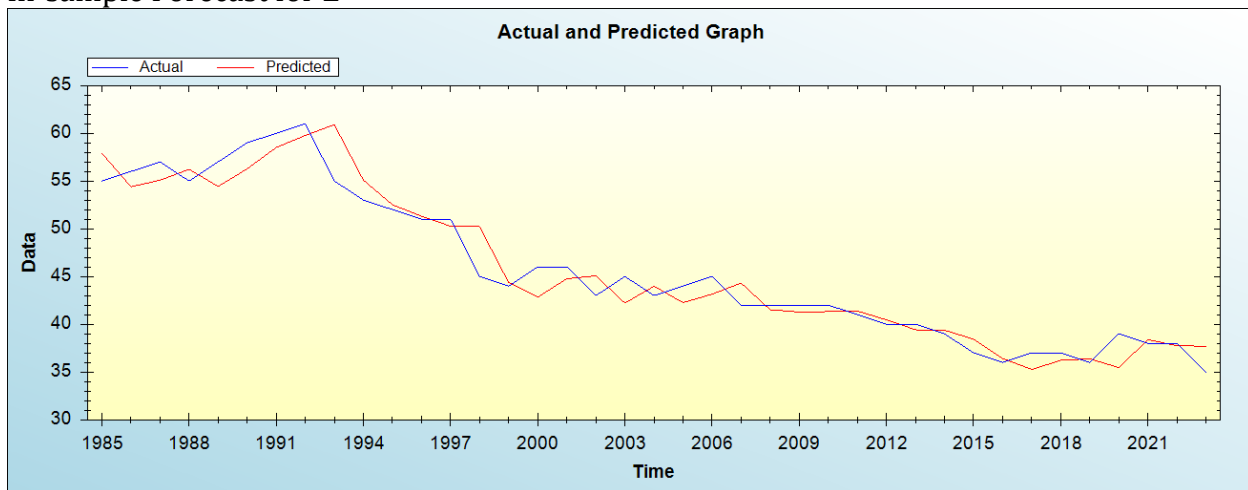
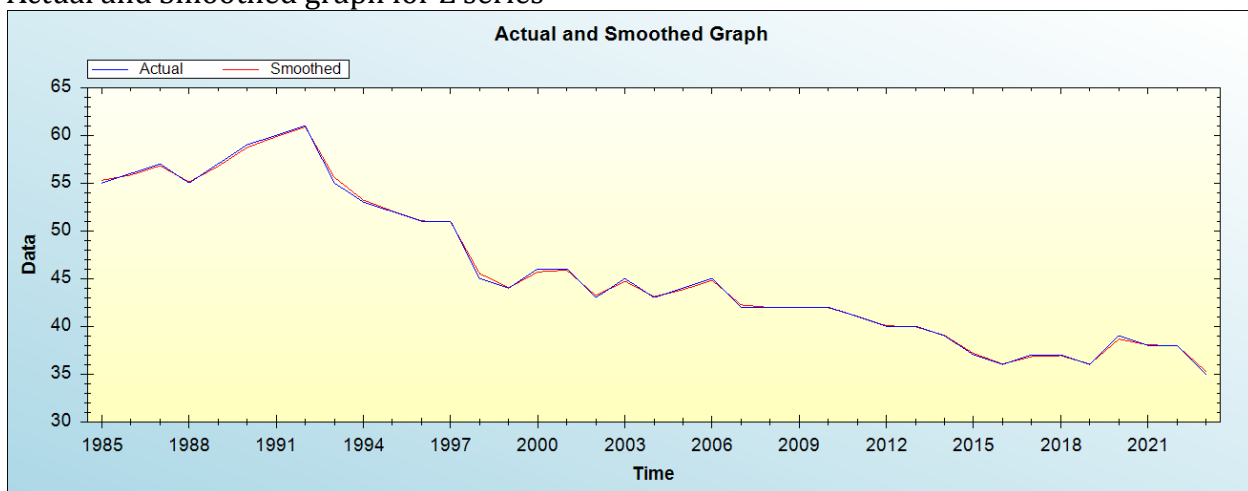


Figure 2: In-sample forecast for the Z series

Actual and Smoothed graph for Z series

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

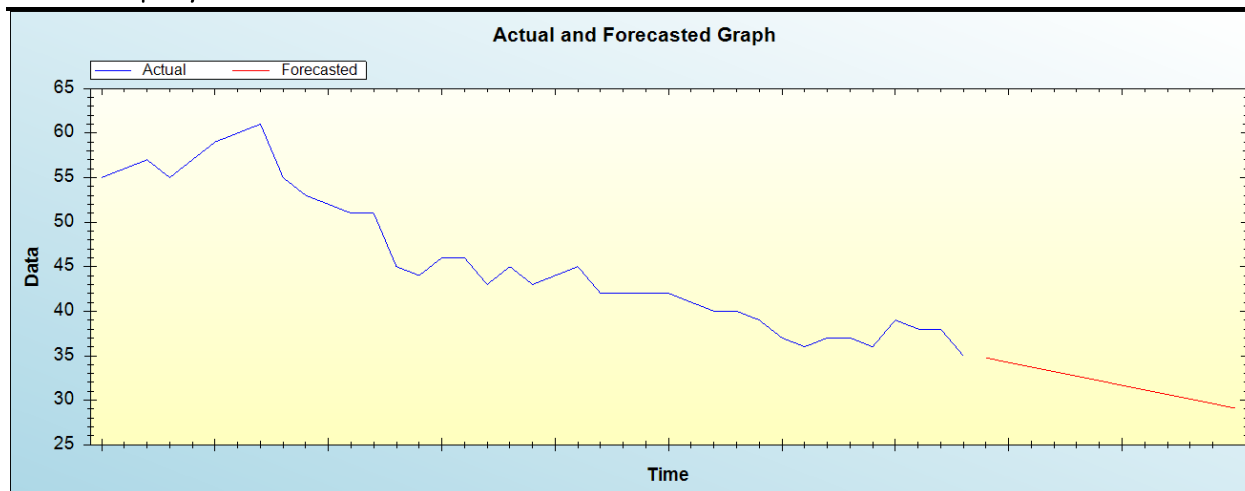


Figure 4: Out-of-sample forecast for Z: actual and forecasted graph

Out-of-Sample Forecast for Z: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Year	Forecasted MMR
2024	34.7564
2025	34.2424
2026	33.7285
2027	33.2145
2028	32.7005
2029	32.1866
2030	31.6726
2031	31.1586
2032	30.6446
2033	30.1307
2034	29.6167
2035	29.1027

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 drop and reach levels around 30 deaths per 100 000 live births by 2035.

Conclusion

Very low MMR in Barbados is a reflection of a successful maternal and child health program. This paper applies the double exponential smoothing model to forecast MMR. The study results highlighted that MMR will continue to decline and reach levels around 30 deaths per 100 000 live births by 2035. There is need for the government to continuously support maternal and child health programs to keep maternal mortality under control. Focus should

also be placed on improving surveillance of severe maternal morbidity.

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