

Eurasian Scientific Herald 		Maternal Mortality Prediction For The Bahamas Using The Double Exponential Smoothing Method	
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ABSTRACT		<i>This study uses annual time series data on MMR for the Bahamas 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 likely to increase and remain high over the out of sample period. Therefore, we encourage authorities to address local factors associated with maternal deaths and ensure availability of adequate medical supplies at all levels of healthcare.</i>	
Keywords:		<i>Exponential smoothing, Forecasting, Maternal Mortality Ratio</i>	

Introduction

The Caribbean region has made significant process in expanding antenatal care (ANC), institutional delivery, and skilled birth attendance. The internationally established goal for maternal mortality ratio is no more than 70 maternal deaths per 100,000 live births by 2030. Countries in Latin America and the Caribbean (LAC), have committed to achieving the 30 maternal deaths per 100,000 live births by 2030 as part of PAHO's Sustainable Health Agenda for the Americas (UN, 2000). Specific attention must be paid to the disparities in health outcomes among different groups of pregnant women and the socioeconomic and geographic drivers of maternal morbidity and mortality, including low educational attainment, racialization, and racial and gender discrimination (UN, 2000). According to the situational report 2023, maternal mortality rate

(MMR) in the Bahamas declined from 79 deaths per 100 000 live births in 2010 to 77 per 100 000 live births in 2020, 99 percent of deliveries are institutional and 99 percent of all deliveries are attended by skilled birth attendants. In addition, 81 percent of pregnant mothers had four antenatal care visits. Most countries in the Caribbean are far away from reaching the regional maternal mortality target of no more than 30 maternal deaths per 100,000 live deaths by 2030. Non-communicable diseases such as obesity and diabetes are the major drivers of maternal deaths in the Caribbean (PAHO, 2023). The purpose of this paper is to model and forecast MMR for the Bahamas using the double exponential smoothing method. The findings of this paper will trigger a national response in order to further reduce maternal morbidity and mortality in this country.

Author(s)	Objective(s)	Methodology	Key finding(s)
Mackin et al. (2026)	to understand how levels of MNH care	Scoping review	Three or four levels of MNH facility care

	are organized in different country contexts		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
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 weight change may help identify women at higher risk of subsequent metabolic abnormalities, particularly dysglycemia, in this high-risk population, although causal relationships cannot be inferred from this observational study
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	Systematic review	Globally, the most common cause of maternal death was hemorrhage (27%;

	needed to accelerate progress		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.
Goicochea et al. (2025)	to identify and analyze maternal complications associated with adolescent pregnancy, with a particular focus on the Latin American context	Mixed methods approach	adolescent pregnancy in Latin America and the Caribbean entails significant medical risks and negatively affects the integral development of adolescents, a situation that is aggravated by the lack of access to health services, education and by factors such as poverty
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 analysis of hospital databases	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
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
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)
Marin et al. (2021)	To describe the epidemiology of NCDs and maternal and child health needs in Venezuelan migrants in major South American host countries	Scoping review	the rate of chronic disease among Venezuelan migrants to range from 9–14% within countries who reported this data. Significant rates of psychiatric conditions such as depression and post-traumatic stress disorder were reported. Other conditions described were ophthalmologic diseases, diabetes, chronic pain, asthma, cough,

			dyslipidemia and hypertension among others
Hill et al. (2009)	To assess the feasibility of measuring maternal mortality in countries lacking accurate birth and death registration through national population censuses by a detailed evaluation of such data for three Latin American countries	Applied demographic techniques	-The PRMRs for Honduras (2001), Nicaragua (2005) and Paraguay (2002) were 168, 95 and 178 per 100 000 live births, respectively -

Methodology

This study utilizes an exponential smoothing technique to model and forecast future trends of MMR for the Bahamas. 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 the Bahamas 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)	9.933064
Sum Square Error (SSE)	11958.822602
Mean Square Error (MSE)	306.636477
Mean Percentage Error (MPE)	-1.397496
Mean Absolute Percentage Error (MAPE)	12.782396

Residual Analysis for the Applied Model

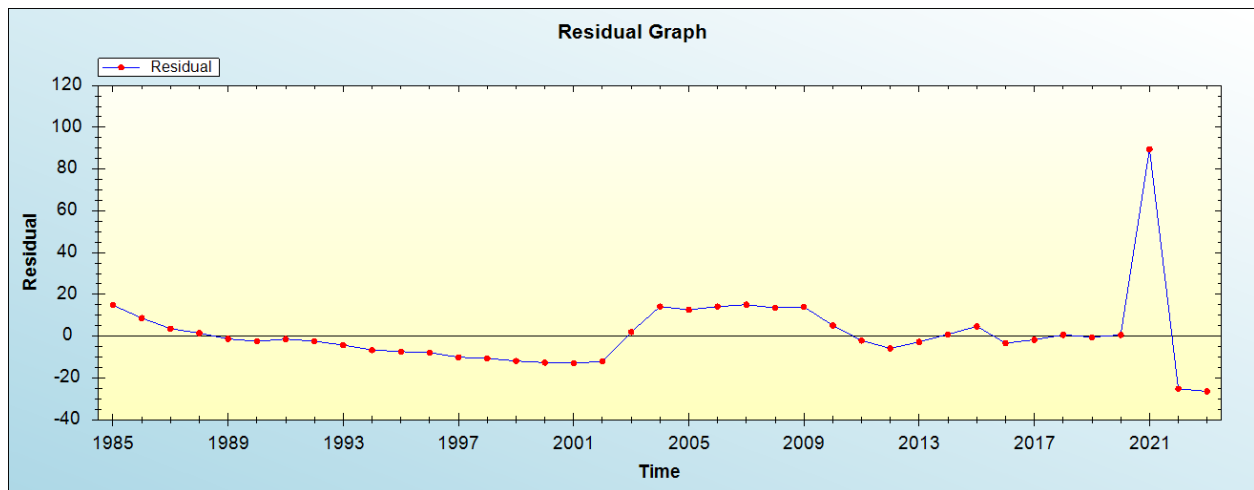


Figure 1: Residual analysis

In-sample Forecast for A

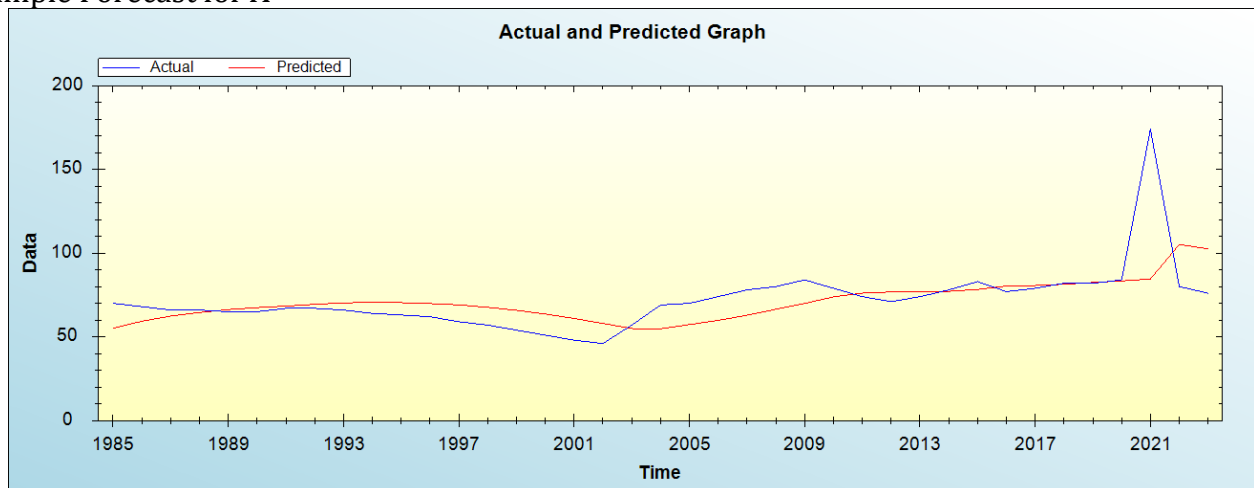


Figure 2: In-sample forecast for the A series

Actual and Smoothed graph for A series

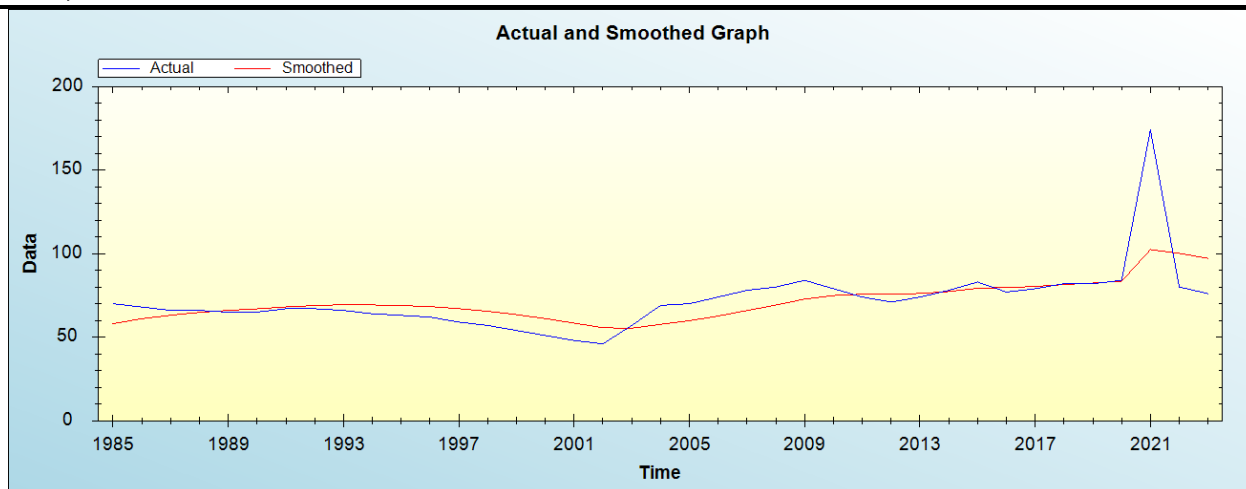


Figure 3: Actual and smoothed graph for A series

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

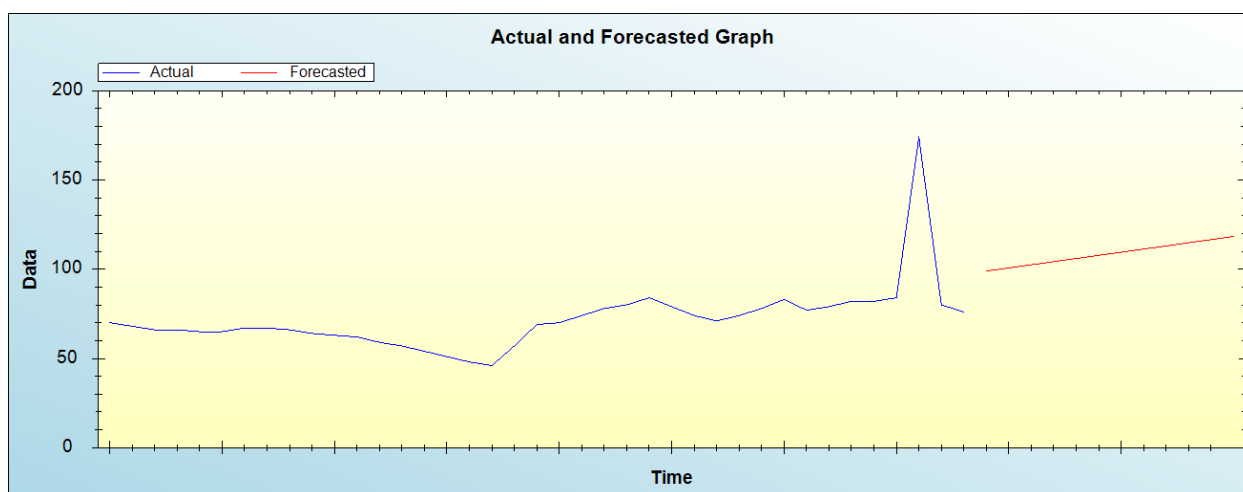


Figure 4: Out-of-sample forecast for A: actual and forecasted graph

Out-of-Sample Forecast for A: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Year	Forecasted MMR
2024	98.9320
2025	100.6957
2026	102.4595
2027	104.2232
2028	105.9869
2029	107.7506

2030	109.5143
2031	111.2780
2032	113.0418
2033	114.8055
2034	116.5692
2035	118.3329

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 and remain high over the out of sample period.

Conclusion

The Bahamas has made significant strides in the reduction of maternal mortality, however more needs to be done in order to further reduce preventable maternal deaths. This paper forecasted MMR for the Bahamas using the double exponential smoothing technique. The findings of this paper indicate that MMR is likely to increase and remain high over the out of sample period. We encourage authorities in this country to address local factors associated with maternal deaths and to ensure availability of medical supplies and staff at all levels of healthcare.

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