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ESTIMATING FUTURE TRENDS OF MATERNAL MORTALITY FOR GRENADA USING THE DOUBLE EXPONENTIAL SMOOTHING APPROACH

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Abstract
This study uses annual time series data on MMR for Grenda 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 hover around 50 deaths per 100 000 live births throughout the out of sample period. Therefore, we encourage authorities to address local causes of maternal mortality.

Keyword(s): - Exponential smoothing, Forecasting, Maternal Mortality Ratio

Introduction

According to WHO, Grenada, Carriacou and Petit Martinique are a tri-island state in the southernmost region of the Caribbean with its economy based on tourism and agriculture to a lesser extent. The population is aging with those aged 60 years and above representing 14% of the population. Non-communicable diseases (NCDs) account for the majority of deaths with the leading causes of morbidity and mortality being malignant neoplasms, endocrine and metabolic diseases and cerebrovascular diseases. The PAHO/WHO STEPS 2011 highlighted that 61.3% of respondents had 1 or 2 risk factors and, 35% had 3 to 5 risk factors for NCDs. Most people (58.7%) were overweight while 25.2% were obese. The government is implementing initiatives targeting NCDs. According to the Global health observatory 2017, Grenada reported a maternal mortality ratio of 27 deaths per 100 000 live births in 2015, the neonatal mortality rate was estimated at 8.3 deaths in 2016. The purpose of this study is to model and forecast MMR for Grenada using double exponential smoothing method. The study findings are expected to inform policy, planning and allocation of resources to the maternal and child health program in order to eliminate all preventable maternal deaths.

Literature Review

Author(s)	Objective(s)	Methodology	Main finding(s)
Marks & Castro (2026)	To examine how MWHs have been implemented across Latin America, analyzing their	Systematic review	The evolution of MWHs suggests that they address a spectrum of needs beyond their

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	evolution, the specific needs they address in different countries, and their impact on maternal and neonatal health outcomes throughout the region		original purposes, such as providing culturally responsive maternal support and psychosocial and early childhood support
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.
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

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			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 Torres Strait Islander women contributed to reduced perinatal death rates	Retrospective population-based cohort study of all births in Victoria from 2000–2019	Changes in key maternal characteristics may have contributed to improved perinatal 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

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			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

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			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

Methodology

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

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

Smoothing equation

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

$0 < \propto < 1$

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Trend estimation equation

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

$0 < \beta < 1$

Forecasting equation

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

G_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 Grenada 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	G
Included Observations	39
Smoothing constants	
Alpha (α) for data	0.800

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Beta (β) for trend	0.100
Forecast performance measures	
Mean Absolute Error (MAE)	2.275349
Sum Square Error (SSE)	397.973473
Mean Square Error (MSE)	10.204448
Mean Percentage Error (MPE)	0.379189
Mean Absolute Percentage Error (MAPE)	4.479913

Residual Analysis for the Applied Model

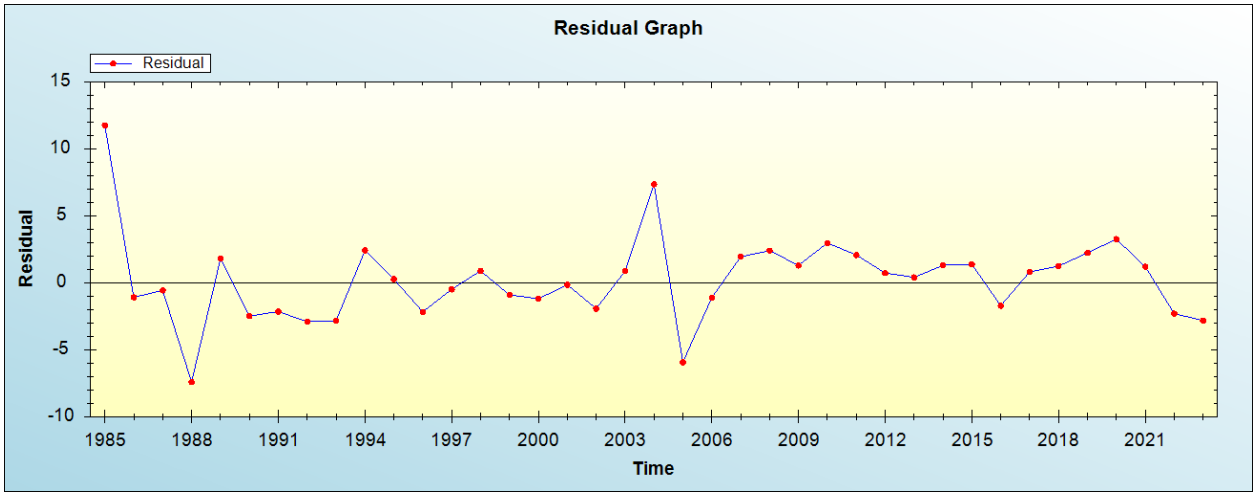


Figure 1: Residual analysis

In-sample Forecast for G

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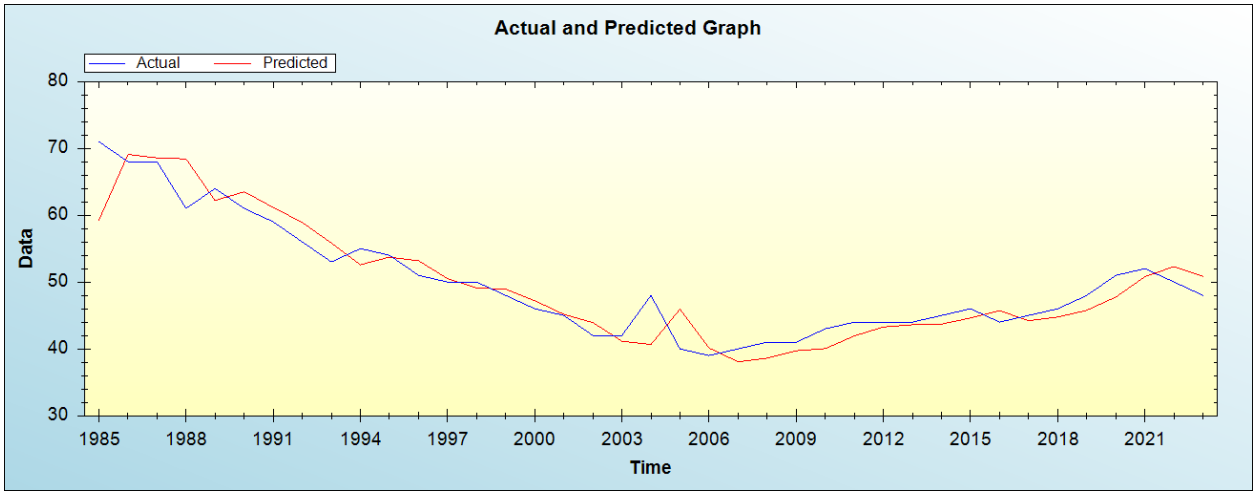


Figure 2: In-sample forecast for the G series

Actual and Smoothed graph for G series

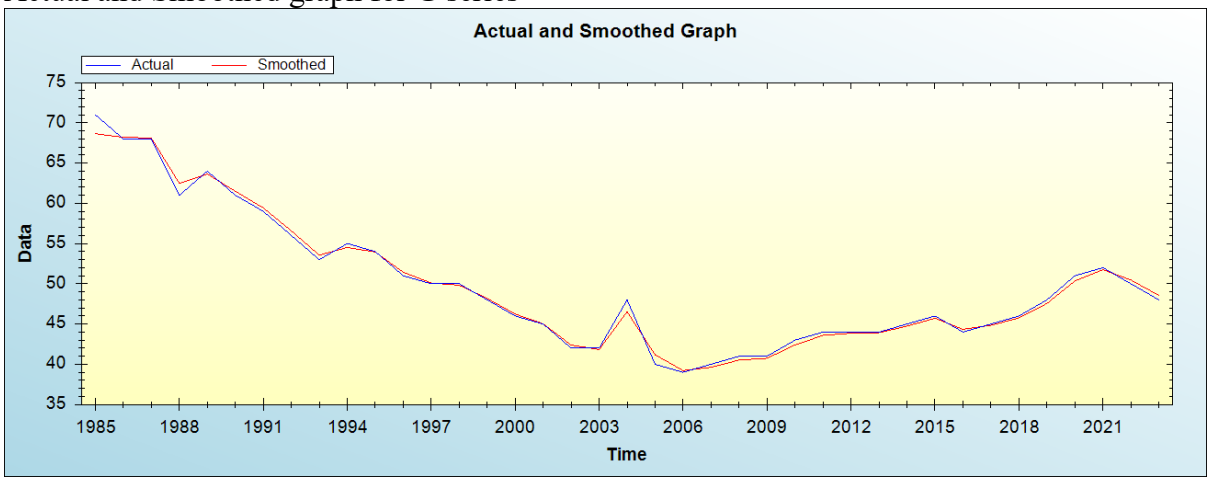
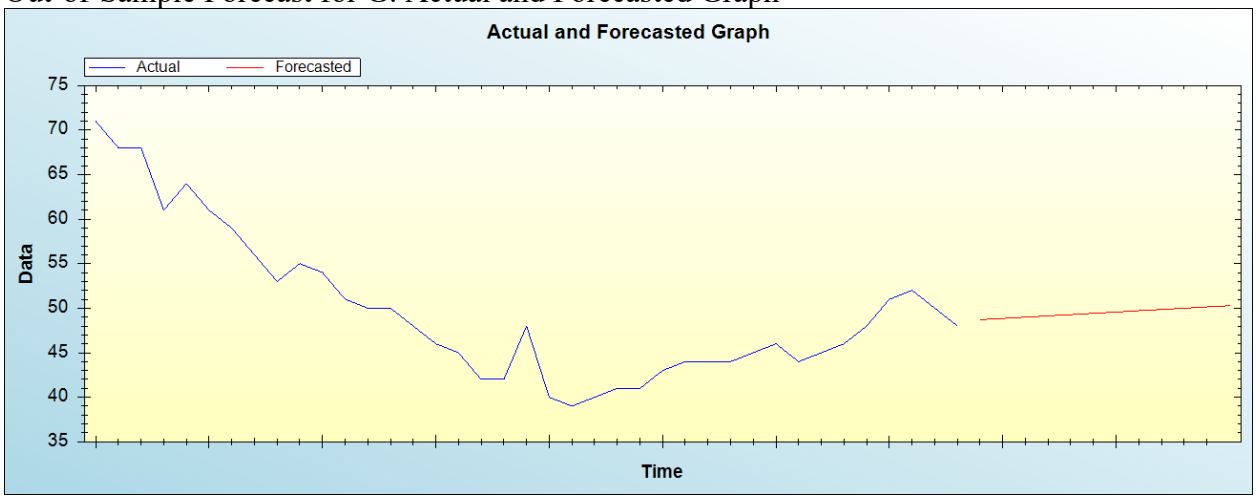


Figure 3: Actual and smoothed graph for G series

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



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

Out-of-Sample Forecast for G: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Year	Forecasted MMR
2024	48.7097
2025	48.8527
2026	48.9957
2027	49.1388
2028	49.2818
2029	49.4248
2030	49.5679
2031	49.7109
2032	49.8539
2033	49.9970
2034	50.1400
2035	50.2830

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 hover around 50 deaths per 100 000 live births in the out of sample period.

Recommendations & Conclusion

This study demonstrates the use of the double exponential smoothing model to forecast MMR for Grenada and the results indicate that MMR will hover around 50 deaths per 100 000 live births the out of sample period. Therefore, we encourage health authorities to address local causes of preventable maternal deaths.

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