

Maternal Mortality Projection For The Dominican Republic Using The Double Exponential Smoothing Model

Smartson. P. NYONI¹, Thabani NYONI²

¹Independent Researcher & Medical Doctor, Harare, Zimbabwe

²Independent Researcher & Health Economist, Harare, Zimbabwe

Abstract

This study uses annual time series data on MMR for the Dominican Republic 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 0.2 respectively based on minimum MSE. The results of the study indicate that MMR will likely increase and remain high over the out of sample period. Therefore, we encourage authorities to address local causes of maternal deaths and pay attention to quality improvement at all levels of the healthcare system.

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

Introduction

The global maternal mortality is persistently high regardless of ongoing public health efforts. According to the WHO statistics, in 2017 close to 295,000 women died during and immediately following pregnancy and childbirth worldwide, with 94% of these deaths being reported in developing countries (WHO, 2019). The etiology of maternal deaths includes antepartum hemorrhage, postpartum hemorrhage (PPH), pre-eclampsia/eclampsia, puerperal sepsis, complications during birth, and unsafe abortion, all of which are preventable if high quality and affordable maternity care services are offered (WHO, 2019). The average maternal mortality ratio for Latin America and the Caribbean was 74 deaths per 100,000 live births in 2017 (World Bank, 2020). The Dominican Republic (DR) has high maternal mortality rates, reporting 95 deaths per 100,000 live births in 2017 (World Bank, 2020). Maternal mortality ratio continues to increase as demonstrated by a maternal mortality ratio of 113 deaths per 100,000 live births reported in 2018 (DR, 2020). The major causes of maternal mortality in the DR as of 2017 were obstetric hemorrhage (23%) and hypertensive disorders (22.1%) (UNFPA, 2017). This high maternal mortality ratio persists despite the fact that 99% of registered births in the DR (as of 2015) were reportedly attended by a skilled healthcare worker (World Bank, 2020). The available data indicates that there is a deficiency in healthcare worker competencies and/or standardized treatment protocols specific to these common causes of maternal mortality (Smith et al. 2021).

The objective of this paper is to model and forecast MMR for the Dominican Republic using the double exponential smoothing model. The study findings are expected to trigger a national response so that major drivers of maternal deaths are promptly addressed.

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
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 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,	ecological observational time-series study	Despite overall progress, regional differences in maternal mortality persist across Latin

	providing key insights to address this issue.		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
Santos-Mercedes & Coutinho (2024)	To estimate the severe maternal morbidity rate and the maternal mortality rate by causes of death	Mixed effects models	-severe maternal morbidity rate decreased from 12.1 to 10.4 per 1,000 live births in 2020 compared to 2019; however, the maternal mortality rate went from 91.4 to 124.2 per 100,000 live births in the same period. In 2021, a significant increase in morbidity and mortality was observed, registering a rate of 16.5 cases of severe maternal morbidity per 1,000 live births and a rate of 153.7 maternal deaths per 100,000 live births - maternal mortality in the Dominican Republic is associated with the sociodemographic 29 and economic conditions of women
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
De Jesus et al. (2023)	to determine the extent to which the	Quantitative approach	Maternal mortality increased as vaginal

	quality of institutionalized healthcare, sociodemographic factors of obstetric patients, and institutional factors affect maternal mortality in the Dominican Republic		birth rates and infant death rates increased whereas it decreased as single mother birth rates increased
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)
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
Gonzalez et al. (2009)	To analyze trends in maternal, newborn, and child mortality in Chile between 1990 and 2004	Data were provided by the Chilean Ministry of Health on all pregnancies between 1990 and 2004 (approximately 4000000).	During the study period, the maternal mortality ratio decreased from 42.1 to 18.5 per 100000 live births. The mortality rate for neonates decreased from 9.0 to 5.7 per1000births, for infants from 7.8to3.1 per 1000 births, and for young children from 3.1 to 1.7 per 1000 live births

Methodology

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

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

Smoothing equation

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

$$0 < \alpha < 1$$

Trend estimation equation

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

$$0 < \beta < 1$$

Forecasting equation

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

D_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 Dominican Republic 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	D
Included Observations	39
Smoothing constants	
Alpha (α) for data	0.900
Beta (β) for trend	0.200
Forecast performance measures	
Mean Absolute Error (MAE)	9.451800
Sum Square Error (SSE)	8313.875242
Mean Square Error (MSE)	213.176288
Mean Percentage Error (MPE)	1.369922
Mean Absolute Percentage Error (MAPE)	7.357224

Residual Analysis for the Applied Model

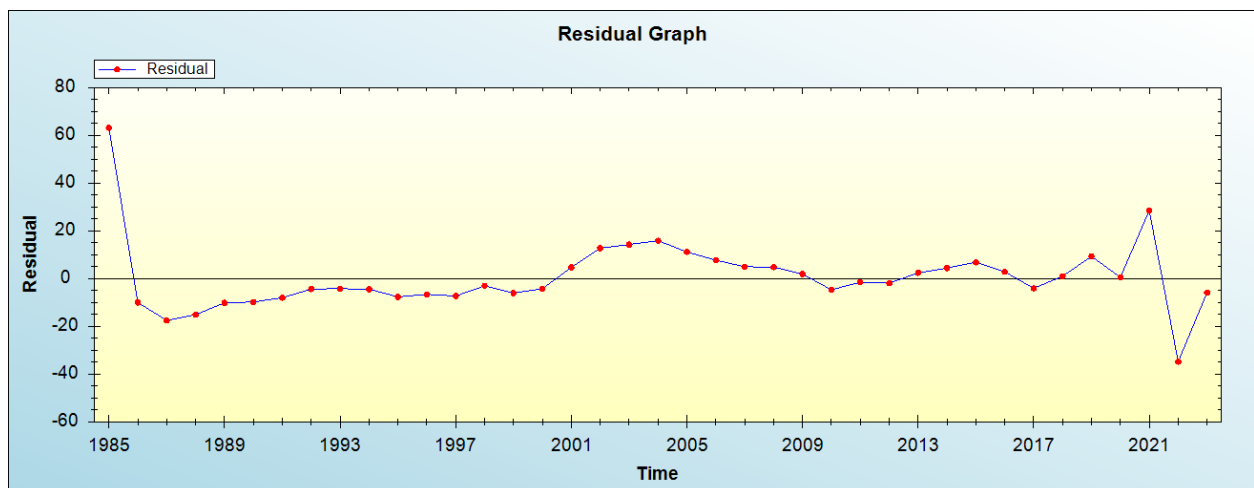


Figure 1: Residual analysis

In-sample Forecast for D

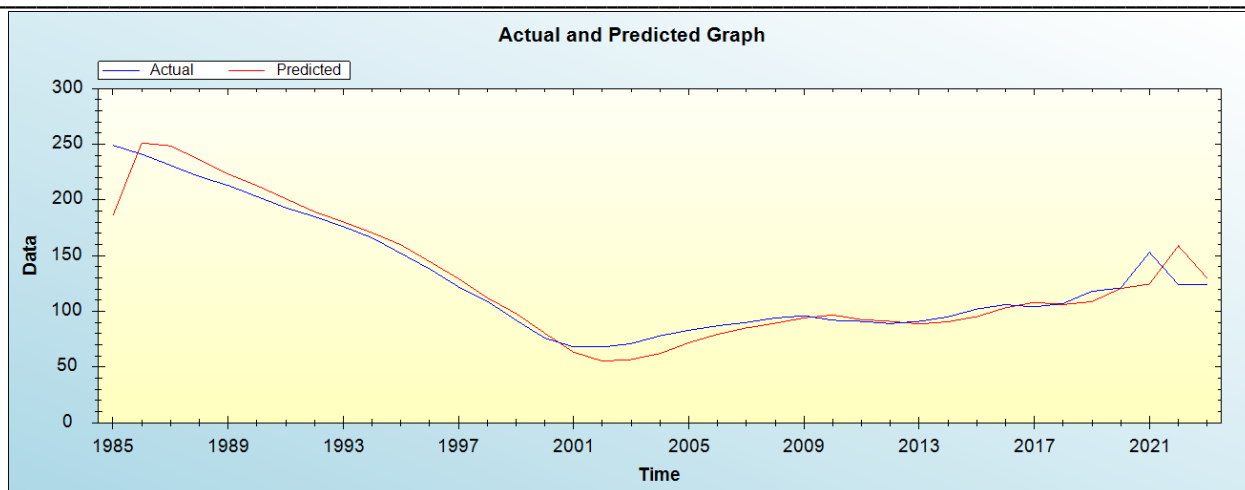


Figure 2: In-sample forecast for the D series

Actual and Smoothed graph for D series

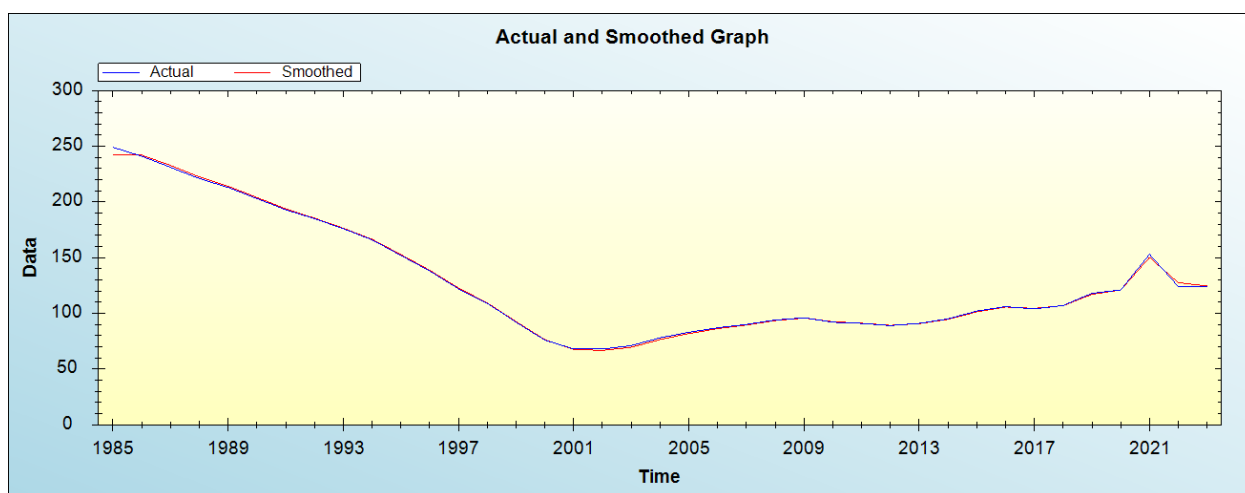


Figure 3: Actual and smoothed graph for D series

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

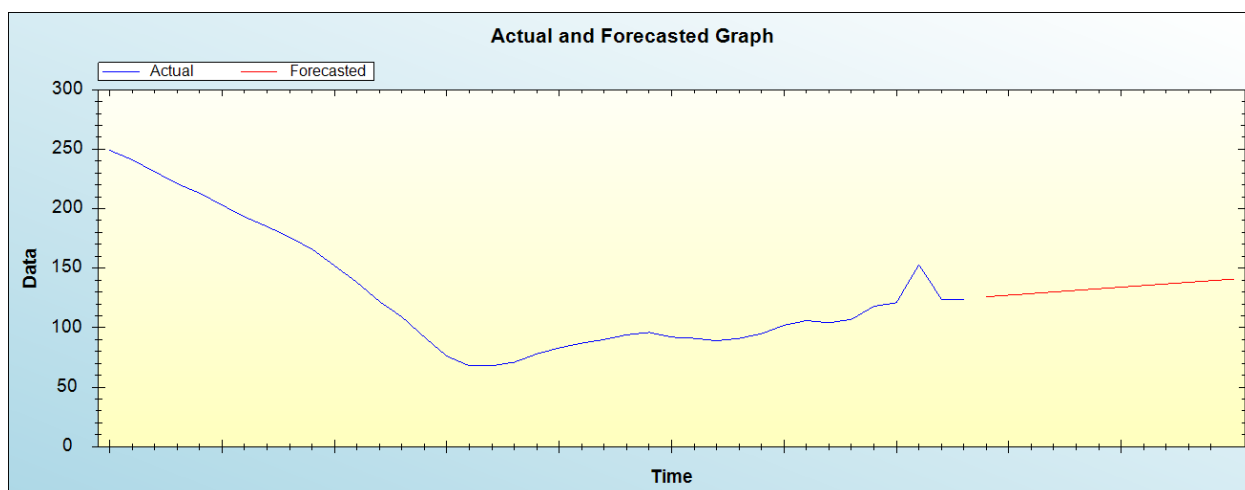


Figure 4: Out-of-sample forecast for D: actual and forecasted graph

Out-of-Sample Forecast for D: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Year	Forecasted
2024	125.9462
2025	127.3021
2026	128.6580
2027	130.0139
2028	131.3698
2029	132.7257
2030	134.0817
2031	135.4376
2032	136.7935
2033	138.1494
2034	139.5053
2035	140.8612

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 likely increase and remain high over the out of sample period.

Recommendations & conclusion

Antenatal care coverage is reportedly high in the Dominican Republic (DR). However, MMR is high not consistent with excellent coverage of maternity services. This reflects certain unidentified or unattended gaps in the continuum of care. This paper used the double exponential smoothing method to forecast MMR for the DR and results indicate that MMR is expected to increase and remain high in the out of sample period. Therefore, we encourage health authorities in the DR to address local causes of maternal deaths and pay special attention to improving the quality of healthcare services across the country.

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