

Projection Of Maternal Mortality For Equatorial Guinea Using The Double Exponential Smoothing Technique

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Abstract

This study uses annual time series data on MMR for Equatorial Guinea 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 0.7 respectively based on minimum MSE. The results of the study indicate that MMR will fall from around 163 in 2024 to about 44 deaths per 100 000 in 2035. Therefore, we encourage health authorities to adopt the suggested 5-fold policy prescription.

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

Introduction

Maternal mortality is a challenging public health problem due to its negative effects on the family and community at large. Approximately 800 women die per day from preventable causes related to pregnancy or childbirth (WHO, 2023). This problem affects low-middle countries more than developed countries. According to the WHO, at the global level, the maternal mortality ratio in 2020 was estimated at 233 per 100,000 live births (WHO, 2020). However, during the recent years, a significant drop of maternal mortality ratio at the global level was observed, with a reduction of 34.3% between 2000 and 2020, an average rate of reduction of 2.9% per year (WHO, 2023; WBG, 2023; WHO, 2020). Data shows that maternal mortality in Equatorial Guinea declined from 427 deaths per 100 000 live births in the year 2000 to 212 deaths per 100 000 live births in 2020 ((MMEIG, 2022). This data implies that maternal mortality is still a huge problem in this country therefore appropriate measures should be taken in order to drastically reduce the number of all preventable maternal deaths. The objective of this paper is to model and forecast MMR for Equatorial Guinea using the double exponential smoothing technique. The findings are expected to stimulate a timeous response to this national problem.

Literature Review

Author(s)	Objective(s)	Methodology	Main finding(s)
Ara et al. (2025)	to summarize the frequencies of sociodemographic characteristics, parity distribution, antenatal care patterns, and causes of death among maternal mortality	Conducted a retrospective study which analyzed maternal mortality at Rangpur Medical College Hospital, Bangladesh, in 2024, reviewing 4,741 birth records with 83 maternal deaths	-Among 83 maternal deaths, majority of deaths occurred among women aged 16–25 (41%) and those from low socioeconomic backgrounds (72.2%). -Parity distribution showed 49.39% had 1–2 children, while 73.4%

			received no antenatal care (ANC), highlighting gaps in healthcare access. - Eclampsia (37.35%) and obstetric hemorrhage (26.50%) were the predominant cause of maternal deaths.
Singh & Swain (2025)	to explore the factors influencing CDMR and its effect on maternal and fetal outcomes	Prospective cohort study	The prevalence of CDMR was 21.35%, which was relatively higher than the World Health Organization's recommended guidelines
Manamo et al. (2023)	to examine the socio-economic differentials of under-five mortality in Botswana within the framework of equality and equity	The was based on the data from 2001 and 2011 Botswana Population and Housing Censuses and the 2017 Botswana Demographic Survey. One census method was used to indirectly estimate under five mortalities for different socio-economic groups using Princeton west model life tables.	socio-economic disparities in under-five mortality disfavoring the worse-off exist in all the selected socio-economic variables
Chacha et al. (2022)	review the current cardiac obstetrics practice, gaps, and potential areas of improvement.	Systematic review	With an increasing number of women with pre-existing cardiac conditions becoming pregnant, the contribution of CVD to maternal mortality is also growing. Consequently, there is a need for accurate diagnosis and appropriate care of pregnant

			women with CVD to minimize adverse outcomes
Isaacson et al. (2021)	to evaluate the prevalence and outcome of twin pregnancies in Botswana	Quantitative analysis	Adverse birth outcomes are common among twins in Botswana, and are often severe
Mohamed et al. (2021)	to determine whether the health crisis in Comoros is attributable to the consequences of the chronic political instability	semi-structured interviews with key informants	political instability and lack of proper leaders' hip from the Government undermine the establishment of health policies which contributed dramatically to the decline in health performance
Akhter et al. (2018)	to present, analyze and interrelate recent data to find barriers to achieving set MDG 5 targets by 2015	literature review has been done as a main method of data collection from Elsevier, Lancet, WHO, UNICEF, BBMS, NIPORT published from 2001 to May 2018	approximately 80% of maternal deaths could be averted if women had access to essential maternity and basic health care services
Oyekale et al. (2018)	To analyze the effect of maternal education and fertility on child survival in the Islands of Comoros	The 2012 Demographic and Health Survey (DHS) data were used. A two-stage probit regression method was used for data analysis	The results showed that about 75% of the children's mothers had given birth to between one and five children, while more than half did not have any form of formal education
Madzimbamuto et al. (2014)	To determine the underlying causes of maternal deaths reported in 2010, to categorize contributory factors and to prioritize	Case-notes for maternal deaths were reviewed by a panel of five clinicians, initially independently then discussed together to achieve consensus on assigning contributory factors, cause of death and whether each death was avoidable or not at	The high number of contributory factors demonstrates poor quality of care even where deaths were not avoidable: 14/23

	appropriate interventions based on the identified causes, to prevent further deaths.	presentation to hospital. Factors contributing to maternal deaths were categorized into organizational/management, personnel, technology/equipment/supplies, environment and barriers to accessing healthcare	(61%) of direct deaths were considered avoidable compared to 12/32 (38%) indirect deaths. Highest ranking categories were: failure to recognize seriousness of patients' condition (71% of cases); lack of knowledge (67%); failure to follow recommended practice (53%); lack of or failure to implement policies, protocols and guidelines (44%); and poor organizational arrangements (35%). Half the deaths had some barrier to accessing health services
Reuter et al. (2014)	learn which diseases are most common and the most common cause of death from the perspective of healthcare workers; and 2) gain an understanding of the healthcare community in Equatorial Guinea	Interview based study	some causes of death, such as serious injuries, may not be currently treatable in country, potentially due to a lack of resources and trauma care facilities. In addition, training and informational programs for both healthcare workers and the general public

			may not be effectively transmitting information to the intended recipients
Alvarez et al. (2009)	to describe and determine different factors associated with the maternal mortality ratio in Sub Saharan countries	An ecological multi-group study compared variables between many countries in Sub Saharan Africa using data collected between 1997 and 2006. The dependent variable was the maternal mortality ratio, and Health care system-related, educational and economic indicators were the independent variables. Information sources included the WHO, World Bank, UNICEF and UNDP	Education and an effective and efficient health system, especially during pregnancy and delivery, are strongly related to maternal death

Methodology

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

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

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

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

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**

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 Equatorial Guinea 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	Z
Included Observations	39
Smoothing constants	
Alpha (α) for data	0.900
Beta (β) for trend	0.700
Forecast performance measures	
Mean Absolute Error (MAE)	8.685650
Sum Square Error (SSE)	7866.940747
Mean Square Error (MSE)	201.716429
Mean Percentage Error (MPE)	0.122630
Mean Absolute Percentage Error (MAPE)	2.022929

Residual Analysis for the Applied Model

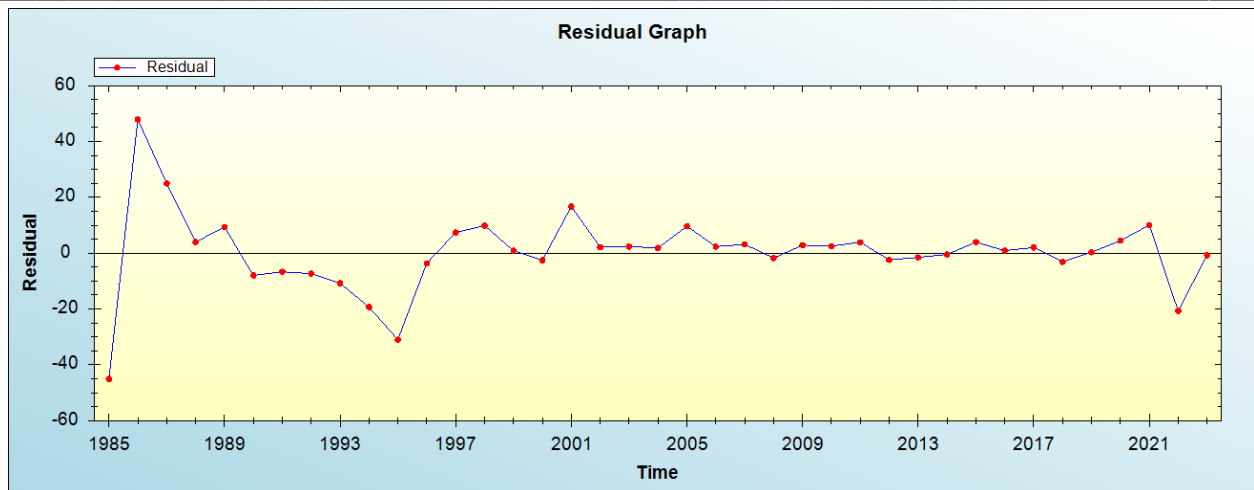


Figure 1: Residual analysis

In-sample Forecast for Z

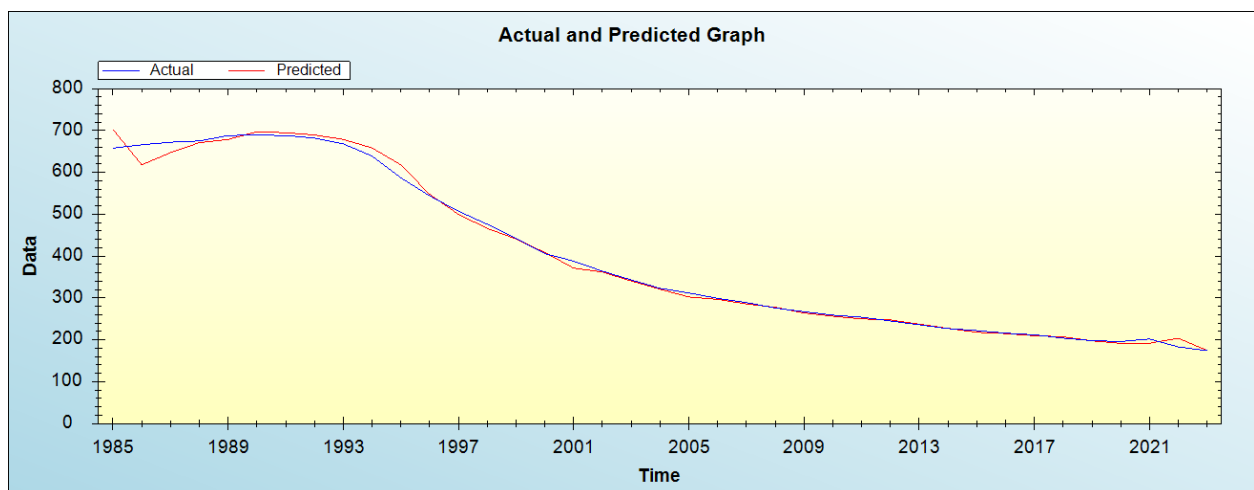


Figure 2: In-sample forecast for the Z series

Actual and Smoothed graph for Z series

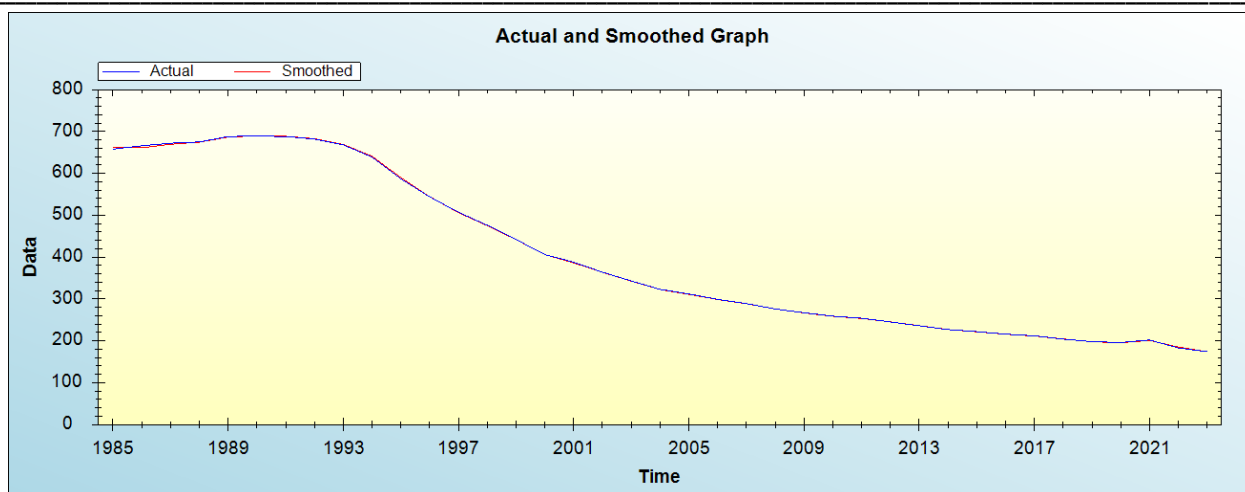


Figure 3: Actual and smoothed graph for Z series

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

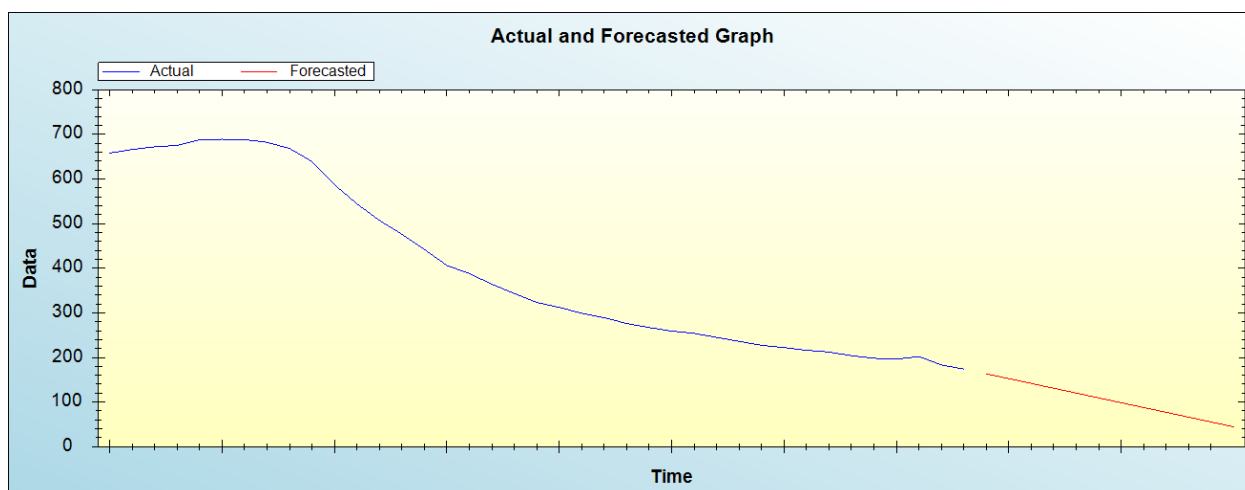


Figure 4: Out-of-sample forecast for Z: actual and forecasted graph

Out-of-Sample Forecast for Z: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Year	Forecasted MMR
2024	163.2776
2025	152.4809
2026	141.6842
2027	130.8876

2028	120.0909
2029	109.2942
2030	98.4975
2031	87.7009
2032	76.9042
2033	66.1075
2034	55.3108
2035	44.5141

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 fall from around 163 in 2024 to about 44 deaths per 100 000 live births in 2035.

Recommendations & Conclusion

Equatorial Guinea (EG) has a high burden of maternal mortality reflecting gaps in the continuum of care. This paper models and projects MMR for EG and the results indicate that MMR will fall from around 163 in 2024 to about 44 deaths per 100 000 live births in 2035. Therefore, we encourage health authorities to adopt the following policy prescription: (1) end adolescent pregnancy by enforcing laws that prohibit early child marriage, promote female education and comprehensive sexual and reproductive health education in schools (2) Improve coverage of maternal and child health services across the country (3) improve the quality of maternity services during the antenatal, childbirth and post-partum periods by carrying out routine quality improvement activities (4) ensure availability of sufficient commodities and medical staff in all medical facilities and (5) creating posts for obstetricians at government general or district hospitals particularly at high volume sites so that specialist services are accessed at the first referral level.

References

- [1] Maternal Mortality Equatorial Guinea 2000-2020. Internationally comparable MMR estimates by the Maternal Mortality Inter-Agency Group (MMEIG): WHO, UNICEF, UNFPA, World Bank Group and the United Nations Population Division.
- [2] WBG (2023). Maternal mortality ratio (modeled estimate, per 100,000 live births) 2023. World Bank Open Data. Available: <https://data.worldbank.org>
- [3] WHO (2020). Maternal Mortality. Available: <https://www.who.int/news-room/fact-sheets/detail/Maternal-mortality>.
- [4] WHO (2023). Trends in maternal mortality 2000 to 2020: estimates by Who, UNICEF, Unfpa, World Bank Group and UNDESA/Population Division. Geneva: World Health Organization; 2023. Licence: CCBY-NC SA3.0IGO.