

CALCULATING ANNUAL MATERNAL MORTALITY RATE FOR GUINEA BISSAU USING THE DOUBLE EXPONENTIAL SMOOTHING TECHNIQUE

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ABSTRACT

This study uses annual time series data on MMR for Guinea Bissau 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 0.6 and 0.5 respectively based on minimum MSE. The results of the study indicate that MMR will continue on a downward trend but still remain very high throughout the out of sample period. Therefore, we encourage authorities to adopt the suggested 5-fold policy prescription.

Keywords: Exponential smoothing, Forecasting, Maternal Mortality Ratio.

INTRODUCTION

The number of females dying during and after pregnancy and childbirth remains unacceptably high, particularly in African countries (WHO, 2019). As of 2017, WHO data highlighted that 830 women die per day of pregnancy-related conditions, with Africa accounting for two-thirds of these deaths (WHO, 2019). When pregnant women die, there are negative effects on their surviving neonates, who become orphaned children, their families, communities, and societies, often lasting beyond one generation (Bazile et al. 2015; Miller et al. 2015). Addressing the etiology and factors contributing to Africa's avoidable maternal mortality burden may have a positive impact on human development (Bazuaye and Okonofua, 2013). The principal causes of maternal deaths in Africa are due to preventable direct obstetric causes, including obstetric bleeding, puerperal sepsis, pregnancy induced hypertension, unsafe abortion, and obstructed labor (Mathai et al. 2015; Say et al. 2014; Souza et al. 2014). Direct obstetric deaths result from obstetric complications of the pregnancy state (pregnancy, labor, and the puerperium), complications of medical or surgical interventions, omission of critical treatment or incorrect treatment, or a chain of events resulting from any of the above (WHO, 2012). While the causes of maternal death remain largely similar between African countries, there is variation in the Maternal Mortality Ratio (MMR) between and within African countries (Collaborators GBDMM, 2016). The objective of this paper is to model and forecast MMR for Guinea Bissau using the double exponential smoothing model. The study results are expected to inform policy and allocation of resources to the health sector in order to further bring down maternal mortality countrywide.

LITERATURE REVIEW

Author(s)	Objective(s)	Methodology	Main finding(s)
Damerow et al. (2025)	To quantify coverage gaps along the continuum of maternal and neonatal care in rural Guinea Bissau and assess background factors associated with continuum-of-care completion	Cross-sectional study	Continuum-of-care completion is low in rural Guinea-Bissau and not fully reflected by individual coverage indicators.
Leno et al. (2024)	to estimate the proportion of women who had completed the different stages of the continuum of maternal health care (four antenatal visits, given birth under the care of qualified personnel, and received postnatal care within 42 days of delivery	cross-sectional analytical study	found that 26.9% of women had completed all stages of the maternal health care continuum, while 73.1% had not. While 56.7% received four antenatal visits, only 29.5% delivered under the care of a qualified healthcare professional. Key factors associated with discontinuity were not attending school (AOR 1.825: 1.594–2.089), unemployment (AOR 4.588: 3.983–5.285), having two or more living children (AOR 1.890: 1.016–1.296), and not receiving a free Long-Lasting Insecticidal Net at the first Antenatal Care
Cisse et al. (2023)	to analyze maternal and child health indicators using CCI	-performed a secondary analysis of Guinea demographic and health surveys (DHS) focused on women aged 15 to 49 and their children aged 1 to 4	This study showed an increase in CCI between 2012 and 2018
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
Muriithi et al. (2022)	to identify these contributing factors and assess the frequency of their reporting in published literature	Scoping review	The most frequently reported contributory factors by level were: (1) Individual—level: Delay in deciding to seek help and in recognition of danger signs (37.5% of articles), (2) Health facility—level: Suboptimal service delivery relating to triage, monitoring, and referral (80.8% of articles) and (3) Wider health system—level: Transport to and between health facilities (84.6% of articles)

Zegeye et al. (2022)	To investigate the magnitude and trends in socioeconomic and geographic-related inequalities in SBA in Guinea from 1999 to 2016 and neonatal mortality rate (NMR) between 1999 and 2012	The study derived data from three Guinea Demographic and Health Surveys (1999, 2005 and 2012) and one Guinea Multiple Indicator Cluster Survey (2016). For analysis, we used the 2019 updated WHO Health Equity Assessment Toolkit (HEAT). We analyzed inequalities in SBA and NMR using Population Attributable Risk (PAR), Population Attributable Fraction (PAF), Difference (D) and Ratio (R)	Disproportionate inequalities in SBA and NMR exist among disadvantaged women such as the poor, uneducated, rural residents, and women from regions like Mamou region
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
Musarandega et al. (2021)	to identify the leading causes of maternal deaths using the international classification of disease – 10th revision, for maternal mortality (ICD-MM)	Systematic review	Obstetric hemorrhage, hypertensive disorders in pregnancy, non-obstetric complications, and pregnancy-related infections are the leading causes of maternal deaths in SSA
Millimouno et al. (2019)	to evaluate the maternal deaths surveillance and response (MDSR) system at the health district level in Guinea	descriptive cross-sectional study was conducted, using an innovative digital approach called District. Team, from April to September 2017	-In total, 23 (61%) district medical officers (DMOs) participated in the study. Out of health districts (87%) which had updated guidelines and standards for the MDSR, 4 (20%) did not apply the content. In two health districts (8.7%), not all health facilities had maternal deaths notification forms. Three districts (13%) did not have maternal death review committees -The weaknesses identified were, among others, insufficiency of human resources and lack of financial resources

METHODOLOGY

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

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

Smoothing equation

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

$$0 < \alpha < 1$$

Trend estimation equation

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

$$0 < \beta < 1$$

Forecasting equation

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

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 Guinea Bissau 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	0.600
Beta (β) for trend	0.500

Forecast performance measures	
Mean Absolute Error (MAE)	37.170203
Sum Square Error (SSE)	101170.612074
Mean Square Error (MSE)	2594.118258
Mean Percentage Error (MPE)	0.131396
Mean Absolute Percentage Error (MAPE)	3.879526

Residual Analysis for the Applied Model

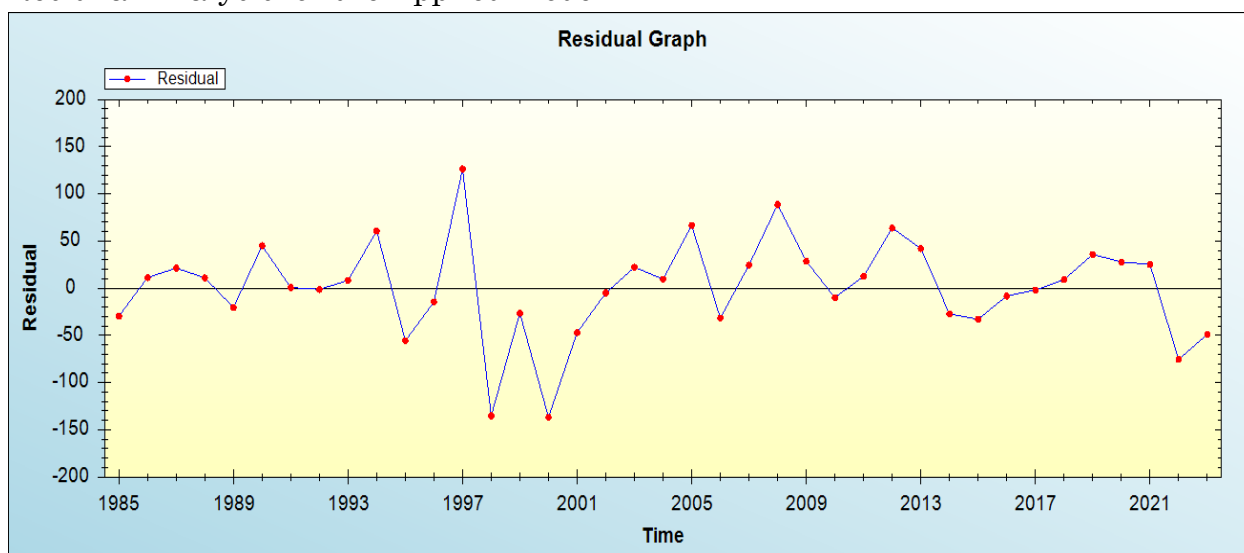


Figure 1: Residual analysis

In-sample Forecast for G

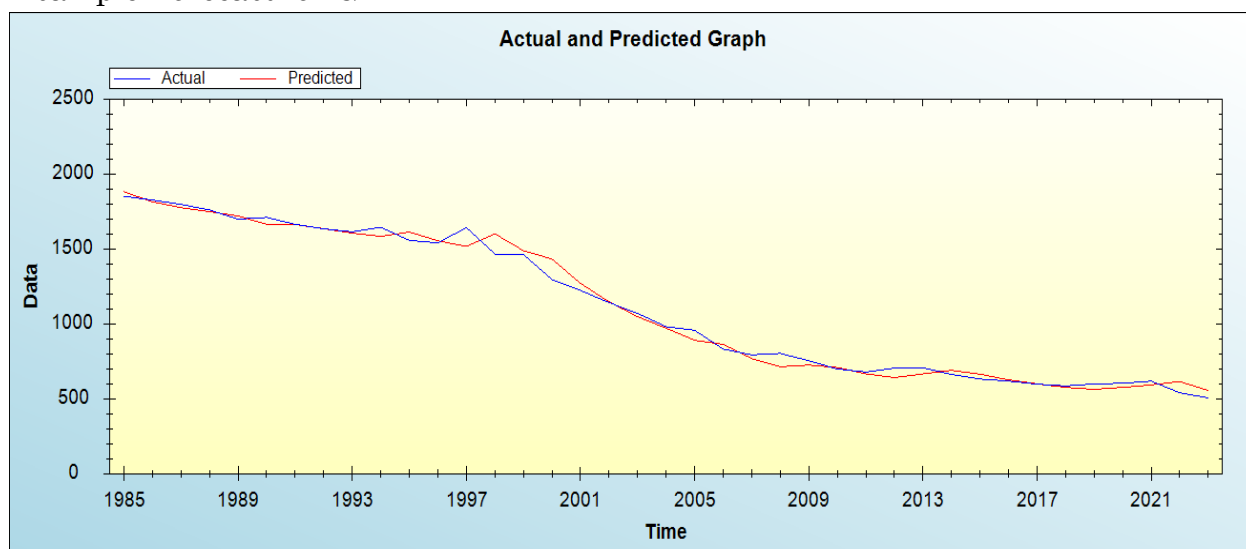


Figure 2: In-sample forecast for the G series

Actual and Smoothed graph for G series

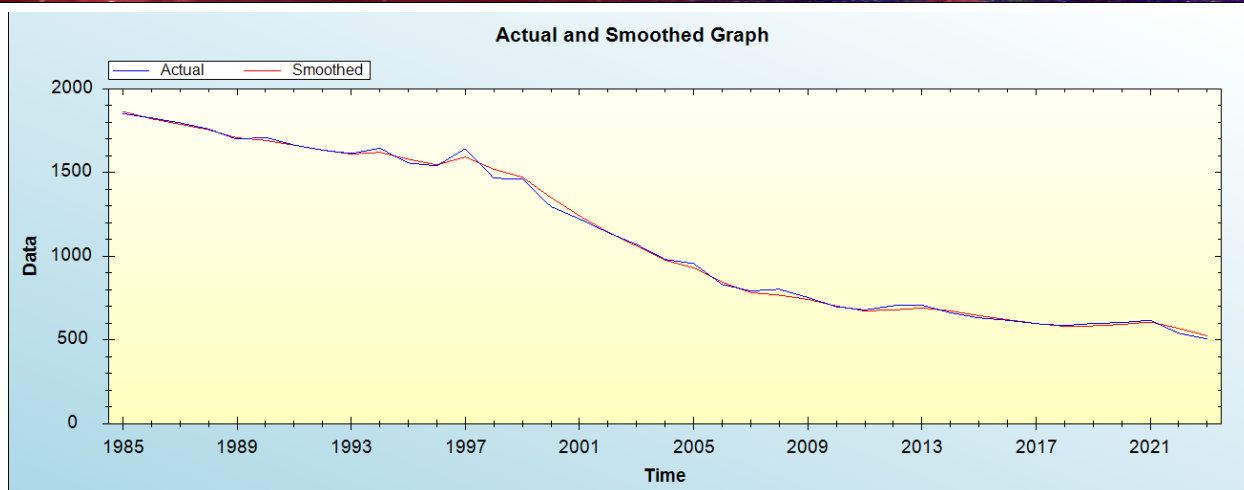


Figure 3: Actual and smoothed graph for G series

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

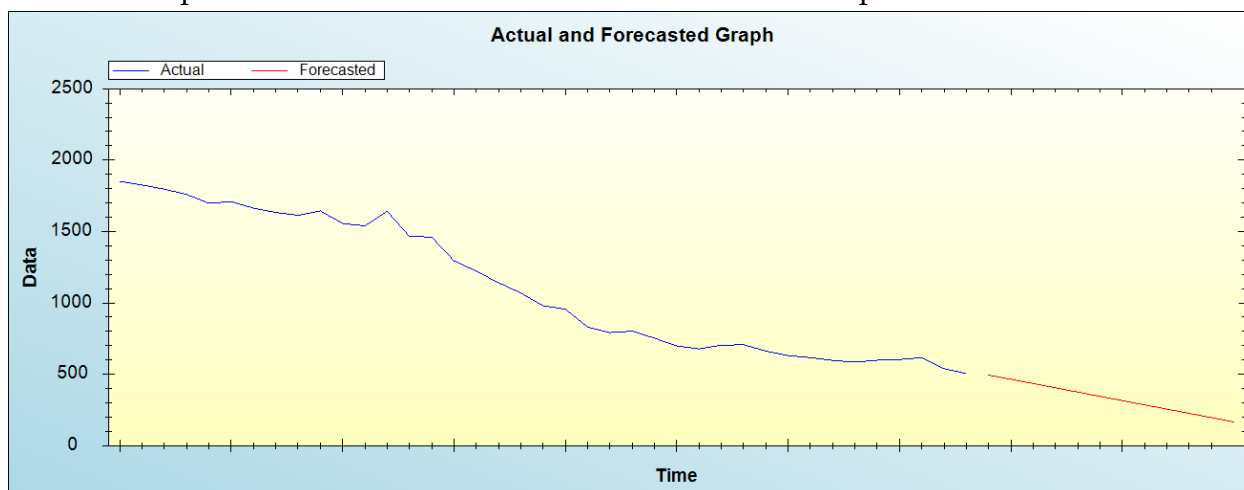


Figure 4: Out-of-sample forecast for G: actual and forecasted graph

Out-of-Sample Forecast for G: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Year	Forecasted MMR
2024	494.7517
2025	464.9015
2026	435.0513
2027	405.2010
2028	375.3508
2029	345.5006
2030	315.6503
2031	285.8001
2032	255.9499
2033	226.0996
2034	196.2494
2035	166.3992

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 on a downward trajectory but still remain very high over the out of sample period.

RECOMMENDATIONS & CONCLUSION

In this paper we applied the double exponential smoothing model to forecast MMR for Guinea Bissau and findings indicate that MMR will continue on a downward trajectory but still remain very high over the out of sample period. Hence, we encourage authorities to adopt the following policy prescription: (1) end teenage 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 quality of maternity services (4) ensure availability of adequate medical supplies and medical staff in all medical facilities and (5) establishing 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. Alternatively, Registrars undergoing Obstetrics & Gynecology training can be attached at high volume district hospitals under the supervision of provincial consultants.

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