

DETERMINATION OF FUTURE VALUES OF ANNUAL MATERNAL MORTALITY FOR GUINEA USING THE DOUBLE EXPONENTIAL SMOOTHING TECHNIQUE

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ABSTRACT

This study uses annual time series data on MMR for 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 0.1 respectively based on minimum MSE. The results of the study indicate that MMR will continue to drop 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

In Guinea, significant progress has been made until to date to improve the quality, accessibility and affordability of maternal and newborn health services (Leno et al. 2024). However, further efforts are still required to save the lives of mothers and children. Maternal mortality is still high and data indicates that maternal mortality ratio (MMR) of 550 per 100,000 live births was reported in 2016 (MICS, 2016). Most of maternal and perinatal deaths are caused by obstetric complications. A substantial proportion of these are preventable when women utilize available health care services offered by skilled health care providers (Hogan et al. 2010; Bhutta et al. 2008; Ronsmans et al. 2006; Van Lerberghe et al. 2005). The 2018 Guinea Demographic and Health Survey (DHS) highlighted that around 81% of women who had a live birth received antenatal visits care from a qualified provider. However, only 35% of women had attended at least 4 antenatal visits. Furthermore, 55% of births were assisted by qualified health personnel. Only 49% of women had a postnatal examination within 48 h of birth (Guinea, 2019). A secondary analysis based on 2018 Demographic and Health Survey data revealed that only 20% of women benefit from a good continuum of maternal care in Guinea (Camara et al. 2021). The objective of this paper is to model and project MMR for Guinea using the double exponential smoothing technique. The study findings are expected to reveal likely future trends of MMR. This will stimulate a national response targeting all the pillars of the maternal health program so as to further lower maternal deaths across the country.

LITERATURE REVIEW

Author(s)	Objective(s)	Methodology	Main finding(s)
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
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
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	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). Researchers analyzed inequalities in SBA	Disproportionate inequalities in SBA and NMR exist among disadvantaged women such as the poor, uneducated, rural residents, and women from regions like Mamou region

	(NMR) between 1999 and 2012	and NMR using Population Attributable Risk (PAR), Population Attributable Fraction (PAF), Difference (D) and Ratio (R)	
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
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

METHODOLOGY

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

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

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

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

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 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	0.900
Beta (β) for trend	0.100
Forecast performance measures	
Mean Absolute Error (MAE)	7.387209
Sum Square Error (SSE)	3426.937049
Mean Square Error (MSE)	87.870181
Mean Percentage Error (MPE)	0.111285
Mean Absolute Percentage Error (MAPE)	0.950863

Residual Analysis for the Applied Model

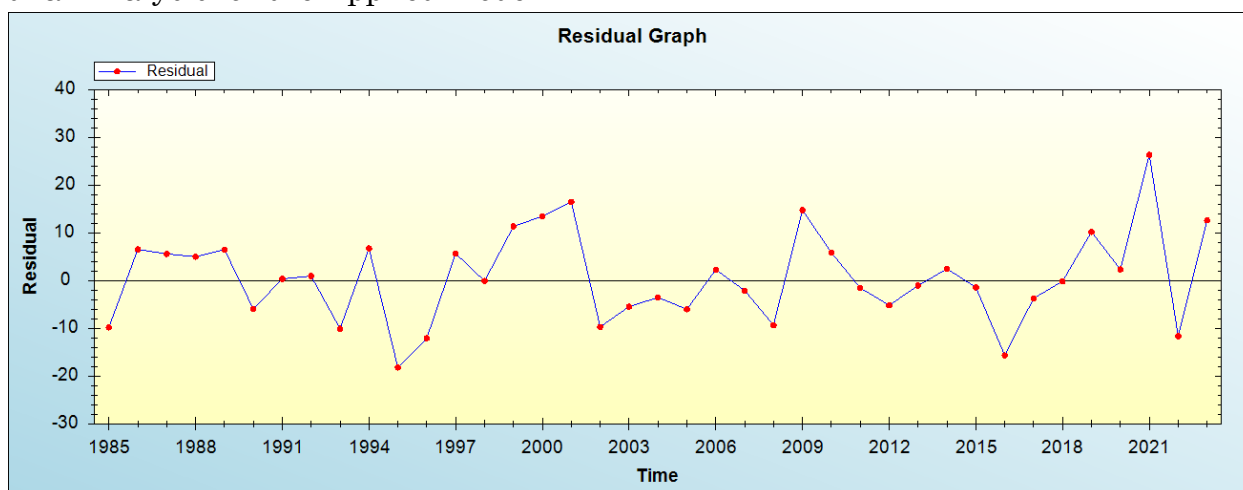


Figure 1: Residual analysis

In-sample Forecast for G

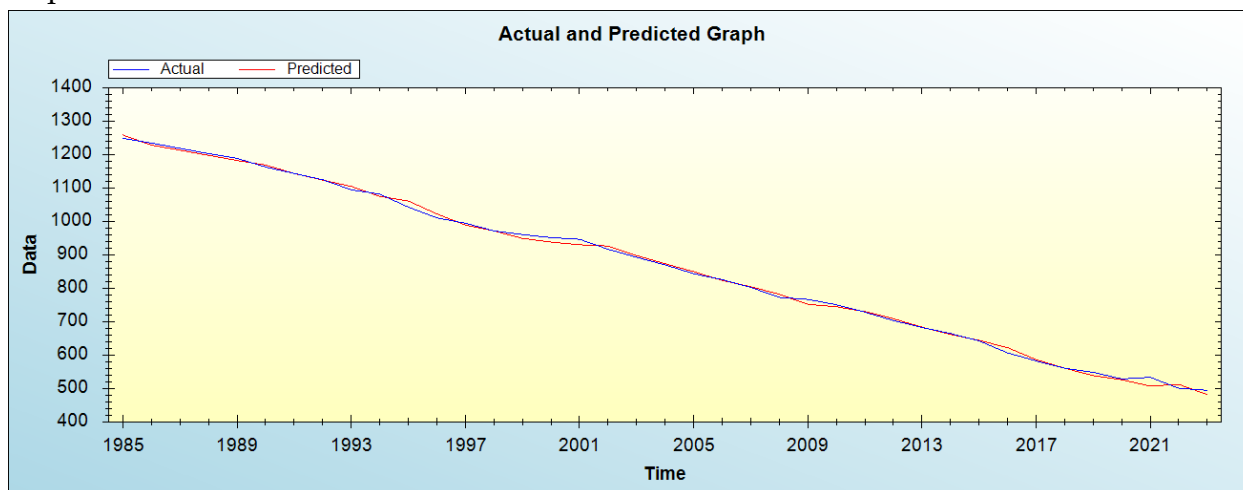


Figure 2: In-sample forecast for the G series

Actual and Smoothed graph for G series

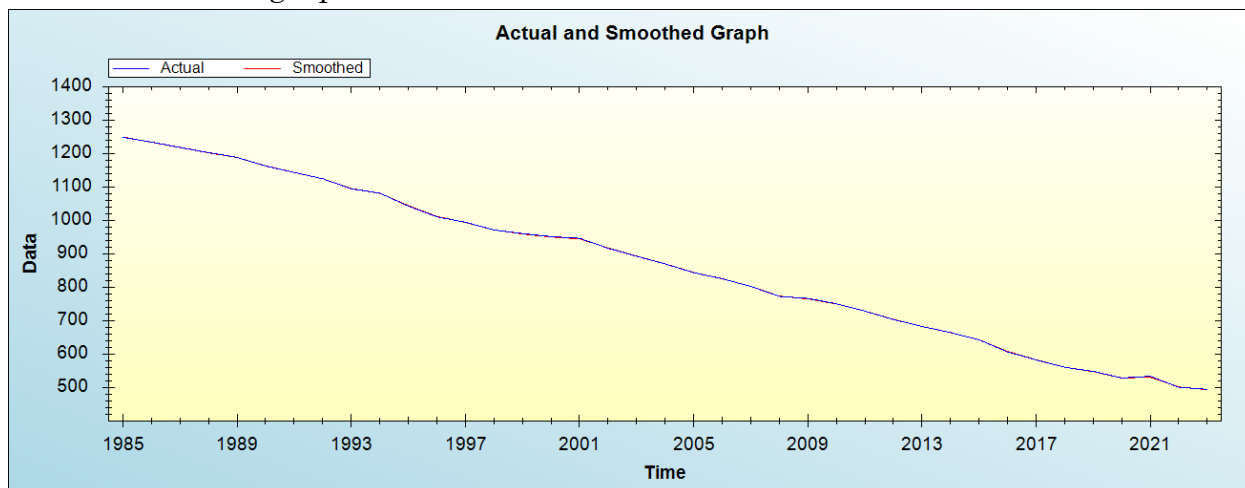


Figure 3: Actual and smoothed graph for G series

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

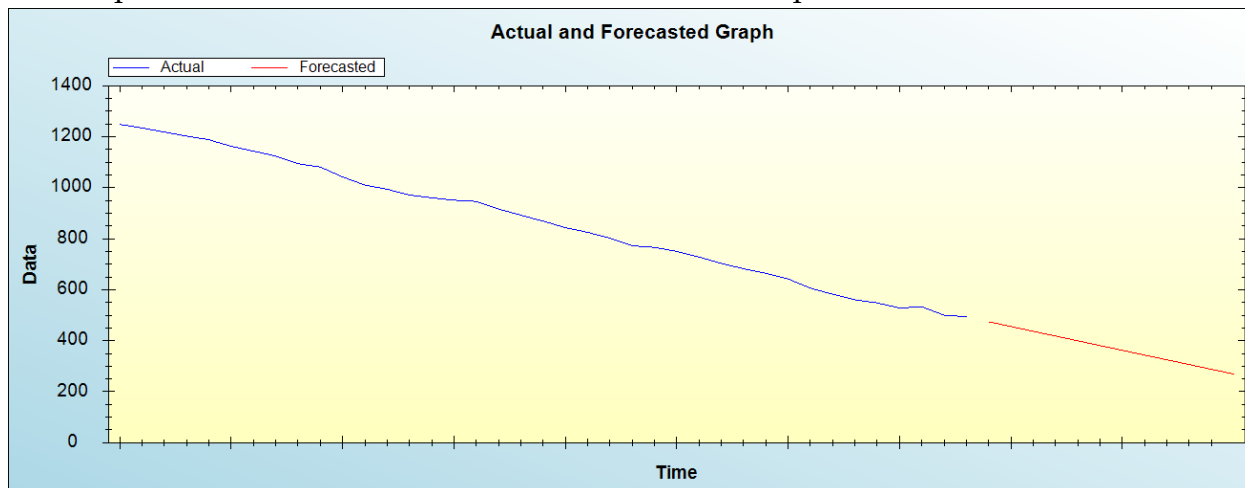


Figure 4: Out-of-sample forecast for G: actual and forecasted graph

Out-of-Sample Forecast for G: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Year	Forecasted MMR
2024	474.1070
2025	455.4741
2026	436.8413
2027	418.2085
2028	399.5756
2029	380.9428
2030	362.3100
2031	343.6771
2032	325.0443
2033	306.4115
2034	287.7786
2035	269.1458

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 to drop but still remain very high over the out of sample period.

RECOMMENDATIONS & CONCLUSION

Tracking future trends of MMR is essential for planning and allocation of resources to the maternal and child health program. This paper applied the double exponential smoothing model to forecast MMR for Guinea and the results indicate that MMR will continue to drop but still remain very high over the out of sample period. Hence, authorities in this country are encouraged to adopt the following recommendations: (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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