

Eurasian Scientific Herald 	Applying The Double Exponential Smoothing Technique To Forecast Maternal Mortality For Angola
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ABSTRACT	This study uses annual time series data on MMR for Angola 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 on a downward path to reach levels below 30 deaths per 100 000 live births by 2035. Therefore, we encourage authorities to adopt the suggested 4-fold policy prescription.
Keywords:	Exponential smoothing, Forecasting, Maternal Mortality Ratio

Introduction

Angola is a Southern African country which had an estimated population size of more than 30.8 million in 2018. It is ranked number 147 out of 189 countries in the Human Development Index despite its rich oil wealth and high per capita GDP (World Bank, 2019). The majority of the population is living in poverty, and is expected benefit from inclusive development policies. According to the 2017 UNICEF report, the country has also been affected by various disasters such as cholera outbreaks, floods and a refugee inflow from the Democratic Republic of the Congo, while continuing to fight against the effects of the El Niño-induced droughts and the yellow fever outbreak. According to the World Health Organization (WHO), a maternal death is the death of a woman while pregnant or within a period of 42 days after the termination of pregnancy, regardless of the duration or location of the pregnancy, due to any cause related to or aggravated by the pregnancy. This can be categorized as direct maternal mortality when related to pregnancy, childbirth or the puerperium and indirect when due to other

causes, but the woman is pregnant (Alves et al. 2013). Currently, around 830 women die every day in the world as a result of avoidable adverse pregnancy, childbirth or postpartum outcomes. The globally, maternal mortality rate (MMR) declined by 2.3 percent per year from 1990 to 2015, the global maternal mortality rate reduced only 2.3% per year (Barreto et al. 2021). It is crucial to mention that more than fifty percent of maternal deaths in the world are reported by Sub-Saharan Africa (SSA), where sociodemographic variables significantly contribute to mortality (Maria, 2021). In Africa, the main direct causes of maternal death are clandestine abortion, anemia, eclampsia, hemorrhage, obstructed labor and puerperal infections. The main indirect causes are HIV/AIDS, malaria, viral hepatitis, pulmonary tuberculosis, infectious diarrheal diseases (cholera, typhoid fever and amoebiasis), tetanus, heart disease and sickle cell anemia (Tavares et al. 2023). The average Maternal Mortality Ratio (MMR) in Africa has dropped from 990 per 100,000 women in 1990 to 460 per 100,000 by the end of 2013. The average per

centage decline in the MMR from the 1990 baseline was 44.8% (Tavares et al. 2023). According to Maria (2021), in Angola, the mortality rate associated with pregnancy is 239 deaths per 100,000 live births. MMR in Angola is persistently high as a result of lack of access to health services, limited coverage by health networks focusing on maternal and child care,

and lack of qualified professionals. The purpose of this study is to model and forecast MMR for Angola using the double exponential smoothing technique. Study results will guide planning and allocation of resources to the MNCH program with a goal of achieving the set SDG target by 2030.

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
Saito and Kondo (2024)	to identify the association between neonatal mortality and MCH services in Angola	-used the Angola Demographic Health Survey 2015–16, which is the latest nationally representative dataset of Angola -applied logistic regression	Doses of maternal tetanus vaccination and postnatal child health check before discharge were modifiable factors associated to late neonatal death
Tavares et al. (2023)	To perform a literature review, highlighting current aspects of maternal mortality.	Literature review	Maternal death is directly related to the living conditions of the population, showing variability from country to country
Critto et al. (2021)	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.	The Argentinian maternal death registry appears sensitive to detect different effects of emerging infectious epidemics on maternal health
Musarandega et al. (2021)	to identify the leading causes of	Systematic literature review	Obstetric hemorrhage,

	maternal deaths using the international classification of disease – 10th revision, for maternal mortality (ICD-MM)		hypertensive disorders in pregnancy, non-obstetric complications, and pregnancy-related infections are the leading causes of maternal deaths in SSA.
Shibre et al. (2020)	to assess the extent of socio-economic, urban-rural and subnational inequality in ANC coverage in Angola	analyzed data from the 2015 Angola Demographic and Health Survey (ADHS) using the World Health Organization (WHO) Health Equity Assessment Toolkit (HEAT) software.	The uptake of ANC services was lower among poor, uneducated, and rural residents as well as women from the Cuanza Sul region
Rosario et al. (2019)	to identify demographic and social factors influencing antenatal care and health facility delivery among women in Dande and to understand their impact on birth outcomes	Applied logistic regression	Antenatal care attendance was a determinant of birth outcomes (stillbirth: unadjusted OR=0.34 95%CI=0.16–0.70; abortion: OR=0.0795%CI=0.04–0.12). Older women, with lower education, living at a greater distance of a health facility and in rural areas, were less likely to use maternal health care.
Umar et al. (2016)	to identify factors that influence the occurrence of maternal deaths in a regional maternity hospital in Kuando Kubango province of Angola	retrospective cross-sectional analysis of case notes of all maternal deaths and deliveries that were recorded from 2010 to 2014. The information collected included data on pregnancy, labor and post-natal period retrieved	The study demonstrated that the MMR in maternity hospital is very high and is higher than the WHO 2014 estimates and the province is yet to achieve the desired MDG 5 target by the end of 2015

		from case notes and the delivery register	
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Methodology

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

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

Smoothing equation

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

$$0 < \alpha < 1$$

Trend estimation equation

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

$$0 < \beta < 1$$

Forecasting equation

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

A_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 Angola 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

Exponential smoothing Model Summary

Table 1: ES model summary

Variable	A
Included Observations	39
Smoothing constants	
Alpha (α) for data	0.900
Beta (β) for trend	0.100
Forecast performance measures	
Mean Absolute Error (MAE)	18.301131
Sum Square Error (SSE)	29493.242787
Mean Square Error (MSE)	756.236995
Mean Percentage Error (MPE)	1.447942
Mean Absolute Percentage Error (MAPE)	3.893386

Residual Analysis for the Applied Model

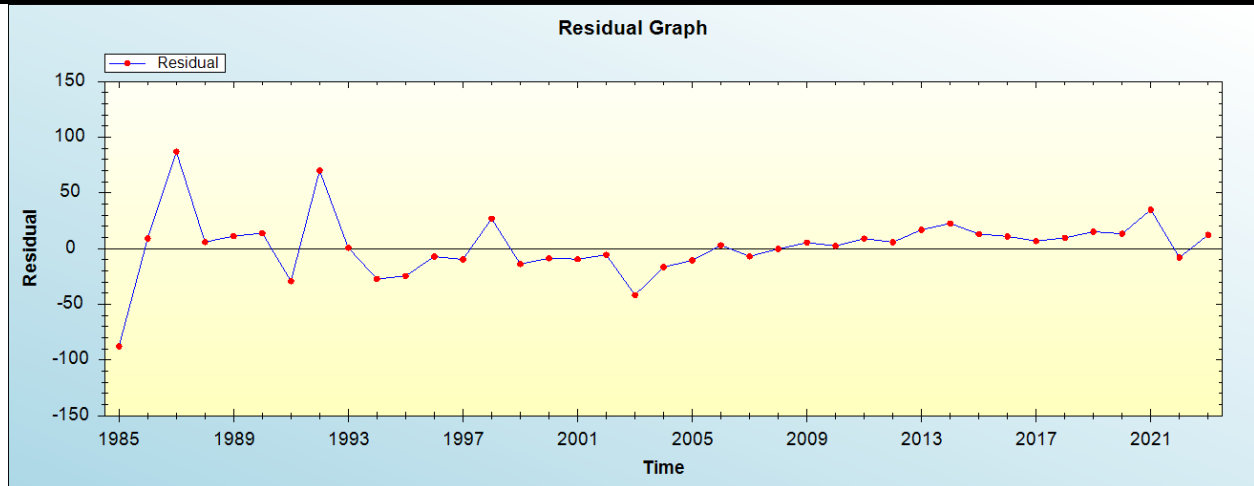


Figure 1: Residual analysis

In-sample Forecast for A

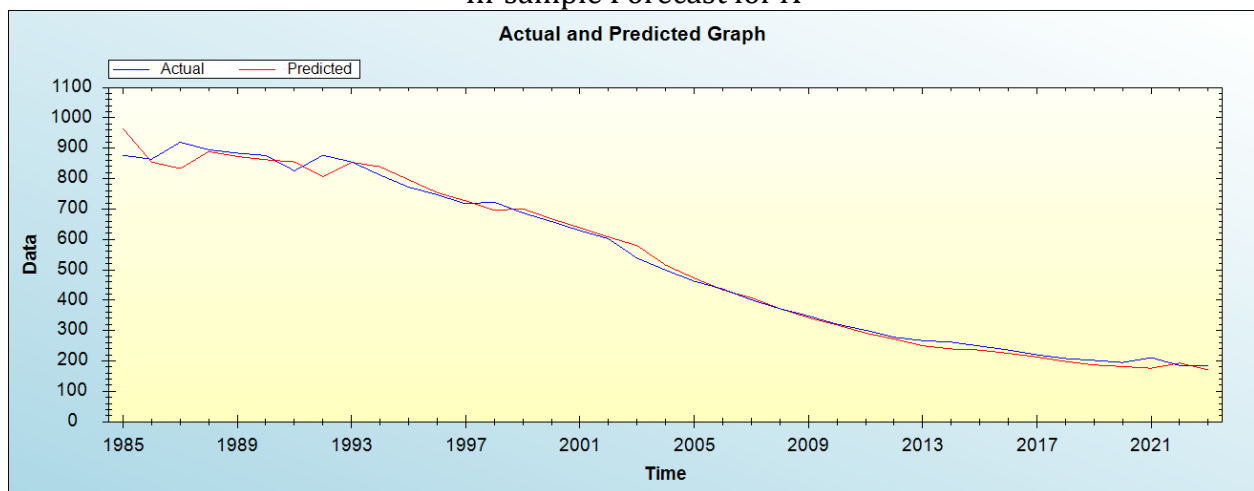


Figure 2: In-sample forecast for the A series

Actual and Smoothed graph for A series

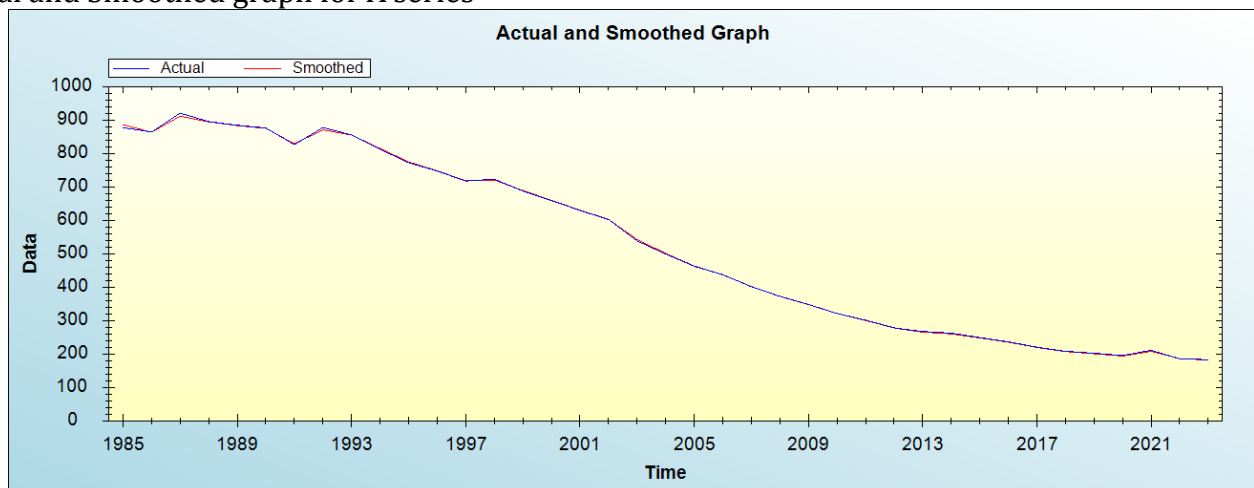


Figure 3: Actual and smoothed graph for A series

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

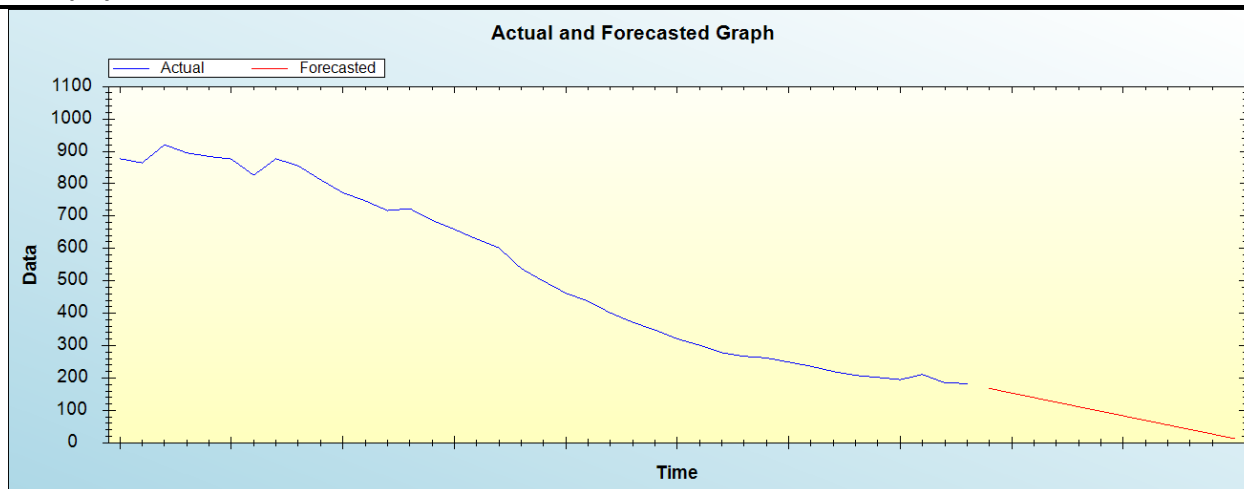


Figure 4: Out-of-sample forecast for A: actual and forecasted graph

Out-of-Sample Forecast for A: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Year	Forecasted MMR
2024	167.6840
2025	153.6069
2026	139.5298
2027	125.4527
2028	111.3756
2029	97.2985
2030	83.2213
2031	69.1442
2032	55.0671
2033	40.9900
2034	26.9129
2035	12.8357

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 path and reach levels below 30 deaths per 100 000 live births by 2035.

Conclusion

Maternal mortality is persistently high in Angola. Direct causes such as hypertensive disorders, obstructed labor, sepsis and unsafe abortions are being reported. Forecast results indicate that MMR will continue on a downward path throughout the out of sample period. It is therefore, necessary for the Angolan government to (1) improve on the coverage of healthcare services including ANC (2) continuous training and retention of medical

staff at all levels of healthcare (3) secondment of Obstetricians at high volume district hospitals as well as Provincial hospitals when resources are permitting and (4) continuous quality improvement activities.

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