

Eurasian Scientific Herald 	Detecting Future Trends Of Maternal Mortality In Algeria Using Holt's Double Exponential Smoothing Approach
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ABSTRACT	This study uses annual time series data on MMR for Algeria 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 decline and reach levels below 30 deaths per 100 000 live births by 2035. Therefore, there is need for continuous implementation of quality improvement initiatives coupled with continuous training and retention of medical staff to ensure adequate staffing levels at all levels of care.
Keywords:	<i>Exponential smoothing, Forecasting, Maternal Mortality Ratio</i>

Introduction More than one thousand women continue to die every day from pregnancy-related causes around the globe, and most of these deaths happen in low- and middle-income countries as a result of avoidable causes (WHO, 2017). Worldwide, greater than seventy percent of maternal mortality cases happen due to problems associated with pregnancy and child birth namely antepartum and post-partum bleeding, pregnancy induced hypertension, puerperal sepsis and abortion (Say et al. 2009). World Health Organization (WHO) guidelines recommend evidence based essential care for pregnant women and newborns to improve birth outcomes and neonatal survival (WHO, 2022; WHO, 2017; WHO; 2016). Maternal sepsis and other pregnancy related complications may lead to in severe maternal and child outcomes. Furthermore, WHO guideline of antenatal care recommends iron supplementation to avoid anemia and any subsequential disorders, and preventive malaria and intestinal parasite drugs in prevalent areas (WHO, 2016). Blood pressure, urine, and blood samples are taken during pregnancy to detect the risk and occurrence of pregnancy complications, such as hypertensive disorders in pregnancy and diabetes. WHO guidelines of neonatal care recommend essential neonatal care, which includes appropriate clean and dry cord care, keeping newborns warm, exclusive breastfeeding, and assessment of the newborn for danger signs during postnatal care (WHO, 2022; WHO, 2017). The objective of this study is to model and forecast maternal mortality rate (MMR) for Algeria using Holt's double exponential smoothing technique. This paper is expected to reveal likely future trends of MMR in this country. This is essential for planning and allocation of resources to the maternal and child health program in Algeria.	
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<u>Literature Review</u>			
Author (s)	Objective(s)	Methodology	Main 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
Cresswell et al. (2025)	To obtain updated evidence on causes of maternal death to accelerate SDG progress	conducted a multi-strategy systematic review to identify causes of maternal deaths occurring in 2009–20	Hemorrhage remains the leading cause of death, despite the existence of effective clinical interventions, emphasizing the need for improved access to quality health care
Kama et al. (2025)	to establish the period prevalence of MNM and mortality index, and to compare near-miss cases with maternal mortality and to identify their risk factors and causes	Cross-sectional study	The leading causes of MNM were eclampsia (47.8%), abruptio placentae (19.7%) and postpartum hemorrhage (8.3%), and the leading causes of maternal death were eclampsia (29.2%), puerperal sepsis (25%) and postpartum hemorrhage (12.5%)
Bhalotra & Clarke (2024)	to investigate the association of women's education with maternal and child mortality	Panel regression	moving an additional 1 percentage point of women into primary education reduces rates of maternal death by 4.6%, and reduces the rate of infant deaths by 1.9%
Duka et al. (2024)	to quantify the inequalities in the distribution of nurses in Albania, analyzing the nurse-to-population ratio and its impact on the quality of healthcare	Descriptive analytic study	The average nurse-to-population ratio in Albania is 28 nurses per 10,000 inhabitants, with significant variations between regions. Tirana has the highest ratio (60 nurses per 10,000 inhabitants), while Kukës and Dibër have the

			lowest values (10 per 10,000 inhabitants)
Balg et al. ((2023)	to examine and critically evaluate existing literature on perceptions and investigations regarding maternal mortality in Southeast Asia, Europe and Africa, utilizing the three delays model approach as a categorization framework	Systematic literature review	Inadequate care is one of the major causes of maternal mortality in majority of regions across the globe. Multiple factors can hinder access to appropriate healthcare. The three delays model plays a significant role in the higher maternal mortality rate
Diguisto et al. (2022)	to compare maternal mortality in eight countries with enhanced surveillance systems	Descriptive multi-country population-based study.	Variations in maternal mortality ratios exist between high income European countries with enhanced surveillance systems. In-depth analyses of differences in the quality of care and health system performance at national levels are needed to reduce maternal mortality further by learning from best practices and each other
Nnadi et al. (2022)	to estimate the effect of maternal mortality on economic development in Sub-Sahara African region	Cross-sectional data analysis of selected member countries in the region under focus was employed using double-log econometric model	The explanatory variables in the model were statistically significant at 5% level while other coefficients like maternal mortality, exports and imports conform to the apriori expectations and impacted negatively on the overall GDP
Pouyanfar et al. (2022)	to investigate the factors affecting the maternal mortality ratio (MMR) in different regions of Iran	Systematic review	The leading causes of maternal death were hemorrhage (43.7%), preeclampsia/eclampsia (24.5%), other hypertensive disorders (24%), and embolism (22.8%)

Sidi-Yakhlef et al. (2021)	to identify some determinants associated with this mortality from data of multiple indicator cluster survey conducted in Algeria in 2012-2013 (mics 4)	retrospective case-control study	In addition to the various reproductive health strategies already adopted by the authorities for health promotion and family planning, action should be taken to evaluate their implementation with sustained assistance for disadvantaged people and in risk areas.
Gabrani et al. (2020)	to identify key factors influencing the utilization of governmental and private primary healthcare services in Albania	cross-sectional health facility survey using a 4-point Likert scale questionnaire to rank the importance of factors driving services utilization.	The use of primary healthcare is strongly influenced by geographical and financial access for public facility users and availability of equipment for private users. This study found that aspects of acceptability and adequacy of services are equally valued
Tamburlini et al. (2011)	to identify issues in maternal and neonatal care and promote action	-A standard based tool was utilized	Neonatal care scored better than obstetric care

Methodology

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

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

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 Algeria 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	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)	8.435676
Sum Square Error (SSE)	7595.445656
Mean Square Error (MSE)	194.755017
Mean Percentage Error (MPE)	0.820265
Mean Absolute Percentage Error (MAPE)	6.319925

Residual Analysis for the Applied Model

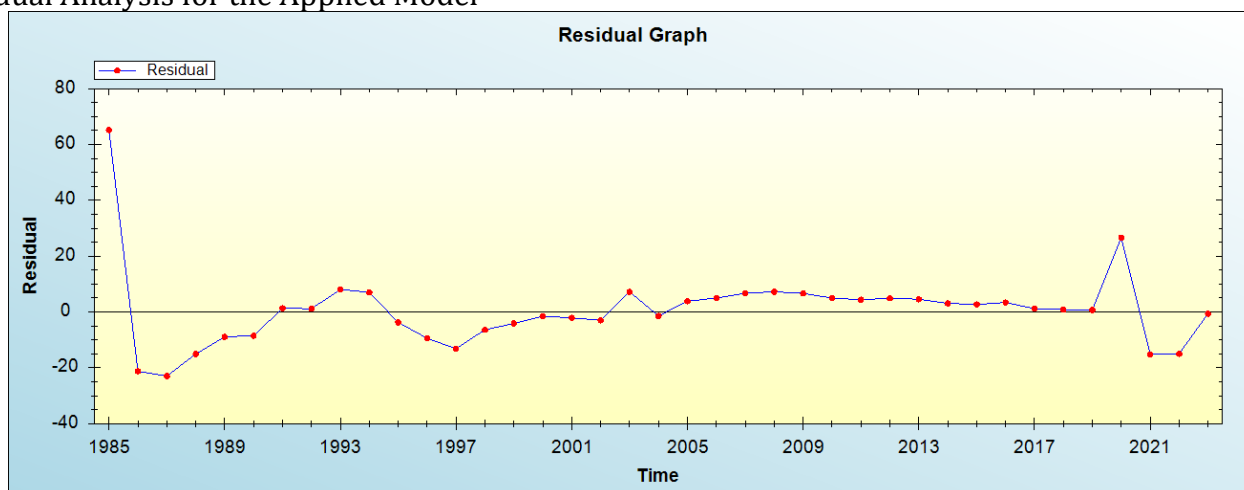


Figure 1: Residual analysis

In-sample Forecast for A

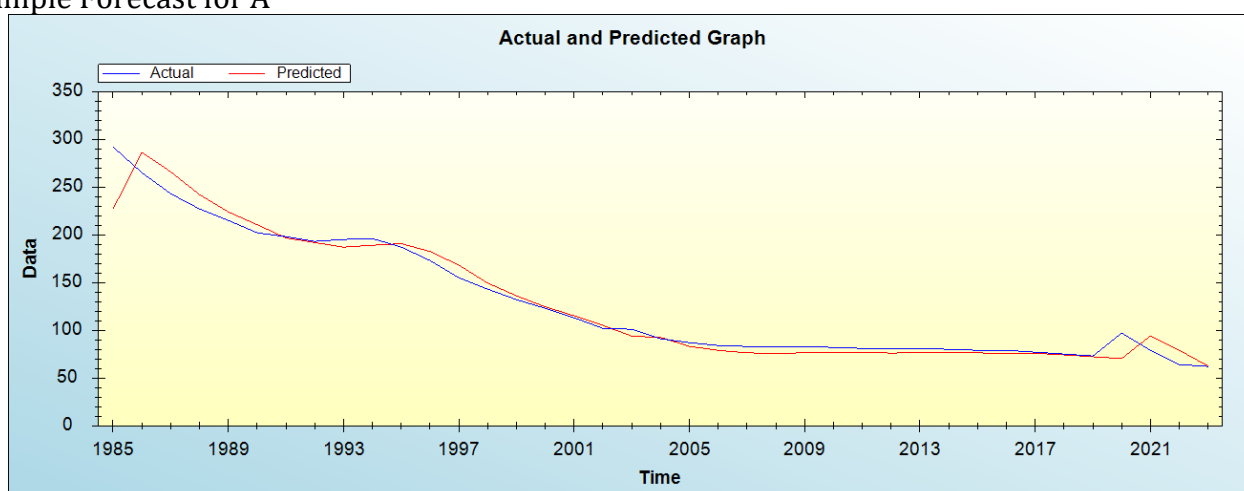


Figure 2: In-sample forecast for the A series

Actual and Smoothed graph for A series

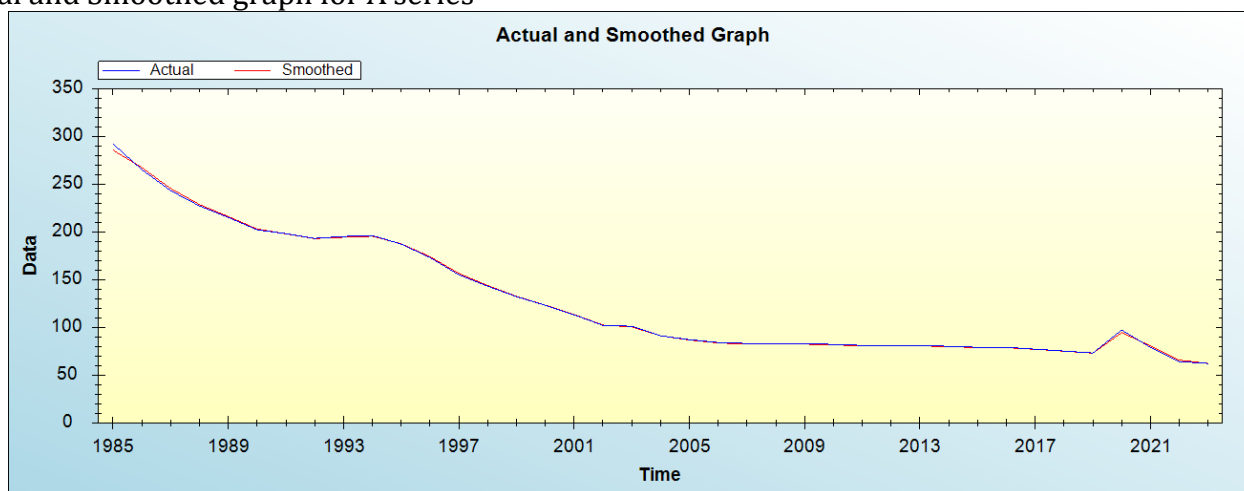


Figure 3: Actual and smoothed graph for A series

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

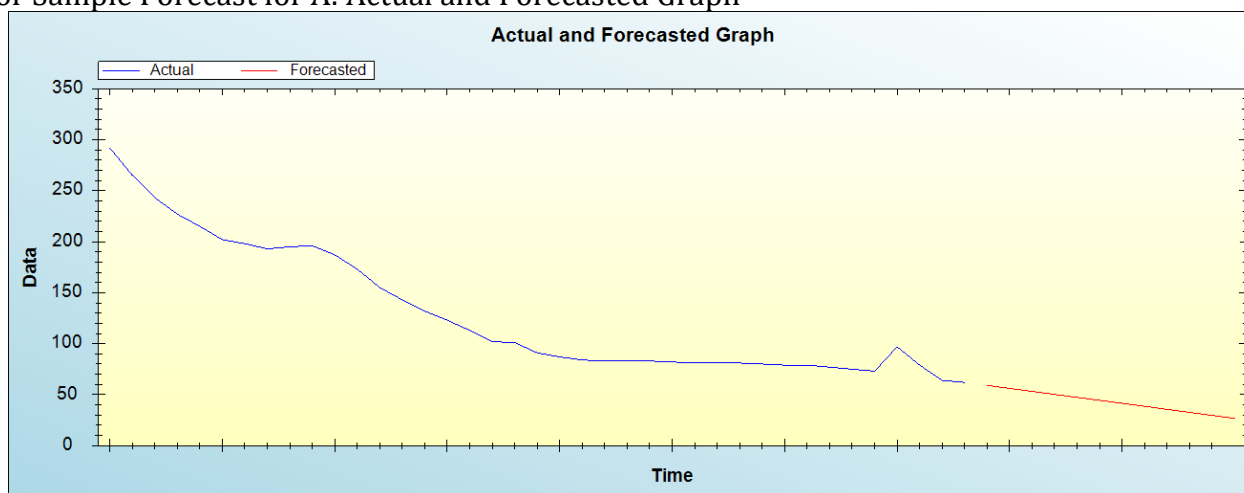


Figure 4: Out-of-sample forecast for A: actual and forecasted graph

Out-of-Sample Forecast for A: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Year	Forecasted MMR
2024	59.1222
2025	56.1830
2026	53.2438
2027	50.3046
2028	47.3654
2029	44.4262
2030	41.4870
2031	38.5478
2032	35.6086
2033	32.6694
2034	29.7302
2035	26.7910

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

Conclusion

Maternal mortality is still an important public health issue in Algeria. The applied double exponential smoothing model revealed that MMR will continue to decline and reach levels below 30 deaths per 100 000 live births by 2035. This paper argues that there is need for continuous implementation of quality improvement initiatives coupled with continuous training and retention of healthcare staff to ensure adequate staffing levels at all levels of care.

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