

Forecasting Maternal Mortality For Albania Using The Double Exponential Smoothing Technique

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ABSTRACT

This study uses annual time series data on MMR for Albania 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 0.7 and 0.1 respectively based on minimum MSE. The results of the study indicate maternal mortality will remain very low throughout the forecast period. Hence, authorities are implored to relentlessly address major drivers of preventable maternal deaths across the country.

Keywords: Exponential smoothing, Forecasting, Maternal Mortality Ratio

Introduction

According to Albania Demographic and Health Survey 2017-2018 report, Albania is located in Southeastern and Southern Europe, with Montenegro bordering to the northwest, Kosovo to the northeast, Macedonia to the east, and Greece to the south and has a total population of 2.9 million inhabitants, according to the most recent estimates. The country has witnessed widespread social and political changes over the past decades. These changes are observed in the economic arena and other spheres of life. The exodus of people has adversely affected the population structure, education, employment, and other sociodemographic variables. The Albania country profile revealed that maternal mortality ratio in 2020 stood at 8.3 deaths per 100 000 live births, in 2022, neonatal mortality was 7.0 deaths per 1000 live births, and under five deaths stood at 9.4 deaths per 1000 live births. In addition, the country profile highlighted that in 2018 antenatal coverage was 77.8 percent. In the year 2022, all births were attended by skilled birth attendants. The purpose of this paper is to model and forecast maternal mortality ratio for Albania using the double exponential smoothing technique. We expect the findings of this study to inform maternal and child programming in the country with a view of eliminating all preventable maternal deaths in the country.

Literature Review

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 in habitants), while Kukës and Dibër have the lowest values (10 per 10,000 inhabitants)
Diguisto et al. (2022)	to compare maternal mortality in eight countries with enhanced	Descriptive multi-country population-based study.	Variations in maternal mortality ratios exist between high income European countries with enhanced surveillance

	surveillance systems		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
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%)
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 Albania. 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

$A_t=\mu_t + \rho_t \mathbf{t} + \varepsilon_t$

Smoothing equation

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

$0<\propto<1$

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 Albania 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	0.700
Beta (β) for trend	0.100
Forecast performance measures	
Mean Absolute Error (MAE)	1.322231
Sum Square Error (SSE)	173.653277
Mean Square Error (MSE)	4.452648
Mean Percentage Error (MPE)	1.065919
Mean Absolute Percentage Error (MAPE)	9.165048

Residual Analysis for the Applied Model

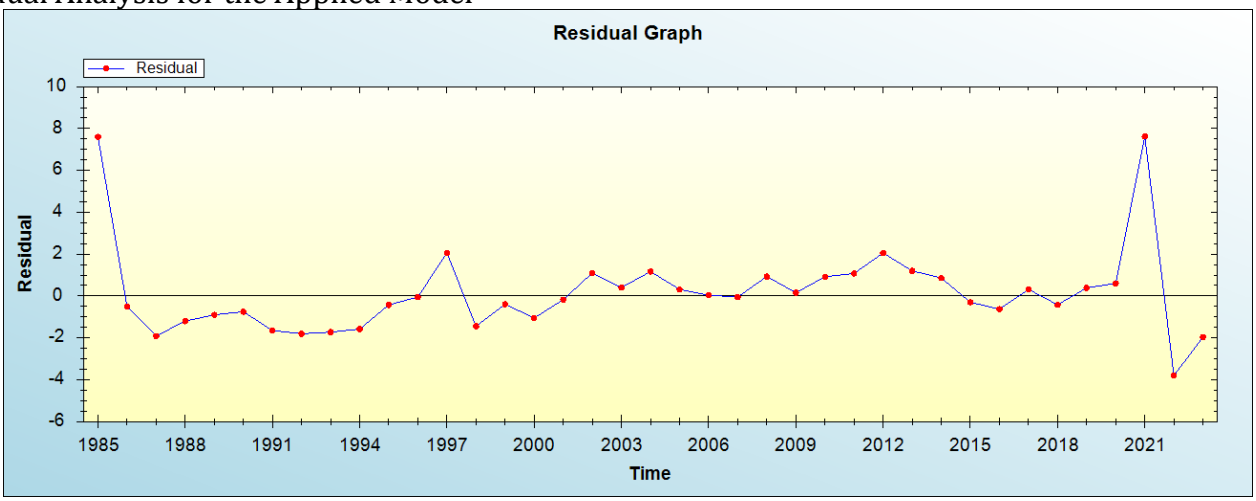


Figure 1: Residual analysis

In-sample Forecast for A

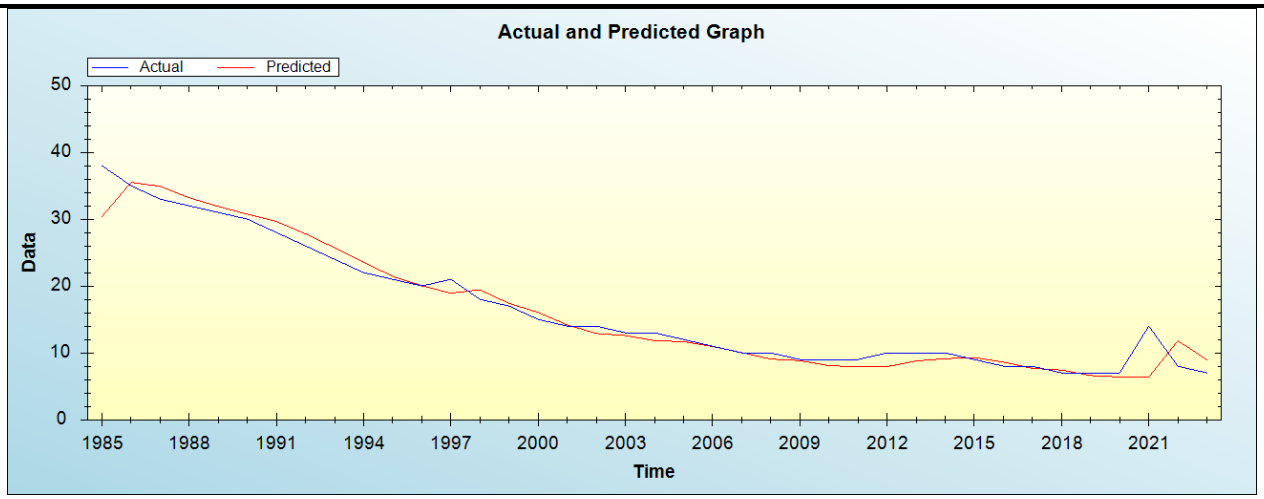


Figure 2: In-sample forecast for the A series

Actual and Smoothed graph for A series

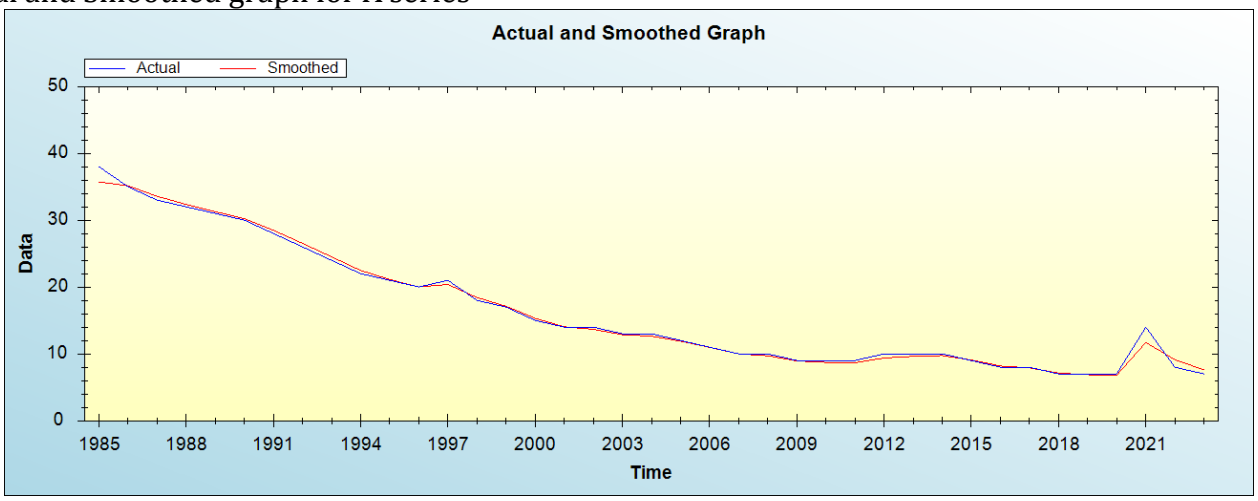


Figure 3: Actual and smoothed graph for A series

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

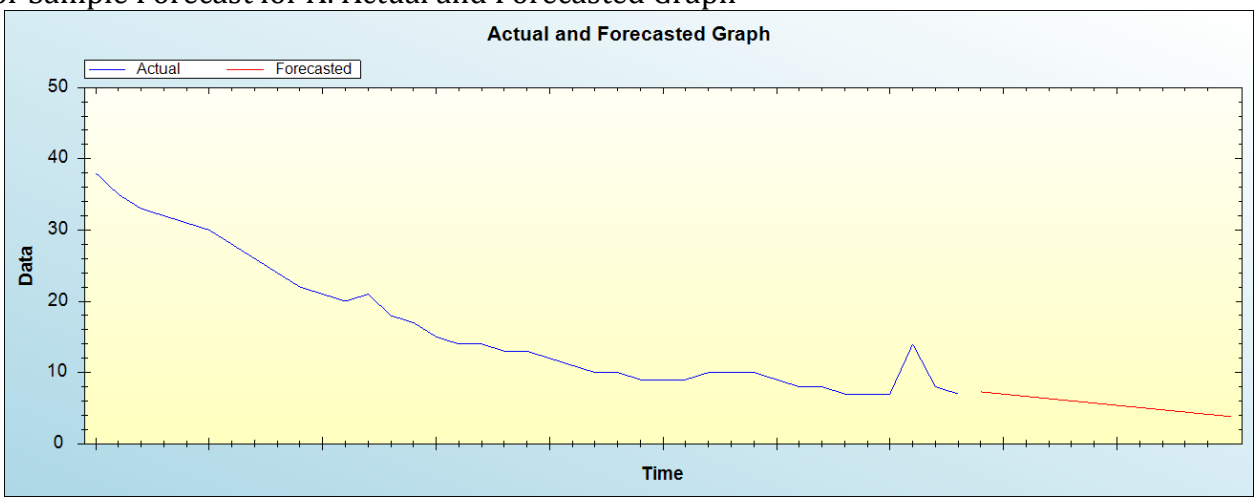


Figure 4: Out-of-sample forecast for A: actual and forecasted graph

Out-of-Sample Forecast for A: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Year	Forecasted MMR
2024	7.2759

2025	6.9623
2026	6.6487
2027	6.3351
2028	6.0215
2029	5.7079
2030	5.3943
2031	5.0807
2032	4.7672
2033	4.4536
2034	4.1400
2035	3.8264

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 throughout the out of sample period.

Recommendations and Conclusion

This study applied Holt's double exponential smoothing technique to forecast the Maternal Mortality Ratio (MMR) for Albania through 2035. The model reveals that MMR will remain consistently very low throughout the out-of-sample forecast period—projected to decline steadily from 7.28 deaths per 100,000 live births in 2024 to 3.83 in 2035. These findings reflect the high overall quality of maternal healthcare services in the country, as evidenced by universal skilled birth attendance and high antenatal coverage.

To maintain this progress and further eliminate preventable maternal deaths, health authorities should implement the following actions based on the study's findings:

i. **Target Indirect Causes of Mortality:** Shift policy focus toward managing indirect causes of maternal death such as diabetes mellitus and cardiovascular disorders which are increasingly prominent in low-MMR contexts.

ii. **Address Regional Resource Disparities:** Resolve geographic inequalities in healthcare distribution, particularly by improving nurse-to-population ratios in underserved regions like Kukës and Dibër to match higher-density areas like Tirana.

iii. **Optimize Primary Care Access:** Enhance financial and geographical access to primary healthcare facilities, ensuring essential medical equipment and high-quality routine care are available across all regions.

iv. **Strengthen Referral Networks:** Ensure strong, equitable links between community-level care and referral facilities to facilitate rapid management of obstetric emergencies.

References

1. Bhalotra, S., & Clarke, D. (2024). Educational expansion and maternal and child mortality. *Journal of Health Economics*, *93*, Article 102832. https://doi.org/10.1016/j.jhealeco.2023.102832
2. Cresswell, J. A., Ronsmans, C., Calvert, C., & Filippi, V. (2025). Causes of maternal death worldwide: A systematic review. *The Lancet Global Health*, *13*(2), e215–e227.
3. Diguisto, C., Saucedo, M., Kallianidis, A., Bloemenkamp, K., Bødker, B., Buoncristiano, M., Donati, S., Gissler, M., Johansen, M., Knight, M., Korbel, M., Kristufkova, A., Nyflot, L. T., & Deneux-Tharaux, C. (2022). Maternal mortality in eight European countries with enhanced surveillance systems: Descriptive population based study. *BMJ*, *379*, Article e070621. https://doi.org/10.1136/bmj-2022-070621
4. Duka, B., Dervishi, A., Grosha, E., Ivziku, D., Rocco, G., Stievano, A., & Notarnicola, I. (2025). Inequalities in the distribution of the nursing workforce in Albania: A regional analysis using the Gini coefficient. *Nursing Reports*, *15*(2), 30.

https://doi.org/10.3390/nursrep15020030

5. Gabrani, J., Schindler, C., & Wyss, K. (2020). Factors associated with the utilisation of primary care services: A cross-sectional study in public and private facilities in Albania. *BMJ Open*, *10*(12), Article e040398. https://doi.org/10.1136/bmjopen-2020-040398
6. Institute of Statistics, Institute of Public Health, & ICF. (2018). *Albania Demographic and Health Survey 2017–2018*. INSTAT, IPH, and ICF.
7. Kama, M., Nombekela, X., & Mfecane, S. (2025). Maternal near-miss and maternal mortality in a rural tertiary hospital. *South African Medical Journal*, *115*(1), 45–52.
8. Mackin, R., Marshall, J., & Lawton, B. (2026). Organization of maternal and newborn facility care globally: A scoping review. *BMC Pregnancy and Childbirth*, *26*(1), Article 112.
9. Pouyanfar, S., Rezaei, S., & Mohammadi, M. (2022). Factors affecting maternal mortality ratio in Iran: A systematic review. *BMC Public Health*, *22*(1), Article 1402. https://doi.org/10.1186/s12889-022-13789-x
10. Tamburlini, G., Di Mario, S., Magrini, N., & Rosati, S. (2011). Evaluation of the quality of maternal and neonatal care in hospital facilities. *International Journal of Gynecology & Obstetrics*, *115*(2), 180–185. https://doi.org/10.1016/j.ijgo.2011.07.012
11. World Bank. (2022). *World Bank country profile: Albania*. World Bank Group. https://data.worldbank.org/country/albania