

Eurasian Scientific Herald 		Forecasting Maternal Mortality For Amernia Using The Double Exponential Smoothing Method	
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ABSTRACT		<i>This study uses annual time series data on MMR for Armenia 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 10 deaths per 100 000 live births by 2035. Therefore, we encourage authorities address local causes of preventable maternal deaths.</i>	
Keywords:		<i>Exponential smoothing, Forecasting, Maternal Mortality Ratio</i>	

Introduction

Armenia is an upper middle-income country with a per capita gross domestic product (GDP) of more than \$4,000 in 2017 (World Bank, 2024). The country reported an economic growth of 4.1 percent between 2010 and 2018 and poverty rate declined from 34.1 in 2009 to 23.5 percent in 2018 (World Bank, 2022). Armenia's economic growth dropped from 12.6 in 2022 to 8.3 percent in 2023 (IMF, 2024). The poverty rate decreased from 26.5 in 2021 to 24.8 percent in 2022 and further to 23.7 percent in 2023 (Armenia, 2024). The country is ranked 76 out of 193 economies and territories using the Human development index (UNDP, 2024). Armenia has made tremendous progress across

several health indicators. Maternal mortality declined from 43 per 100,000 live births in 2000 to 27 per 100,000 live births in 2020, and infant mortality fell from 27 deaths per 1,000 live births in 2000 to 10 per 1,000 live births in 2021.8 The incidence of tuberculosis dropped from 50 to 25 cases per 100,000 population over the period 2015-2022 (WHO, 2024) and tuberculosis-related mortality from 2.4 to 0.4 cases per 100,000 population (WHO & GH0, 2024). The aim of this study is to model and forecast MMR for Armenia using the double exponential smoothing technique. The findings of the study will guide policy formulation and allocation of resources to the Maternal and Child health program.

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
Cresswell et al. (2025)	To get updated evidence on causes of maternal death to accelerate progress	Systematic review	Globally, the most common cause of maternal death was hemorrhage (27%; 80% uncertainty interval 22–32), followed by indirect obstetric deaths (23%, 18–30), and hypertensive disorders (16%, 14–19). The proportion of hemorrhage deaths varied substantially by region and was highest in sub-Saharan Africa and Western Asia and Northern Africa
Rostomian et al. (2023)	To investigate the effects of armed conflict on maternal and infant health in Armenia and the 2020 Nagorno-Karabakh	Mixed methods study	Maternal and infant health measures showed adverse trends during the 2020 Nagorno-Karabakh war, potentially amplified by the concurrent COVID-19 pandemic
Ghukasyan (2022)	to determine and analyzed the first data on the structure and frequency of caesarean section in Armenia in the hospital of the Erebouni multidisciplinary clinic before the introduction of the M. Robson scale	-retrospective study of the history of childbirth in 38,111 patients registered at the Erebouni Medical Center for the period 2016-2021 -The materials of the study were case histories, hospitalization materials and annual reports	According to the obtained data, 80.5% of caesarean section operations were performed as planned. Only 14% of pregnant women were delivered by caesarean section according to absolute indications, the frequency of that in this maternity hospital increased from 36.77% to 44.95% over the analyzed period
Pouyanfar et al. (2022)	to investigate the factors affecting the maternal mortality ratio (MMR) in	Systematic review	The maternal mortality rate (MMR) during the study period ranged from 15.8 per 100,000 live births in Tehran to

	different regions of Iran		384 per 100,000 live births in Sistan and Baluchestan province The leading causes of maternal death were hemorrhage (43.7%), preeclampsia/eclampsia (24.5%), other hypertensive disorders (24%), and embolism (22.8%)
Samad et al. (2021)	To examine the association between predictive capacity of intimate partner violence and pregnancy termination among women in Armenia	The study analyzed the 2015–16 Armenia Demographic and Health Survey (ADHS) data on women aged 15–49 (Mean: 31.49; Standard Deviation, SD: 9.51)	Women who ever experienced sexual violence were about 10 times likely to experience pregnancy termination than women who did not experience sexual violence (aOR: 9.76, 95% CI: 1.91–49.96)
Khatooni et al. (2019)	To examine maternal and child health indicators in the early years of the SDGs in Iran relative to several other countries	secondary analysis of maternal and child health indicators in Iran	Iran has attained better results than other countries with respect to maternal mortality, family planning, skilled birth attendance, under-5 deaths, incidence of hepatitis B, diphtheria-tetanus-pertussis vaccination coverage, and antenatal care
Karimi-Zarchi et al. (2016)	to determine the frequency and causes of pregnancy-related mortality rates in Yazd Province, Iran	This cross-sectional study examined the maternal deaths related to pregnancy that were recorded in Yazd Province, Iran, from 2002 to 2011	Cesarean section and its complications were the main cause of death in many cases
Alizadeh et al. (2015)	To compare some reproductive health (RH) indicators before and after implementation of the family physician program in rural areas of East Azerbaijan, Iran	-ecologic-time trend study -data of 191075 births of rural women of East Azerbaijan from 2001 to 2010 was extracted from vital horoscope (ZIJ) and used for calculation	Perinatal care and safe delivery even for pregnancies outside the typical child-bearing ages are promoting after implementation of rural family physician program in East Azerbaijan. Also decreasing unsafe

		of 20 important RH indicators. The paired t-test and correlation analysis wear used for data analysis	delivery and stillbirth rate can be considered as achievements of running this program in this province
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Methodology

This study utilizes an exponential smoothing technique to model and forecast future trends of MMR for Armenia. 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 Armenia 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)	3.079087
Sum Square Error (SSE)	1863.334949
Mean Square Error (MSE)	47.777819
Mean Percentage Error (MPE)	-2.376259
Mean Absolute Percentage Error (MAPE)	8.918871

Residual Analysis for the Applied Model

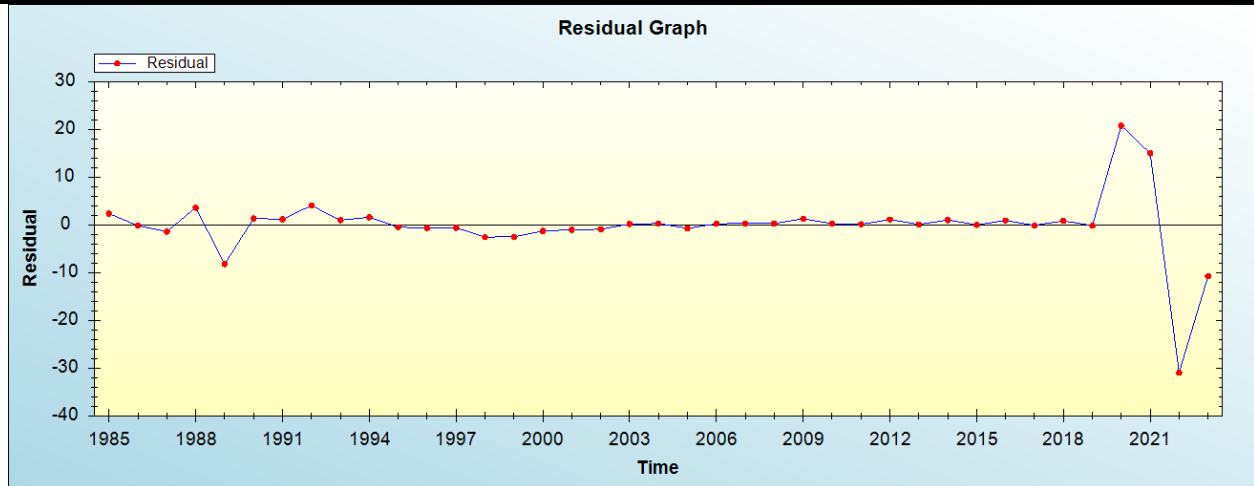


Figure 1: Residual analysis

In-sample Forecast for A

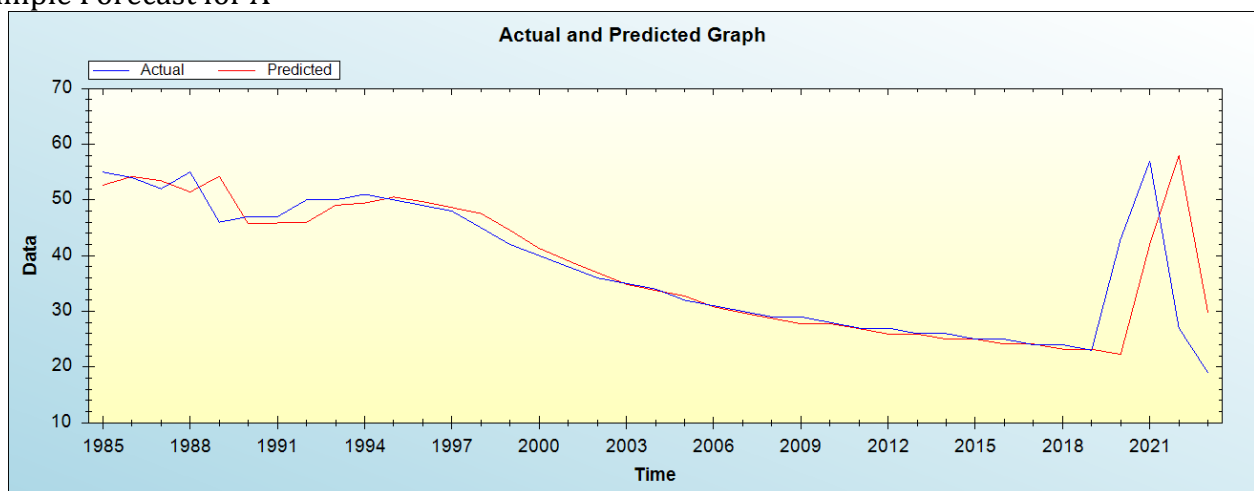


Figure 2: In-sample forecast for the A series

Actual and Smoothed graph for A series

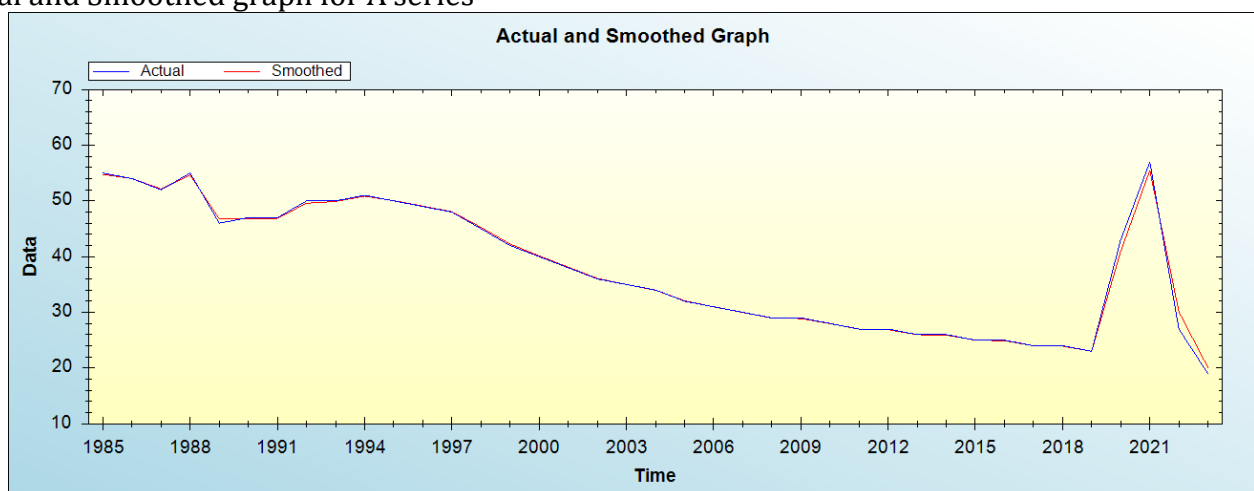


Figure 3: Actual and smoothed graph for A series

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

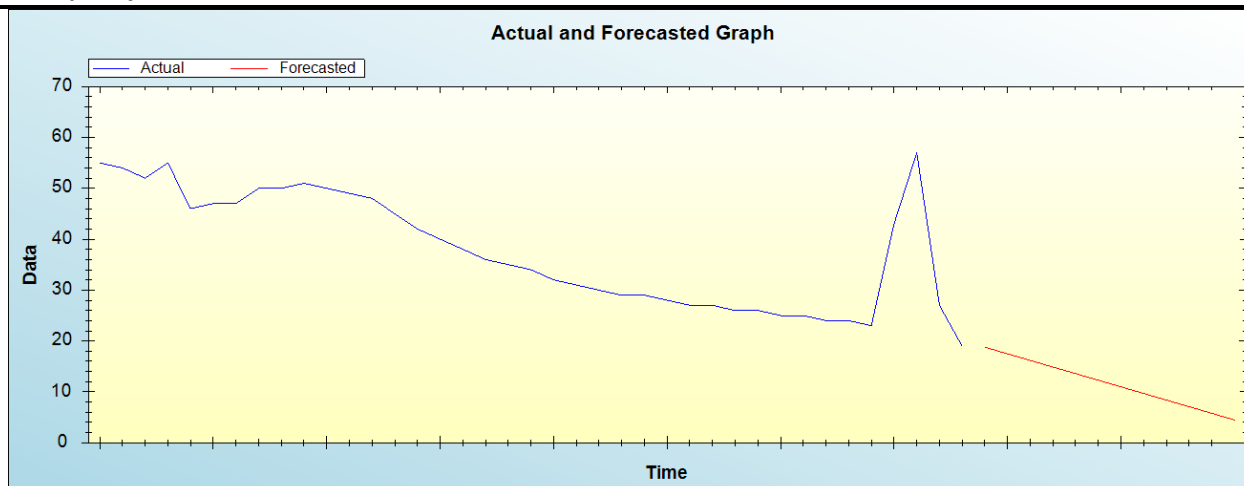


Figure 4: Out-of-sample forecast for A: actual and forecasted graph

Out-of-Sample Forecast for A: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Year	Forecasted MMR
2024	18.7782
2025	17.4797
2026	16.1812
2027	14.8827
2028	13.5842
2029	12.2858
2030	10.9873
2031	9.6888
2032	8.3903
2033	7.0918
2034	5.7934
2035	4.4949

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 decrease and reach levels below 10 deaths per 100 000 live births by 2035.

Conclusion

Armenia has made significant strides in the reduction of maternal mortality by bringing down MMR to levels below 30 per 100 000 live births. Forecast results highlight that MMR will decline and reach levels below 10 deaths per 100 000 live births by 2035. Therefore, authorities are encouraged to address local causes of preventable maternal deaths.

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