



Tracking Future Trends Of Maternal Mortality For Afghanistan Using The Double Exponential Smoothing Technique

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ABSTRACT

This study uses annual time series data on MMR for Afghanistan 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 0.6 and 0.1 respectively based on minimum MSE. The results of the study indicate that annual MMR will continue on a downward trajectory but 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

Afghanistan's healthcare system has suffered as a result of armed conflict which affected delivery of healthcare services across the country. Access to healthcare services became a major contributing factor to maternal and neonatal mortality (Latifi, 2019). The country reported one of the highest rates of maternal, infant and child mortality in the world (Ezadi et al. 2022; Faiz, 1997). The regime's ban on women working outside the home or attending school, including female health care professionals had an adverse effect on women's lives and their children (Ezadi et al. 2022; Faiz, 1997). In addition, shortage of skilled healthcare workforce aggravated the situation (Latifi, 2019). However, the Afghan authorities managed to train and recruit more midwives. Targeted investments in the health care sector brought positive results evidenced by reduction of maternal mortality from approximately 1,450

deaths per 100,000 live births in 2000 to 638 deaths per 100,000 live births in 2017 (UNICEF & Afghanistan, 2022); World Bank, 2022). Furthermore, infant mortality dropped from 88 deaths per 1,000 live births in 2001 to 45 deaths per 1000 live births in 2020 and under 5 years mortality fell from 125 death per 1,000 in 2001 to 58 deaths per 1000 in 2020 (UNICEF & Afghanistan, 2022). There are several challenges that have hindered the success of the maternal and child health (MNCH) program in the country namely lack of educational opportunities and limits on women's rights that reduce their opportunities to participate in governance and access justice (Akseer et al. 2018), and rural women not attending school, or women seeking permission from their male counterparts to go to work. The second delay from the 3 delays model contributes significantly to maternal and neonatal mortality in the country (Bjelica, 2021; Allen & Felbab-

Brown, 2020). The purpose of this study is to model and forecast maternal mortality for Afghanistan using the double exponential

smoothing technique. We expect the findings to guide MNCH policy and allocation of resources to the health sector.

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 of peer-reviewed literature published after 2009.	-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
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	-A prospective cross-sectional study was carried out at Nelson Mandela Academic Hospital, a rural tertiary hospital in the Eastern Cape Province, over a 6-month period between January 2019 and June 2019. All cases that met the WHO criteria for MNM, together with maternal mortality cases, were identified and included in the study	-The conditions that resulted in the highest fatality rate were potentially preventable, namely eclampsia and puerperal sepsis. Many patients with life-threatening conditions were low-risk patients, and this emphasizes the need for more vigilant surveillance of patients during the antenatal, intrapartum and postpartum periods
Maruf et al. (2025)	-To illustrate the potential impact that continued improvements in maternal and neonatal health can have in terms of lives saved, and progress towards development goals	-modelling approach	-If coverage of evidence-based neonatal and maternal interventions reaches 90% of those in need by 2030, the neo natal mortality rate would drop from 36 to 16 per 1,000 live births, and the maternal

			mortality ratio from 638 to 237 per 100,000 live births
Glass et al. (2023)	-to examine Afghan health workers' experiences and perceptions of availability and quality of maternal and child health care	-conducted a survey	-The combination of economic collapse, lack of sustained donor support for health care and Taliban interference with human rights has severely compromised access and quality of maternal and child health care
Tawfiq et al. (2023)	-to address this knowledge gap	-Data were used from the Afghanistan Health Survey 2018. Women's knowledge in terms of danger signs or symptoms during pregnancy was assessed.	-findings suggest that pregnant women's healthcare seeking behavior is influenced among others by women's knowledge of danger signs and symptoms during pregnancy, women's education, socioeconomic status and access to media
Pouyanfar et al. (2022)	-to investigate the factors affecting the maternal mortality ratio (MMR) in different regions of Iran	-Systematic Review	-While Iran has made significant progress in reducing maternal mortality, rates varied considerably across provinces, ranging from 15.8 to 384 per 100,000 live births
Bartlett et al. (2017)	-to study maternal mortality risk and causes, care-seeking patterns, and costs within the country	-household survey (RAMOS-II) in the urban area of Kabul city and the rural area of Ragh, Badakshan. Questionnaires were administered to senior female household members and data were collected by a team of female	-Remarkable maternal and other mortality reductions have occurred in Afghanistan, but the disparity between urban and rural sites is alarming, with all maternal mortality indicators significantly higher in Ragh than in Kabul

		interviewers with secondary school education	
Najafizada et al. (2017)	-to examine the impact of various social determinants of health on maternal health in Afghanistan, filling an important gap in the existing literature	-This narrative review was conducted using Arksey and O'Malley's framework of (1) defining the question, (2) searching the literature, (3) assessing the studies, (4) synthesizing selected evidence in context, and (5) summarizing potential programmatic implication of the context. We searched Medline, CABI global health database, and Google Scholar	-social determinants such as maternal education, sociocultural practices, and social infrastructure have a significant impact on maternal health
Tamburlini et al. (2011)	-to identify priority issues and promote action in maternity and newborn care	-A standard-based tool was used	Quality of care is essential in order to improve maternal and neonatal outcomes
Bimbashi et al. (2010)	-To survey attitudes and an audit of practice in a large maternity hospital in Albania	-Survey of 35 obstetricians and audit of practice during the third stage of labor was conducted in July 2008 at a tertiary referral hospital in Tirana. The survey questionnaire was self-completed.	-Most obstetricians reported always or usually using active management for the third stage of labor. For timing and choice of the uterotonic drug, reported practice was similar to actual practice

METHODOLOGY

This study utilizes an exponential smoothing technique to model and forecast future trends of MMR for Afghanistan. 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 Afghanistan 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	0.600
Beta (β) for trend	0.100
Forecast performance measures	
Mean Absolute Error (MAE)	59.109965
Sum Square Error (SSE)	381607.208172
Mean Square Error (MSE)	9784.800210
Mean Percentage Error (MPE)	0.193564
Mean Absolute Percentage Error (MAPE)	4.550967

Residual Analysis for the Applied Model

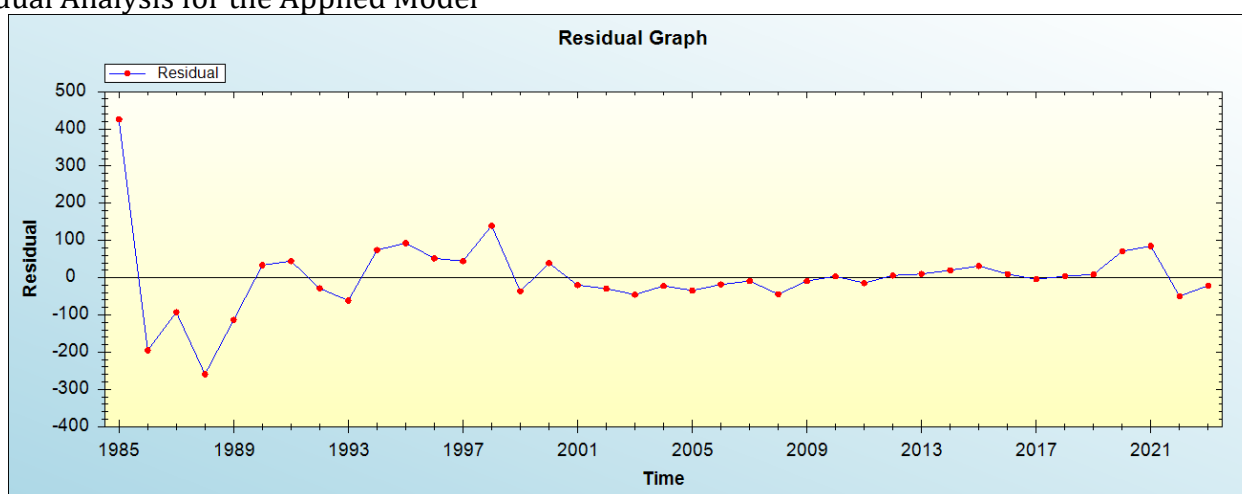


Figure 1: Residual analysis

In-sample Forecast for A

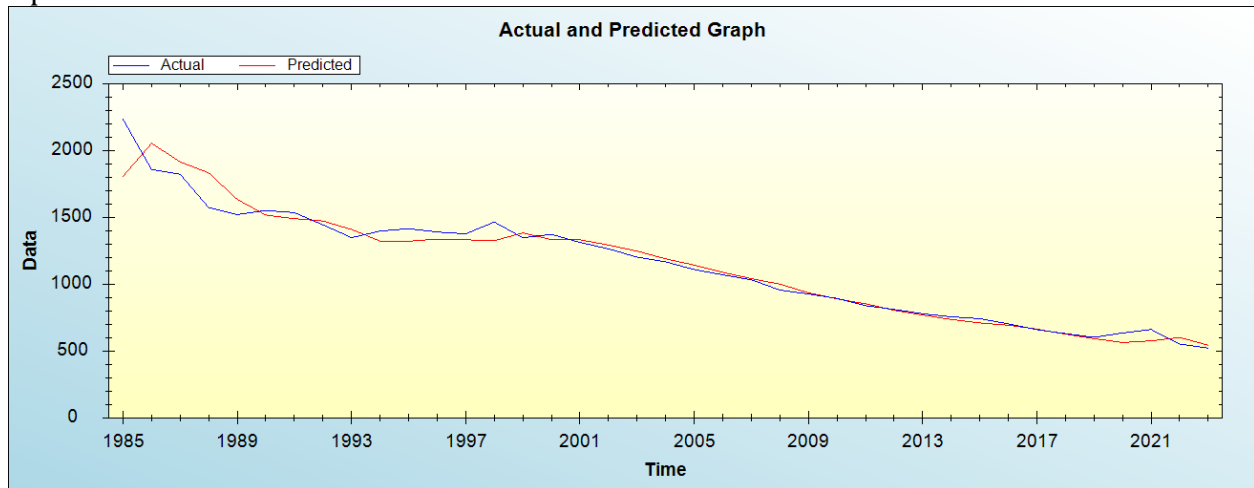


Figure 2: In-sample forecast for the A series

Actual and Smoothed graph for A series

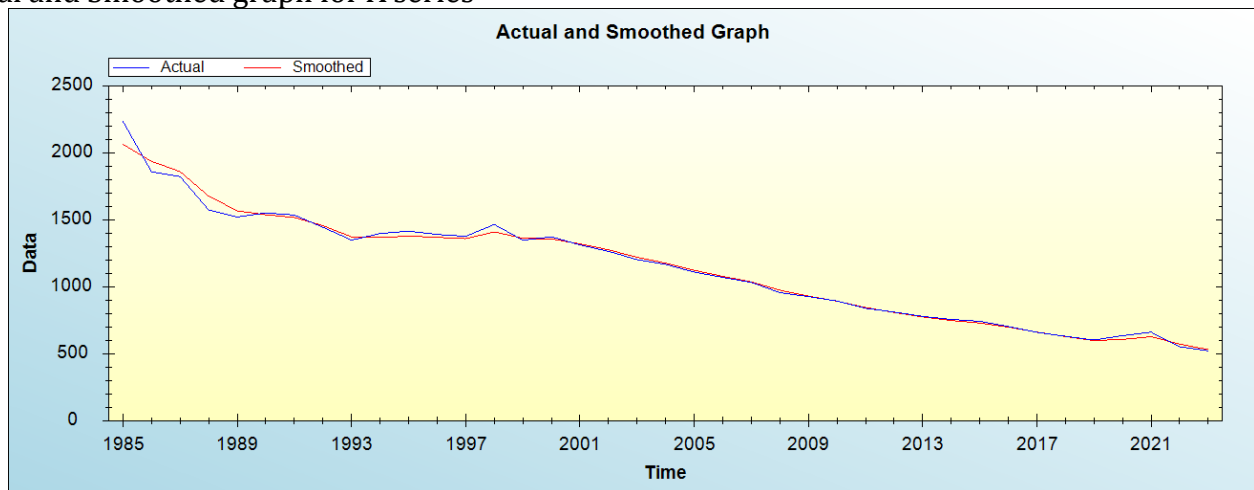


Figure 3: Actual and smoothed graph for A series

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

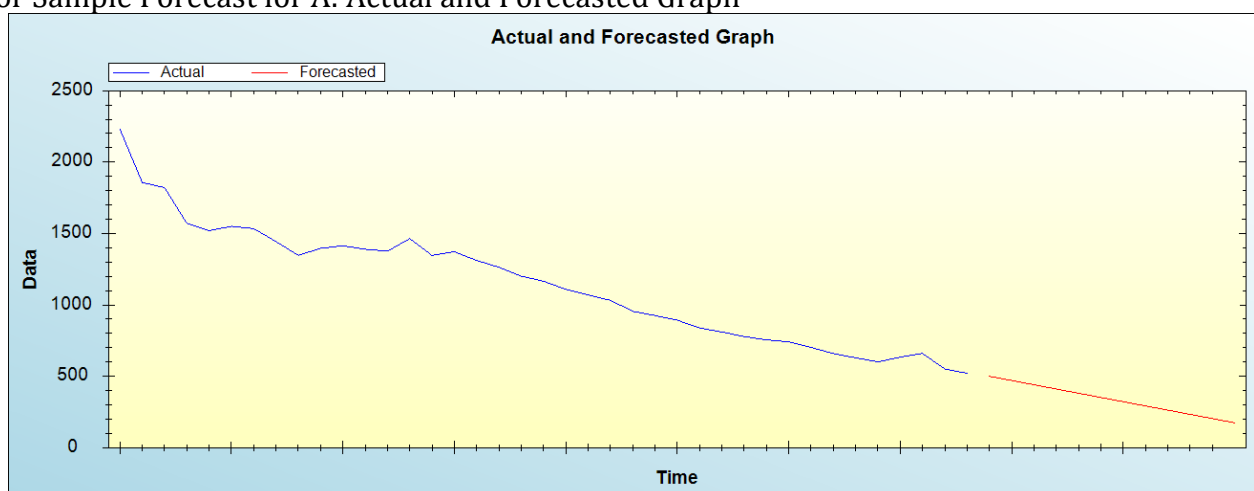


Figure 4: Out-of-sample forecast for A: actual and forecasted graph

Out-of-Sample Forecast for A: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Year	Forecasted MMR
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2024	499.9469
2025	470.2989
2026	440.6510
2027	411.0031
2028	381.3551
2029	351.7072
2030	322.0593
2031	292.4113
2032	262.7634
2033	233.1155
2034	203.4675
2035	173.8196

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 trajectory but remain very high throughout the out of sample period.

RECOMMENDATIONS AND CONCLUSION

This study utilized Holt's double exponential smoothing technique to forecast the Maternal Mortality Ratio (MMR) for Afghanistan through 2035. The applied model indicates that while annual MMR will continue on a downward trajectory, decreasing from a projected 499.9 deaths per 100,000 live births in 2024 to 173.8 in 2035; it will remain persistently high throughout the out-of-sample period.

To address the key drivers of maternal mortality and accelerate this decline, Afghan authorities should implement targeted interventions, including:

- i. **Upholding Reproductive Rights:** Respect and safeguard the sexual and reproductive health rights of women and girls.
- ii. **Promoting Female Education:** Expand educational opportunities for women to mitigate delays in seeking care and empower informed health decisions.
- iii. **Mitigating Socio-Cultural Barriers:** Address harmful socio-cultural practices and traditions that restrict women's mobility and healthcare access.
- iv. **Ensuring Healthcare Resources:** Guarantee adequate staffing, particularly of qualified female healthcare workers and midwives, alongside the consistent

supply of medical commodities across all care levels.

- v. **Upgrading Health Infrastructure:** Strengthen healthcare infrastructure countrywide to ensure timely, equitable access to maternal and child health services.

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