

PREDICTION OF MATERNAL MORTALITY FOR THE STATE OF KUWAIT USING THE SINGLE EXPONENTIAL SMOOTHING TECHNIQUE

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ABSTRACT

This study uses annual time series data on MMR for Kuwait from 1985 to 2023 to predict future trends of MMR over the period 2024 to 2035. The study utilizes single exponential smoothing model. The optimal value of the smoothing constants α is 0.1 based on minimum MSE. The results of the study indicate that MMR will hover around 15.7 deaths per 100 000 live births throughout the out of sample period. Therefore, we encourage authorities to address local causes of maternal mortality and continue routine surveillance of severe maternal morbidity.

Keywords: Exponential smoothing, Forecasting, Maternal Mortality Ratio.

INTRODUCTION

Maternal mortality is a global public health problem. Nearly 800 women die each day from preventable causes related to pregnancy or childbirth (WHO, 2023). This problem affects low-middle countries more than the developed countries. According to the WHO, at the global level, the maternal mortality ratio in 2020 was estimated at 233 per 100,000 live births (WHO, 2020). However, during the recent years, a significant decline of maternal mortality ratio at the global level was noted, with a reduction of 34.3% between 2000 and 2020, an average rate of reduction of 2.9% per year (WHO, 2023; WBG, 2023; WHO, 2020). Kuwait is a small country with a population estimate of 4 million and two-thirds of the population are non-Kuwaitis, with females comprising 39.9% of the total population. Women of childbearing age (15–49 years) account for 25.3% of the total population. The life expectancy at birth is 78.7 years for males and 79.4 years for females. Key health indicators, including infant mortality ratio, under-five mortality ratio, and maternal mortality ratio are estimated to be 8.7, 10.3, and 5.2 per 1,000 live births, respectively (Al-Taïar et al. 2025). The purpose of this study is to model and forecast MMR for the State of Kuwait using the single exponential smoothing technique. The study findings are expected to highlight future trends of MMR. This will then trigger an appropriate national response in order to eliminate all preventable maternal deaths.

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
Al-Taïar et al. (2025)	to assess the prevalence of anemia in pregnant women and its associated factors in the Kuwait Birth Cohort study	Prospective cohort study	-The prevalence of anemia was 28.16% (95% CI:25.53–30.91%), with 8.75% of women experiencing moderate anemia and 19.40% mild anemia. No cases of severe anemia were observed -Multivariable analysis identified current iron supplement use, (Adjusted Odds Ratio [AOR] 0.52, 95%CI:0.28–0.99; $p = 0.049$), vitamin D status (sufficient vs. insufficient/deficient), (AOR 0.63, 95%CI:0.43–0.92; $p = 0.018$), iron levels ($p < 0.001$), and ferritin levels ($p < 0.001$) as factors significantly associated with anemia
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)
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
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 the State of Kuwait. 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 single exponential smoothing technique because it is an appropriate technique for modeling data without a trend and seasonal pattern

The single exponential smoothing model is specified as follows;

$$K(t) = \beta(t) + \varepsilon(t)$$

Where $\beta(t)$ is a constant at time t , $\varepsilon(t)$ is a stochastic error term

$K(t)$ is the actual value of the time series variable at time t

The forecast equation is then expressed as follows:

$$F_{t+1} = \alpha K_t + (1-\alpha) F_t$$

Where F_t is the forecast value of variable K at time t

F_{t+1} is the forecast value of variable K at time $t+1$

α is the smoothing constant

Data Issues

This study is based on annual MMR in the State of Kuwait 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	K
Included Observations	39
Smoothing constant	
Alpha (α)	0.100
Forecast performance measures	
Mean Absolute Error (MAE)	3.735261
Sum Square Error (SSE)	4905.492591
Mean Square Error (MSE)	125.781861
Mean Percentage Error (MPE)	-10.251069
Mean Absolute Percentage Error (MAPE)	20.822945

Residual Analysis for the Applied Model

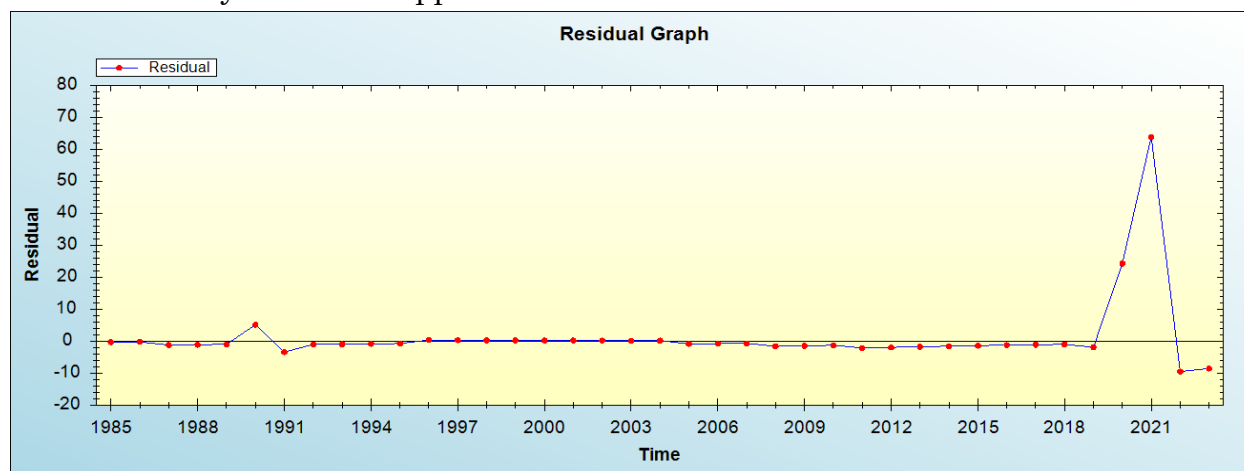


Figure 1: Residual analysis

In-sample Forecast for K

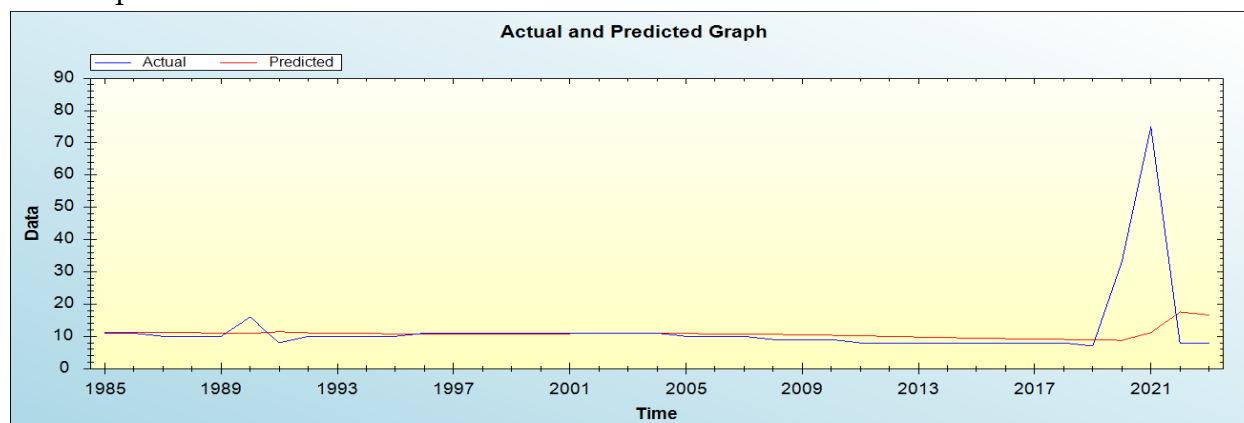


Figure 2: In-sample forecast for the K series

Actual and Smoothed graph for K series

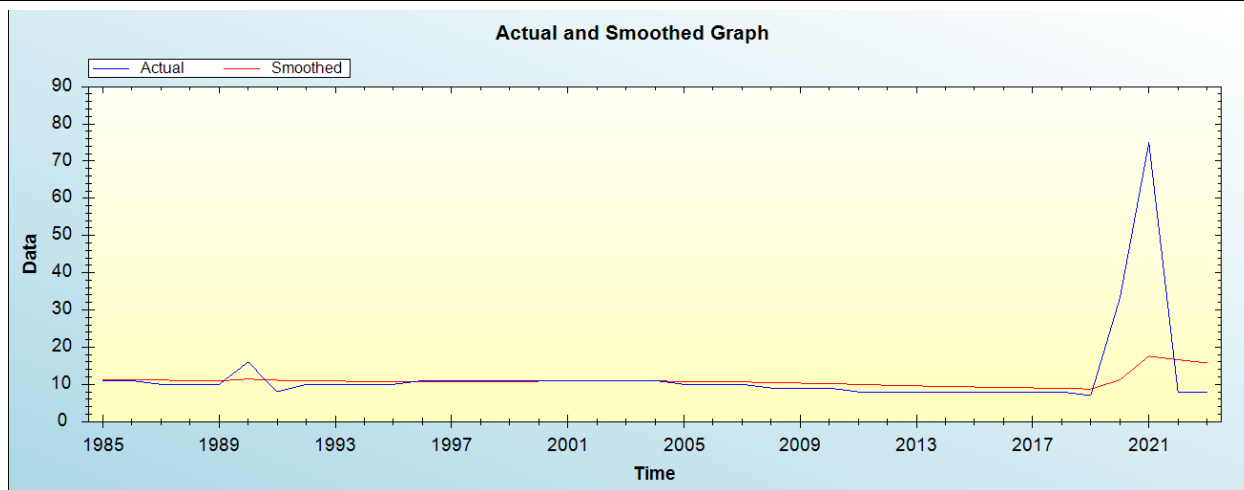


Figure 3: Actual and smoothed graph for K series

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

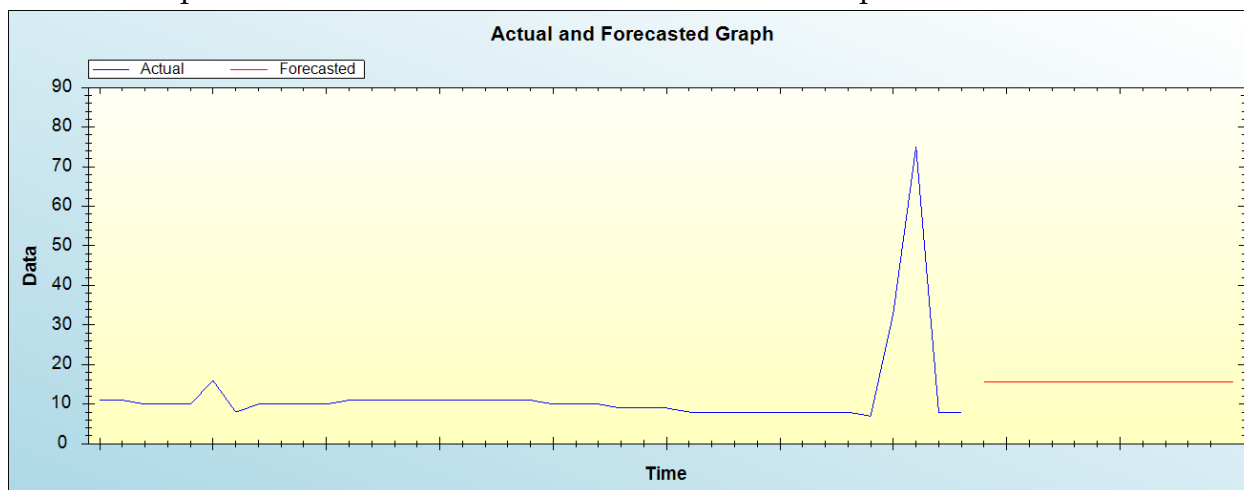


Figure 4: Out-of-sample forecast for K: actual and forecasted graph

Out-of-Sample Forecast for K: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Year	Forecasted MMR
2024	15.7436
2025	15.7436
2026	15.7436
2027	15.7436
2028	15.7436
2029	15.7436
2030	15.7436
2031	15.7436
2032	15.7436
2033	15.7436
2034	15.7436
2035	15.7436

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 hover around 15.7 deaths per 100 000 live births in the out of sample period.

RECOMMENDATIONS & CONCLUSION

Maternal mortality rates in Kuwait are very low signifying high quality maternal healthcare services. This study used the single exponential smoothing method to forecast MMR for Kuwait and results indicate that MMR will hover around 15.7 deaths per 100 000 live births over the out of sample period. Hence, health authorities in Kuwait must relentlessly attend to local causes of maternal mortality and continue routine surveillance of severe maternal morbidities.

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