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# MATERNAL MORTALITY PREDICTION FOR QATAR USING THE DOUBLE EXPONENTIAL SMOOTHING TECHNIQUE

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***Abstract***
*This study uses annual time series data on MMR for Qatar 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 that MMR will remain very low over the out of sample period. Therefore, we encourage authorities to continue addressing local causes of maternal deaths.*

***Keyword(s): -****Exponential smoothing, Forecasting, Maternal Mortality Ratio*

## Introduction

According to Qatar Health Report 2024, as of August 2024, Qatar's population stood at 3,054,365, with a predominant working-age population of 73.2 percent, reflecting the country's reliance on expatriate labor. Males represent 70.8 percent of the population due to labor migration. Mortality rates remain low indicating the effectiveness of healthcare strategies and maternal-child health programs. The crude mortality rate is 83.5 per 100,000 population, with adult mortality at 43.2 per 100,000. Neonatal, infant, and under-five mortality rates remain relatively low. However, non-communicable diseases (NCDs) continue to pose a significant public health challenge. This paper models and forecast MMR for Qatar using the double exponential smoothing technique. The findings of this paper will inform policy and allocation of resources to the health sector.

## Literature Review

| Author (s) | Objective(s) | Methodology | Main finding(s) |
|---|---|---|---|
| Al-Taiar 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<br>-Multivariable analysis identified current iron |

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| | | | 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 |
| Hamdan et al. (2025) | To describe postpartum Hemorrhage Burden, Management and Challenges in Malaysia | Scoping review | the review identified critical gaps in blood loss estimation methods, with visual estimation being unreliable and leading to underdiagnosis, while patient intrinsic factors such as uterine atony, retained placenta, and placenta accreta spectrum disorders contribute to treatment complexity. |
| 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 | 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 |

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| | identify their risk factors and causes | | (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) |
| Chin et al. (2023) | to understand the demography, case characteristics and causes of maternal mortality in Sabah from 2015 through 2020 | Retrospective study | Majority of deceased women, 56.7%, never attended antenatal visits prior to their death in the latest pregnancy. Overall, 63.88% deaths were due to direct obstetric causes, postpartum hemorrhage was the leading direct cause of death (24.53%), and most of the maternal deaths (65.5%) were preventable |
| 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 |

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| | 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%) |
| Salama et al. (2021) | To review the demographics and socioeconomic determinants of preterm birth (PTB) compared to term births among the Qatari population | This was a retrospective data analysis of 59,308 births. Data were retrieved from a Population-based Cohort Study | The prevalence of preterm birth was 9%. There were more Saudi nations in the preterm group compared to term (33% vs. 28%, p-value < 0.001). There were more preterm births than term births among working mothers (40% vs. 35%), high-risk pregnancies (24% vs. 18%), those that has used assisted conception (18% vs. 3%), those without antenatal care (11% vs. 5.6%), and those delivered in a tertiary women hospital (88.5% vs. 84.5%) (all p-values < 0.001) |
| Gabrani et al. (2020) | to identify key factors influencing the utilization of governmental and private primary | cross- sectional health facility survey using a 4-point Likert scale questionnaire to | The use of primary healthcare is strongly influenced by geographical and financial access for |

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| | healthcare services in Albania | rank the importance of factors driving services utilization. | public facility users and availability of equipment for private users. This study found that aspects of acceptability and adequacy of services are equally valued |
| Norhayati et al. (2016) | to study severe maternal morbidity and maternal near miss among women in two tertiary hospitals in Kota Bharu, Kelantan, Malaysia | A cross-sectional study with record review was conducted in 2014. Severe maternal morbidity and maternal near miss were classified using the new World Health Organization criteria. Health indicators for obstetric care were calculated and descriptive analyses were performed using SPSS version 22.0 | The maternal near miss mortality ratio was 23.5 and the mortality index was 4.1 %. The process indicators for essential interventions were almost 100.0 %. Hemorrhagic disorders were the most common event for severe maternal morbidity (68.6 %) and maternal near miss (80.9 %) and management-based criteria accounted for 85.1 % |

## Methodology

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

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

*Smoothing equation*

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

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$0<\propto<1$

*Trend estimation equation*

$b_t = \beta\,(S_t - S_{t-1}) + (1-\beta)b_{t-1}$

$0<\beta<1$

*Forecasting equation*

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

$Q_t$ is the actual value of MMR at time t

$\varepsilon_t$ is the time varying **error term**

$\mu_t$ is the time varying mean (**level**) term

$\rho_t$ 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

$\alpha$ is the exponential smoothing constant for the data

$\beta$ 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 Qatar 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 | Q |
|---|---|
| Included Observations | 39 |
| **Smoothing constants** | |

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| | |
|---|---|
| Alpha (α) for data | 0.700 |
| Beta (β) for trend | 0.100 |
| **Forecast performance measures** | |
| Mean Absolute Error (MAE) | 0.646366 |
| Sum Square Error (SSE) | 30.970967 |
| Mean Square Error (MSE) | 0.794127 |
| Mean Percentage Error (MPE) | -0.560407 |
| Mean Absolute Percentage Error (MAPE) | 8.547489 |

Residual Analysis for the Applied Model

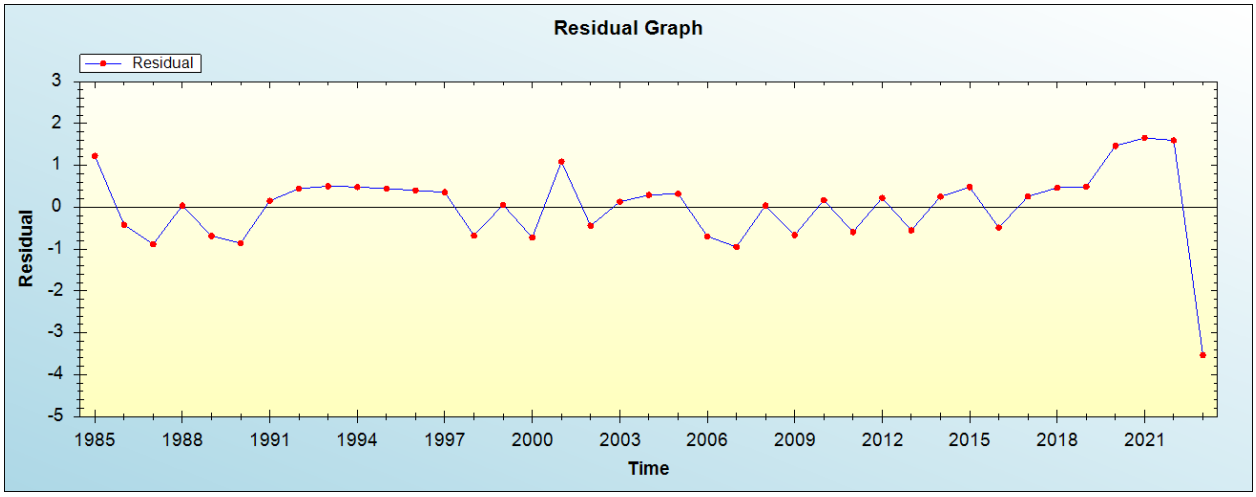



Figure 1: Residual analysis

In-sample Forecast for Q

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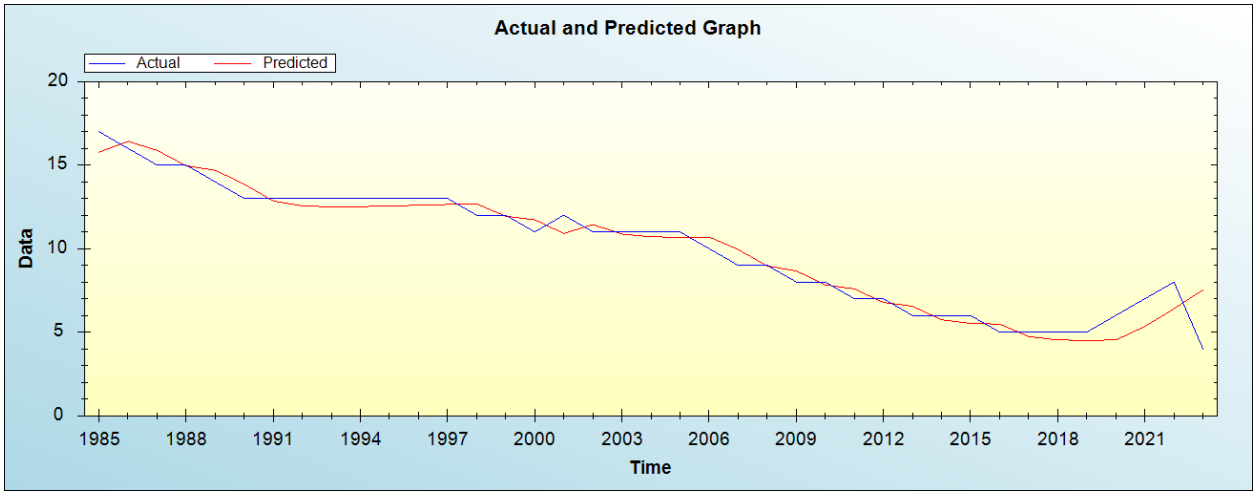



Figure 2: In-sample forecast for the Q series

Actual and Smoothed graph for Q series

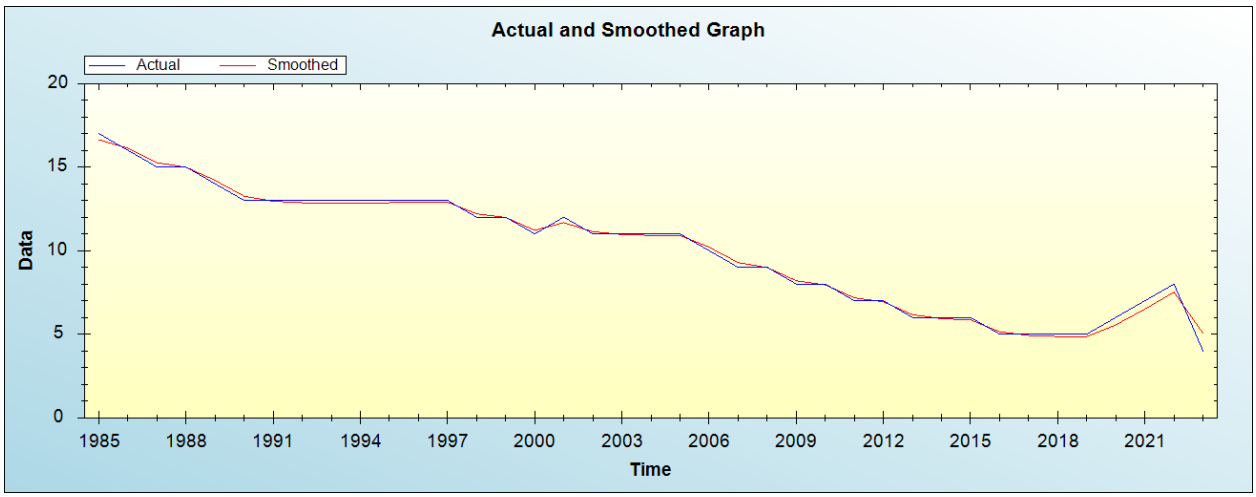



Figure 3: Actual and smoothed graph for Q series

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

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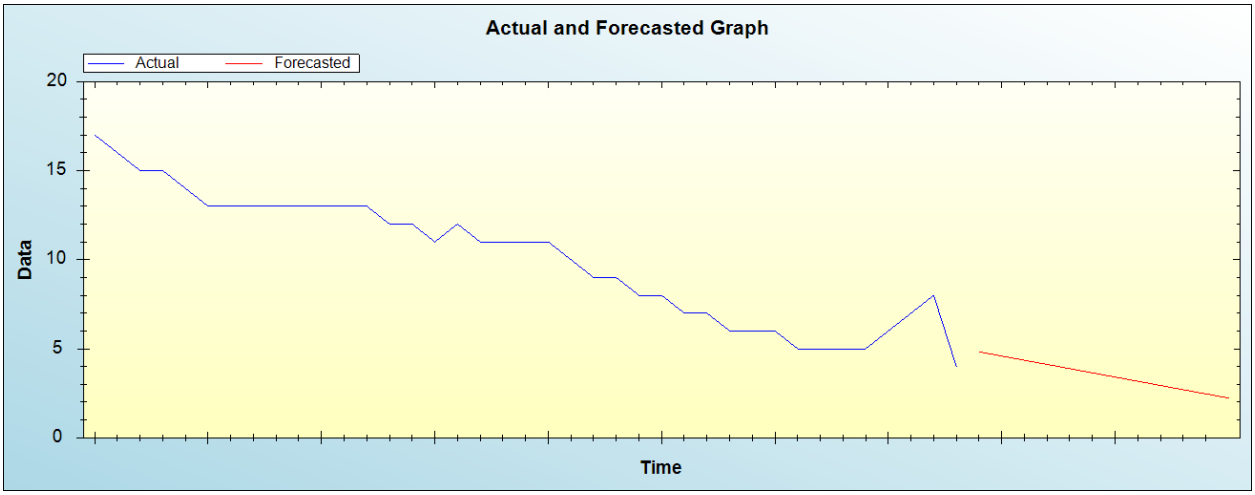



Figure 4: Out-of-sample forecast for Q: actual and forecasted graph

Out-of-Sample Forecast for Q: Forecasts only

Table 2: Tabulated out-of-sample forecasts

| Year | Forecasted MMR |
|---|---|
| 2024 | 4.8237 |
| 2025 | 4.5877 |
| 2026 | 4.3517 |
| 2027 | 4.1158 |
| 2028 | 3.8798 |
| 2029 | 3.6439 |
| 2030 | 3.4079 |
| 2031 | 3.1719 |
| 2032 | 2.9360 |
| 2033 | 2.7000 |
| 2034 | 2.4641 |
| 2035 | 2.2281 |

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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 remain very low over the out of sample period.

## Conclusion

This study utilized the double exponential smoothing method to forecast MMR for Oatar and results indicate that MMR will remain very low over the out of sample period. Hence, health authorities are encouraged to continue addressing local causes of maternal deaths.

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