

PROJECTION OF ANNUAL MATERNAL MORTALITY RATE FOR JORDAN USING THE DOUBLE EXPONENTIAL SMOOTHING METHOD

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ABSTRACT

This study uses annual time series data on MMR for Jordan 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 0.2 and 0.1 respectively based on minimum MSE. The results of the study indicate that MMR will decline from around 38 in 2024 to about 31 deaths per 100 000 live births in 2035. Therefore, we encourage authorities to continue addressing local causes of maternal mortality.

Keywords: Exponential smoothing, Forecasting, Maternal Mortality Ratio.

INTRODUCTION

The Maternal and Child health program in Jordan is generally of high quality (Khader et al. 2018). Jordan has made significant progress in lowering maternal mortality rate (MMR), maintaining it at a relatively low level. Jordan conducted its national maternal mortality study in 2007–2008. The MMR was reported at 19.1 per 100,000 live births (LB) (Amarin et al. 2010). Although the average MMR in the Middle East and North Africa (MENA) region was estimated at 54 per 100 000 live births in 2018, Jordan had an MMR of 29.8 per 100 000 (World Bank, 2020). The majority (94%) of Jordanian women have at least four antenatal visits and about 98% of mothers are delivered within a health institution providing skilled care at birth (Ministry of Health, 2007). However, because of factors including a population increase, a shortage in the water supply, an influx of Syrian refugees, and a relatively high unemployment rate (World Bank, 2023). Jordan's health system is facing increasing challenges in addressing the health needs of its population and is seeking more efficient approaches to use available resources in the health system given budget restrictions (Zeng et al. 2026). The purpose of this paper is to model and forecast MMR for Jordan using the double exponential smoothing method. The study findings are expected to stimulate an appropriate national response so that maternal mortality is put under control.

LITERATURE REVIEW

Author(s)	Objective(s)	Methodology	Main finding(s)
Zeng et al. (2026)	to estimate the economic burden of maternal deaths in Jordan and examine its social and geographic variations	This study used data from JMMSR and applied a cost-of-illness approach to estimate the economic burden of maternal death in Jordan. The length of stay and characteristics of the deceased pregnant women and survival of	The non-COVID-19 maternal mortality rate was 29.8, 32.4, 30.0, and 29.8 per 100 000 live births in 2018, 2019, 2020, and 2021, respectively. The overall burden was between JOD 43.74 (US dollars \$61.60) and JOD 51.03 (US dollars \$71.87) million per year,

		fetuses were obtained from JMMSR, whereas the unit cost data were obtained from the literature. The indirect cost due to productivity loss was estimated using the value of statistical life	accounting for an average of 1.95% of annual current health expenditure and 4.89% of public health expenditure
Nunn et al. (2025)	To explore whether changes in key characteristics among Victorian Aboriginal and/or Torres Strait Islander women contributed to reduced perinatal death rates	Retrospective population-based cohort study of all births in Victoria from 2000–2019	Changes in key maternal characteristics may have contributed to improved perinatal death rates among babies of Victorian Aboriginal and/or Torres Strait Islander women
Al-Kharabsheh et al. (2024)	To provide an update on the prevalence of anemia during pregnancy in southern Jordan	This cross-sectional study was conducted at a government referral hospital in southern Jordan	Maternal anemia rates in southern Jordan remained high, despite a slow decline.
Haninger-Vacariu et al. (2024)	To describe pregnancy and delivery outcomes in women with Fabry disease	Retrospective cohort-study of women with Fabry disease in Austria using a specific questionnaire and the Austrian Mother–Child Health Passport	The cohort-study in women with Fabry disease showed an increase of pain burden during pregnancies and clearly points to an increased risk for preeclampsia, prematurity, and neonates small for gestational age. With a substantial number of high-risk pregnancies, neonatal outcomes are somewhat worse in Fabry disease than in the general public
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
Pinchas-Mizrachi et al. (2022)	To examine the disparities in breast cancer-related mortality rates among women from urban areas compared to rural areas in Israel	This was a retrospective, follow-up study on mortality from breast cancer among 894,608 Israeli women born between the years of 1940 and 1960	A higher incidence of mortality from breast cancer in Israel was found among urban women compared to rural women (1047.8/100,000 compared to 837/100,000, respectively)
Rottenstreich et al. (2020)	To determine the prevalence of obstetric ICU admissions in one medical center in Israel and to characterize this population	In this retrospective study the files of women coded for pregnancy, birth, or the perinatal period and admission to the ICU were pulled for data extraction (2005–2013)	Most pregnancies (71.2%) were uneventful prior to admission. ICU admissions were divided equally between direct (usually hemorrhage) and indirect (usually cardiac disease) obstetric causes
Morong et al. (2017)	This study was a retrospective cohort study of cases of in-hospital	to determine if American and Australian women have a similar rate of	Women from Louisiana, United States and Queensland, Australia have

	maternal deaths in the Ochsner Health System (Louisiana, United States) and the Queensland Health System (Australia) from 1995 to 2013	preventable maternal death and if the deaths were attributable to the same factors	similar rates of preventable maternal death. No statistically significant factors explained trends in Australian maternal death; American maternal mortality was significantly associated with point of entry into prenatal care, likely influenced by insurance status
Nahidi & Hajifoghaha (2017)	To provide the current situation and trend of MMR in the Eastern Mediterranean region between 1990 and 2015	Systematic review	Based on the collected data, 36 out of 66 studies met the required criteria and were chosen for analysis. All countries of this region showed a downward trend between 1990 and 2015, and this change varied from 16.30% in Yemen to 76.56% in Lebanon. The maternal mortality reduction was 69.88% in Iran in the same time
Khader et al. (2018)	to assess the maternal and newborn services in Jordanian hospitals to provide policymakers, health professionals, and researchers with a clear picture about the current status of maternal and newborn health services	Quality assessment	The findings revealed an overall satisfactory quality of maternal and newborn care and services, however, some deficiencies existed
Schildberger et al. (2017)	-To investigate the personal meanings and experiences of women with disabilities in regard to pregnancy, childbirth and the puerperium	Conducted semi-structured interviews	Participants reported limited acceptance of their life decisions and experienced an environment of discriminatory attitudes. They experienced a lack of support and lack of confidence in their parenting abilities, which negatively influenced their self-efficacy and self-awareness. Violations of personal borders and a feeling of being watched and controlled were reported

METHODOLOGY

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

$$J_t = \mu_t + \rho_t t + \varepsilon_t$$

Smoothing equation

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

$$0 < \alpha < 1$$

Trend estimation equation

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

$$0 < \beta < 1$$

Forecasting equation

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

J_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 Jordan 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	J
Included Observations	39
Smoothing constants	
Alpha (α) for data	0.200
Beta (β) for trend	0.100
Forecast performance measures	
Mean Absolute Error (MAE)	3.971560
Sum Square Error (SSE)	2793.717886
Mean Square Error (MSE)	71.633792
Mean Percentage Error (MPE)	0.513700
Mean Absolute Percentage Error (MAPE)	6.529276

Residual Analysis for the Applied Model

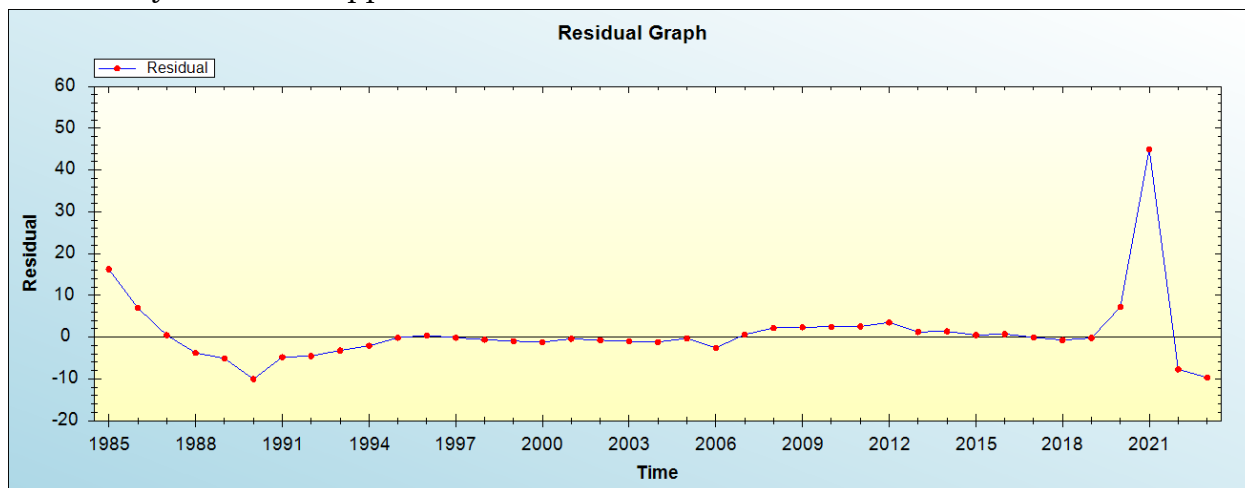


Figure 1: Residual analysis

In-sample Forecast for J

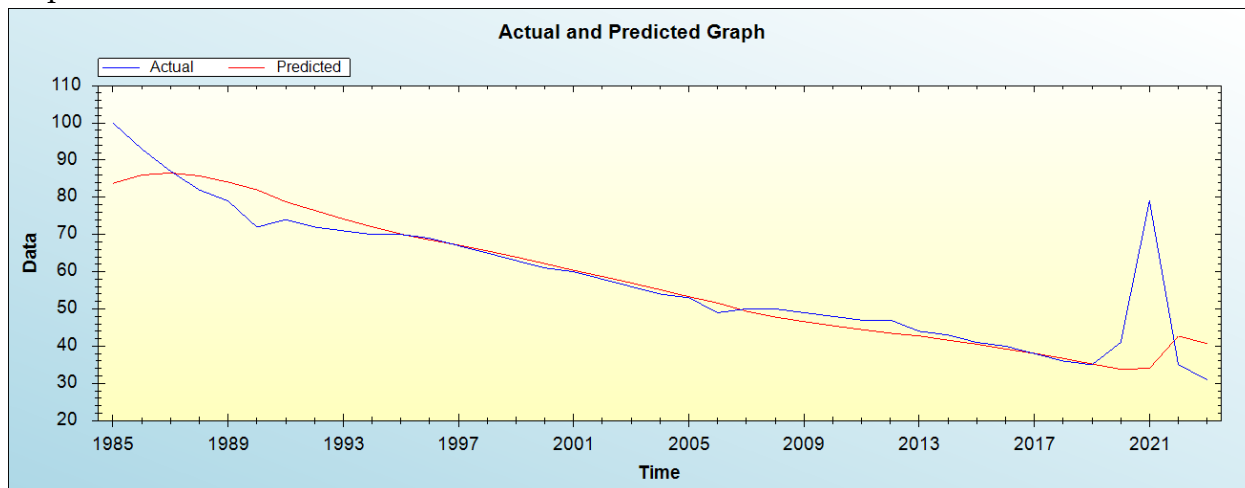


Figure 2: In-sample forecast for the J series

Actual and Smoothed graph for J series

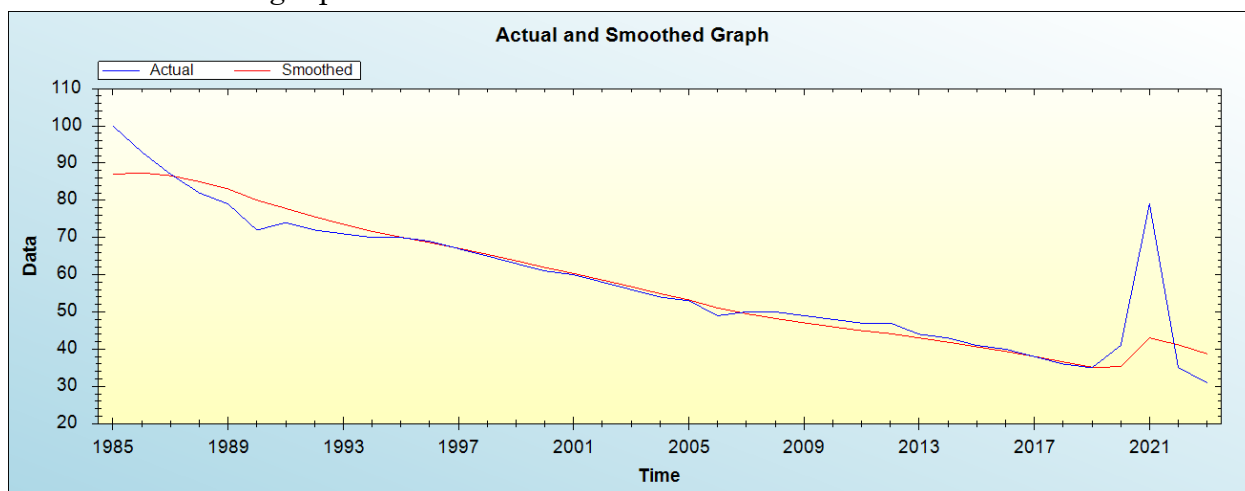


Figure 3: Actual and smoothed graph for J series

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

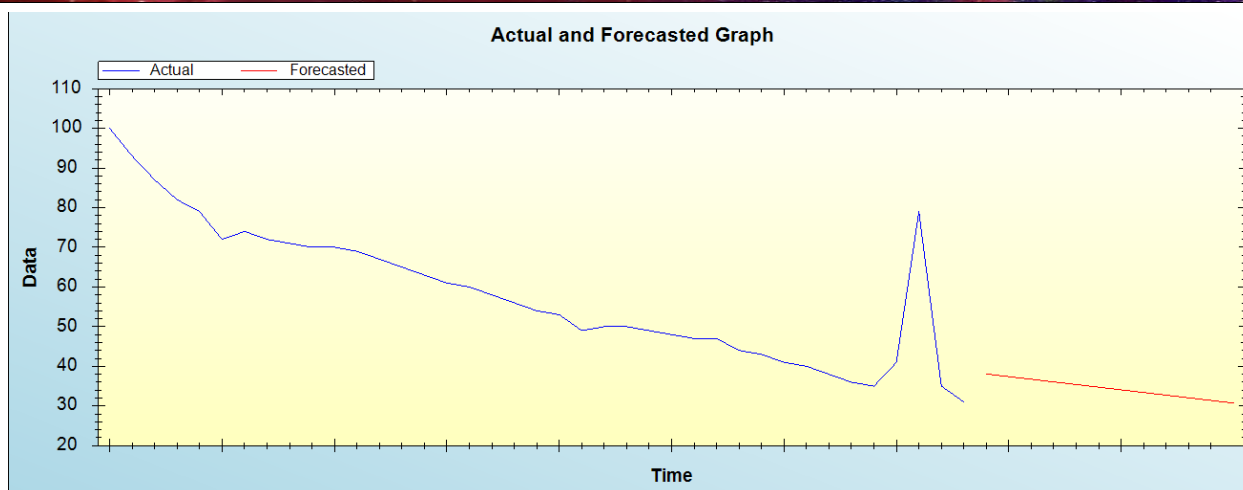


Figure 4: Out-of-sample forecast for J: actual and forecasted graph
Out-of-Sample Forecast for J: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Year	Forecasted MMR
2024	38.0770
2025	37.4095
2026	36.7419
2027	36.0744
2028	35.4069
2029	34.7394
2030	34.0718
2031	33.4043
2032	32.7368
2033	32.0693
2034	31.4018
2035	30.7342

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 decline from around 38 in 2024 to about 31 deaths per 100 000 live births by 2035.

RECOMMENDATIONS & CONCLUSION

Maternal mortality in Jordan is generally low as a result of high-quality maternal healthcare services offered during the antenatal, child birth and post-partum period. Antenatal care coverage is very high and 98% of deliveries occur in medical facilities. This paper applied the double exponential smoothing method to model and forecast MMR for Jordan and the findings indicate that MMR will decline from around 38 in 2024 to about 31 deaths per 100 000 live births in 2035. Hence, we encourage Jordanian authorities to continue addressing local drivers of maternal mortality.

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