

Eurasian Scientific Herald 		Application Of Holt’s Linear Method To Project Maternal Mortality For Austria	
Smartson. P. NYONI¹		<i>¹Independent Researcher & Medical Doctor, Harare, Zimbabwe</i>	
Thabani NYONI²		<i>²Independent Researcher & Health Economist, Harare, Zimbabwe</i>	
ABSTRACT		This study uses annual time series data on MMR for Austria 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 on a downward path and reach levels below 10 deaths per 100 000 live births by 2035. Therefore, we encourage authorities to address local causes of preventable maternal deaths.	
Keywords:		Exponential smoothing, Forecasting, Maternal Mortality Ratio	

Introduction

According to Austria Health systems review 2018, Austria is relatively sparsely populated with an estimated population size of 8.7 million inhabitants. In 2016, the country reported a gross domestic product (GDP) of €40 000 per capita, making it 6th among EU Member States. Austria’s overall growing population and labor force and its relatively low unemployment rates have significantly contributed to the growth of its domestic economy over the past decades. Life expectancy at birth in this country is above the European Union (EU) average of 80.9 years and has increased by more than three years since 2000, to 81.6 years in 2016. Cardiovascular diseases such as stroke and myocardial infarction as well cancer account for two thirds of all deaths in Austria. Provision of healthcare services in Austria is characterized by relatively unrestricted access to all levels of care including

general practitioners (GPs), specialists and hospitals. Austria reported worrying trends of high-risk pregnancies due to older women giving birth and more in vitro fertilizations (OECD, 2017p). In addition, risky behavior of pregnant women regarding alcohol, smoking and obesity is also of great concern (Habimana et al., 2015). Adolescent fertility rates have declined since the 1980s from 33.4 births per 1 000 women aged 15 to 19 years to 6.8 births in 2015. Maternal mortality has halved since 1990 to 4 deaths per 100 000 live births in 2015. The objective of this study is to model and forecast maternal mortality rate (MMR) for Austria using the double exponential smoothing approach. Results are expected to inform policy and allocation of resources to the healthcare sector with a view of eliminating all avoidable 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.
Tsushima et al. (2026)	To determine the long-term incidence of dysglycemia and dyslipidemia after GDM and evaluated whether postpartum changes in body mass index (BMI) independently predicted these outcomes.	Prospective cohort study	Postpartum BMI increase was independently associated with new-onset dysglycemia. No independent predictor of T2DM progression was identified. Dyslipidemia was independently associated with higher pre-pregnancy BMI and multiparity, whereas postpartum BMI change was not independently associated after multivariable adjustment
Yue et al. (2026)	to perform an umbrella review to summarize the current evidence to provide a reference for clinicians and future research	Systematic review	Positive aPLs significantly increased the risk of miscarriage rate in assisted reproductive technology (ART) and were also associated with total fetal loss, PE, intrauterine growth

			retardation and placental abruption
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
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
Morong et al. (2017)	This study was a retrospective cohort study of cases of in-hospital maternal deaths in the Ochsner Health System (Louisiana, United States) and the Queensland Health System	-to determine if American and Australian women have a similar rate of preventable maternal death and if the deaths were attributable to the same factors	Women from Louisiana, United States and Queensland, Australia have similar rates of preventable maternal death. No statistically significant factors explained trends in

	(Australia) from 1995 to 2013		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
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

Bouvier-Colle et al. (2012)	To assess capacity to develop routine monitoring of maternal health in the European Union using indicators of maternal mortality and severe morbidity	Analysis of aggregate data from routine statistical systems compiled by the EURO-PERISTAT project and comparison with data from national enquiries	Currently available data on maternal mortality and morbidity are insufficient for monitoring trends over time in Europe and for comparison between countries
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Methodology

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

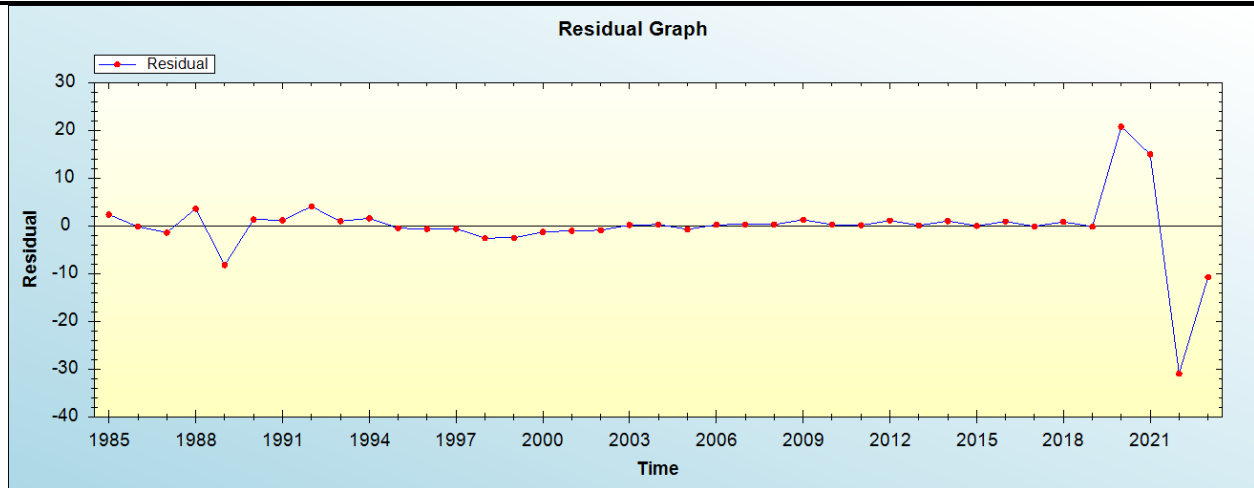


Figure 1: Residual analysis

In-sample Forecast for A

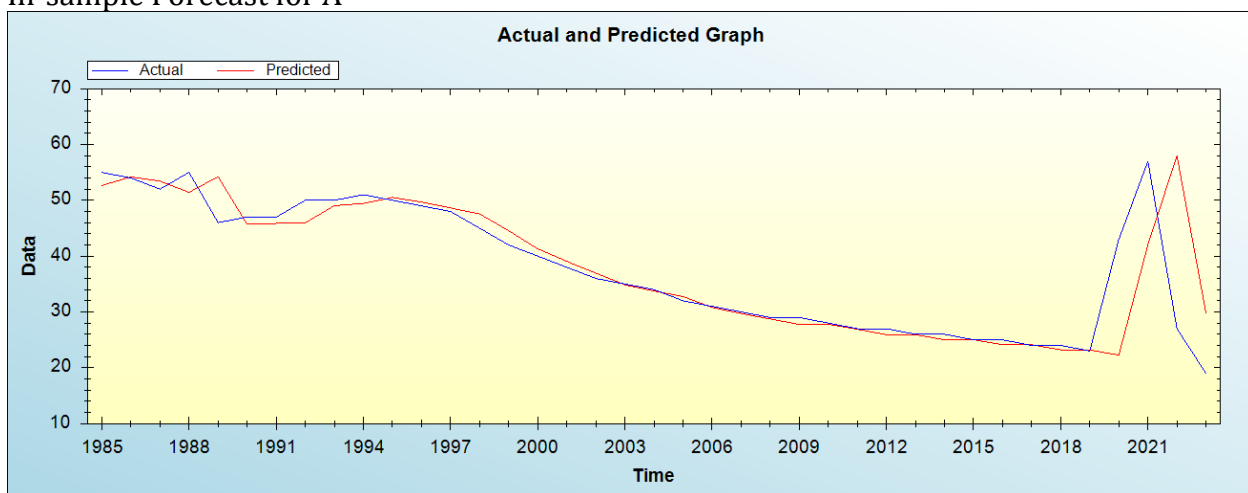


Figure 2: In-sample forecast for the A series

Actual and Smoothed graph for A series

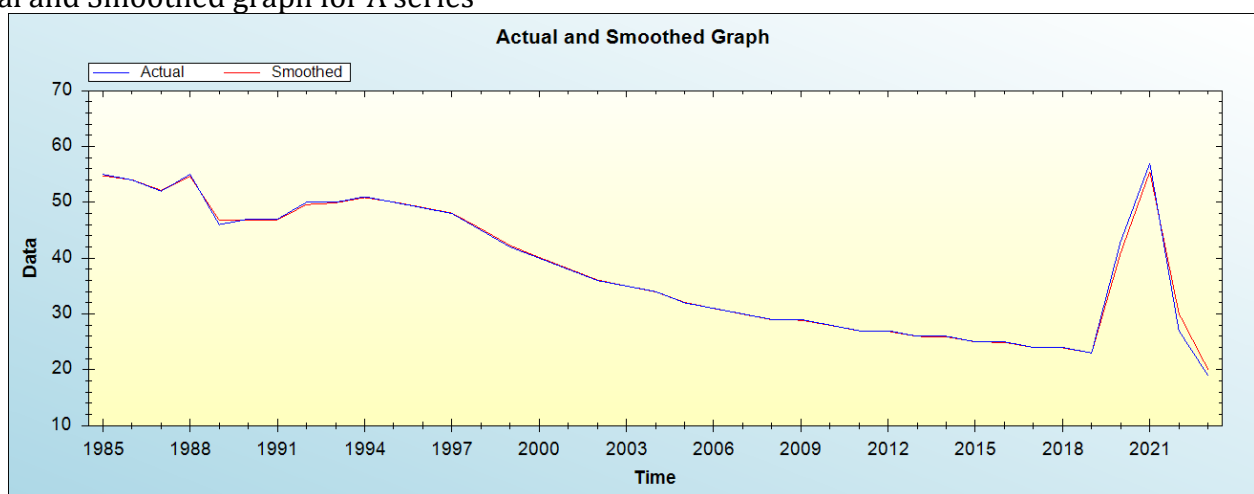


Figure 3: Actual and smoothed graph for A series

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

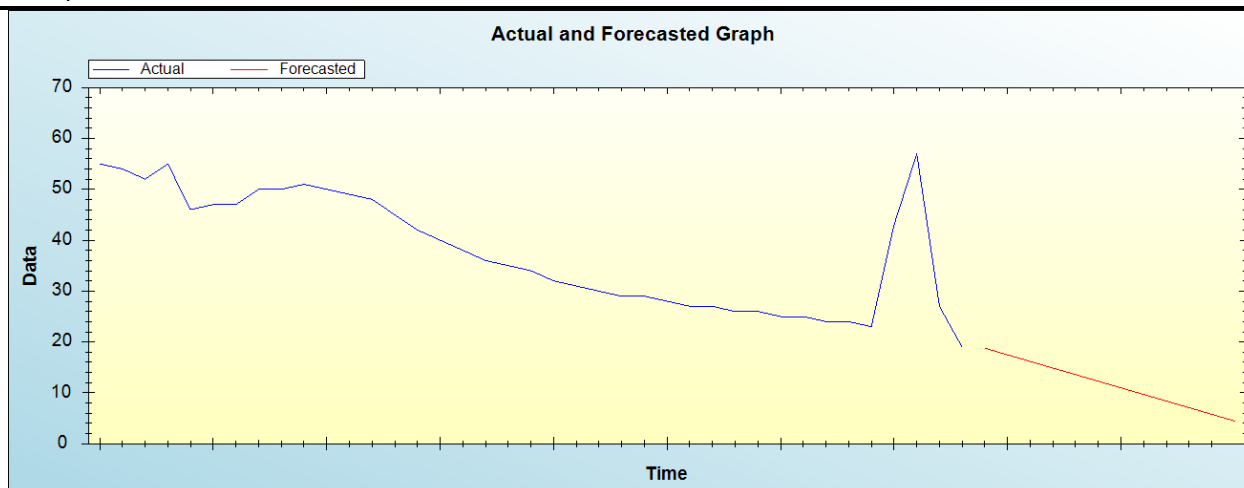


Figure 4: Out-of-sample forecast for A: actual and forecasted graph

Out-of-Sample Forecast for A: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Year	Forecasted
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 continue on a downward path and reach levels below 10 deaths per 100 000 live births by 2035.

Conclusion

This paper applies the double exponential smoothing technique to forecast MMR for Austria. The forecast results indicate that MMR will continue on a downward path and reach levels below 10 deaths per 100 000 live births by 2035. Therefore, health authorities are encouraged to address local factors (indirect causes) that are linked to maternal deaths.

References

1. Bachner, F., Bobek, J., Habimana, K., Ladurner, J., Schmidt, A. E., Ostermann, H., Ladits, M., & Winklbaauer, F. (2018). *Austria: Health system review* (Health Systems in Transition, Vol. 20, No. 3). European Observatory on Health Systems and Policies.
2. Bouvier-Colle, M.-H., Mohangoo, A. D., Gissler, M., Novak-Antolič, Z., Velebil, P., Alexander, S., & Zeitlin, J. (2012). What about maternal mortality and morbidity in Europe? *European Journal of Obstetrics & Gynecology and Reproductive Biology*, 160(2), 232–233. <https://doi.org/10.1016/j.ejogrb.2011.11.002>
3. Diguisto, C., Deneux-Tharaux, C., Alexander, S., Donati, S., Zwart, J. J., Velebil, P., Zhang, W. H., & Vandenberghe, G. (2022). Maternal mortality in eight

- European countries with enhanced surveillance systems: A population-based study. *BJOG: An International Journal of Obstetrics & Gynaecology*, 129(8), 1289–1298. <https://doi.org/10.1111/1471-0528.17066>
4. Habimana, K., Bachner, F., Bobek, J., Ladurner, J., & Ostermann, H. (2015). *Das österreichische Gesundheitswesen im internationalen Vergleich* [The Austrian health care system, an international comparison]. Bundesministerium für Gesundheit.
 5. Haninger-Vacariu, M., Kölbl, H., Sunder-Plassmann, G., & Pollak, A. (2024). Pregnancy and delivery outcomes in women with Fabry disease: A retrospective cohort study in Austria. *Wiener klinische Wochenschrift*, 136(3), 85–92.
 6. Mackin, R., Marshall, J., & Lawton, B. (2026). Organization of maternal and newborn facility care globally: A scoping review. *BMC Pregnancy and Childbirth*, 26(1), Article 112.
 7. Morong, J., Caughey, A. B., & Miller, H. S. (2017). Preventable maternal deaths in Louisiana and Queensland: A retrospective comparative study. *American Journal of Obstetrics and Gynecology*, 216(1), S381–S382. <https://doi.org/10.1016/j.ajog.2016.11.458>
 8. Nahidi, F., & Hajifoghaha, M. (2017). Trend of maternal mortality ratio in the Eastern Mediterranean Region from 1990 to 2015: A systematic review. *International Journal of Community Based Nursing and Midwifery*, 5(4), 316–328.
 9. Nunn, A., Coory, M., & Stewart, A. (2025). Trends in perinatal mortality among Victorian Aboriginal and Torres Strait Islander babies from 2000 to 2019: A population-based cohort study. *Australian and New Zealand Journal of Obstetrics and Gynaecology*, 65(1), 45–52. <https://doi.org/10.1111/ajo.13840>
 10. Organisation for Economic Co-operation and Development. (2017). *Health at a glance 2017: OECD indicators*. OECD Publishing. https://doi.org/10.1787/health_glance-2017-en
 11. Schildberger, B., Zenzmaier, C., & Koenig-Bachmann, M. (2017). Experiences of Austrian women with disabilities during pregnancy, childbirth, and the puerperium: A qualitative study. *BMC Pregnancy and Childbirth*, 17, Article 321. <https://doi.org/10.1186/s12884-017-1517-5>
 12. Tsushima, A., Morokuma, S., & Yasuhi, I. (2026). Long-term incidence of dysglycemia and dyslipidemia after gestational diabetes mellitus and the impact of postpartum body mass index changes. *Journal of Diabetes Investigation*.
 13. Yue, L., Zhang, X., & Liu, Y. (2026). Impact of systemic autoimmune diseases on pregnancy and assisted reproductive outcomes: A systematic review. *Frontiers in Immunology*, 17, Article 1054321.