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PROJECTION OF MATERNAL MORTALITY FOR LATVIA USING THE DOUBLE EXPONENTIAL SMOOTHING TECHNIQUE

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Abstract

This study uses annual time series data on MMR for Latvia 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 decline from around 19 in 2024 to about 11 deaths per 100 000 live births by 2035. Therefore, we encourage authorities to relentlessly address local causes of maternal mortality.

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

Introduction

According to Latvia country Health Profile 2025, in 2024 Latvia had a population estimate of 1 871 882 inhabitants. Its gross domestic product (GDP) in 2023 was reported to be $28 031 per capita. The fertility rate reported in 2023 was 1.4 births per woman. In 2024, life expectancy at birth in Latvia was 76.7 years – 5 years below the EU average. In 2021, nearly one third of deaths in Latvia could be due to behavioral and environmental risk factors. Latvia had the worst preventable mortality rate in the EU in 2022, with over 540 deaths per 100 000 population – more than twice the EU average. Cardiovascular diseases (CVDs) and cancer are the top causes of death, morbidity and disability in Latvia, reflecting EU-wide patterns. Over the period 2000-2017, maternal mortality ratio (MMR) dropped from 34 deaths per 100 000 live births to 19 deaths per 100 000 live births MMEIG, 2017). The Latvia policy country profile-2018 revealed that in 2020 maternal mortality was 18.3 deaths per 100 000 live births. The objective of this paper is to model and forecast MMR for Latvia using the double exponential smoothing technique. The study findings will stimulate an appropriate national response in order to keep maternal mortality under control.

Literature Review

Author(s)	Objective(s)	Methodology	Main finding(s)
Tsushima et al. (2026)	To determine the long-term incidence of dysglycemia and dyslipidemia after GDM and evaluated	Prospective cohort study	Postpartum BMI increase was independently associated with new-onset

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	whether postpartum changes in body mass index (BMI) independently predicted these outcomes.		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	Retrospective cohort-study of women with Fabry disease in Austria	The cohort-study in women with Fabry disease showed an increase of pain

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	women with Fabry disease	using a specific questionnaire and the Austrian Mother–Child Health Passport	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
Kornyicki & Fedor (2024)	to publish findings on the lifestyle factors of pregnant women in Hungary and their impact on early childhood health status by examining changes over time and regional/geographical disparities	Secondary analysis of raw indicators reported by health visitors as per mandatory annual report data for the period of 1997–2019 in Hungary	Interventions to improve early childhood health in some counties of Hungary are urgently needed to reduce regional disparities
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
Wami et al. (2022)	To explore both real maternal and feto-neonatal characteristics associated with Hungarian homebirths	Retrospective cohort study	Aggregated maternal complications (primary uterine inertia, prolonged second stage labor, and third stage hemorrhage) were prevalent among homebirth cases

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			(1.29% vs. 0.72%, p < 0.05) and were associated with an average of 11.77% rate of transfer to a health care institution. On the other hand, the rate of operative (vaginal or caesarean) delivery was 26.31% among institutionalized births
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 Latvia. 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.

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Holt's linear method is specified as follows:

Model equation

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

Smoothing equation

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

$0<\propto<1$

Trend estimation equation

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

$0<\beta<1$

Forecasting equation

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

Z_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 Latvia 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

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Exponential smoothing Model Summary

Table 1: ES model summary

Variable	Z
Included Observations	39
Smoothing constants	
Alpha (α) for data	0.900
Beta (β) for trend	0.100
Forecast performance measures	
Mean Absolute Error (MAE)	3.586995
Sum Square Error (SSE)	1380.482969
Mean Square Error (MSE)	35.396999
Mean Percentage Error (MPE)	-1.001591
Mean Absolute Percentage Error (MAPE)	10.182353

Residual Analysis for the Applied Model

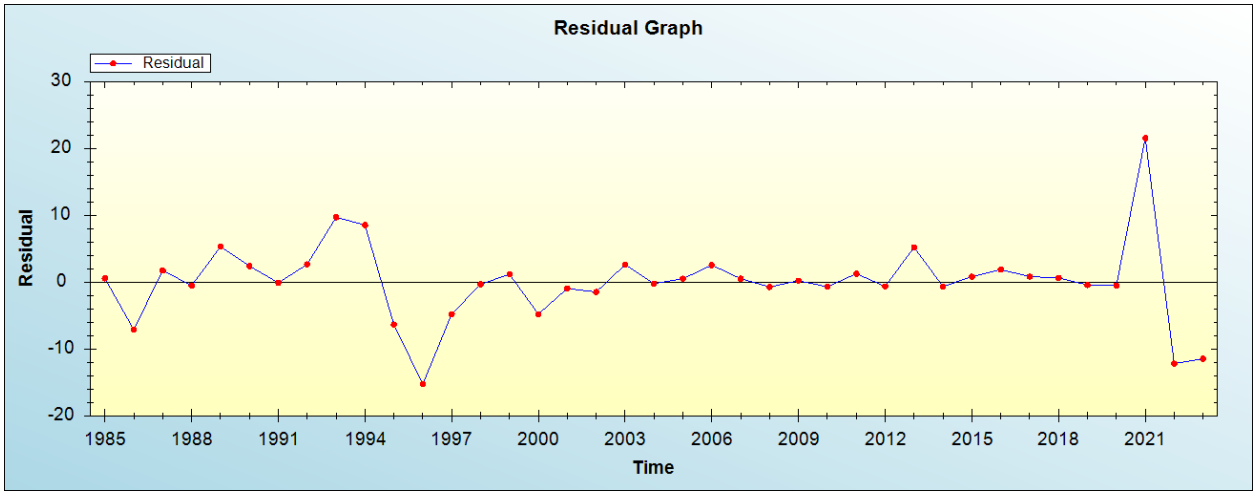


Figure 1: Residual analysis

In-sample Forecast for Z

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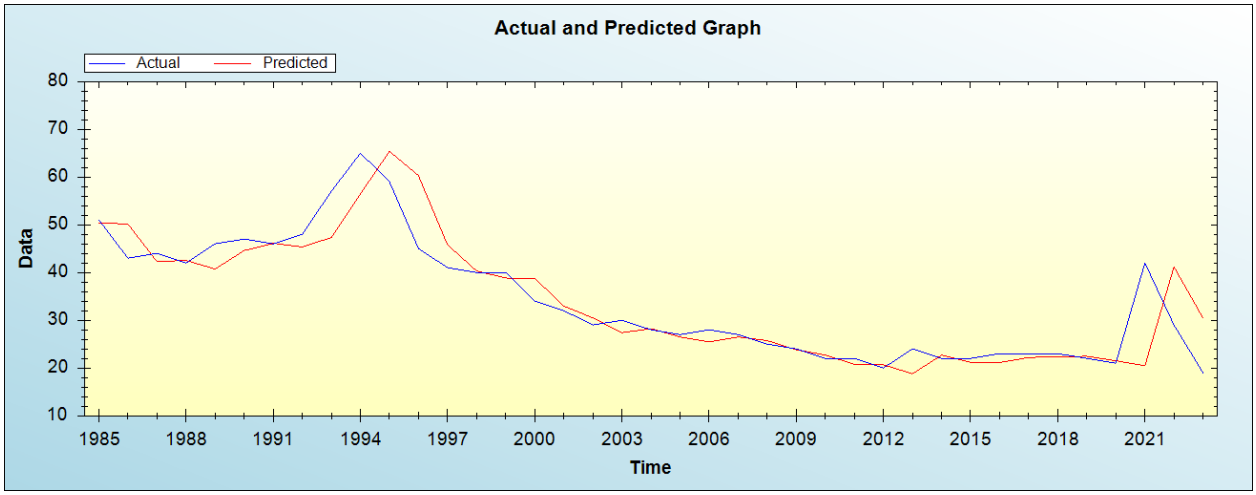


Figure 2: In-sample forecast for the Z series

Actual and Smoothed graph for Z series

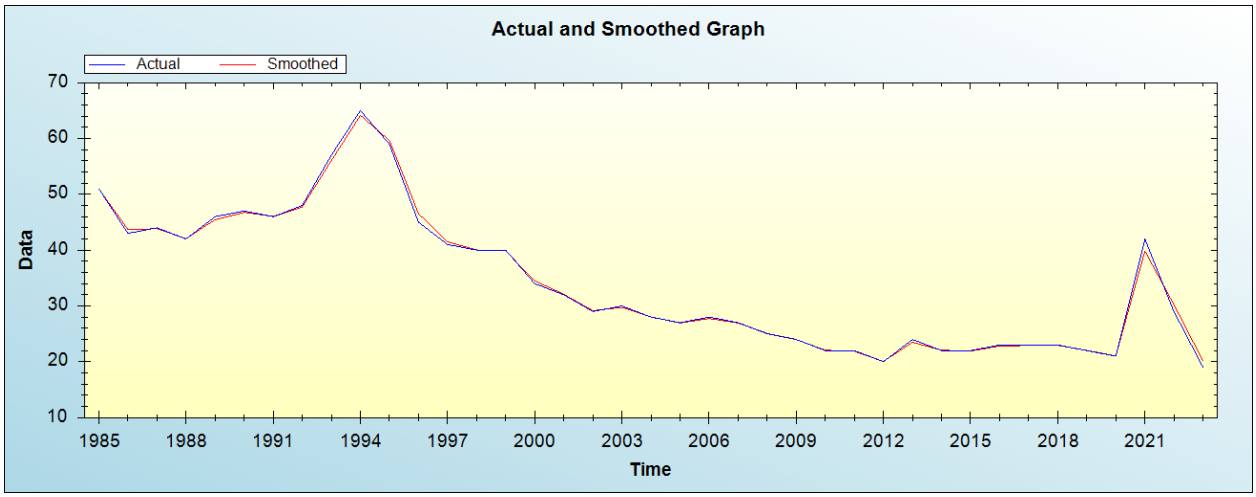


Figure 3: Actual and smoothed graph for Z series

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

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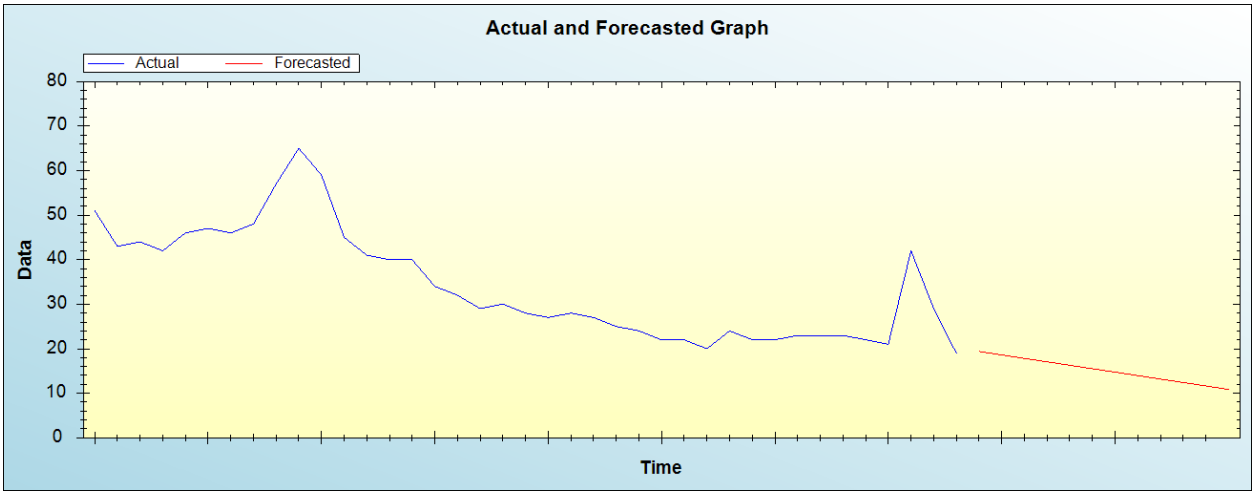


Figure 4: Out-of-sample forecast for Z: actual and forecasted graph

Out-of-Sample Forecast for Z: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Year	Forecasted MMR
2024	19.3749
2025	18.6018
2026	17.8287
2027	17.0555
2028	16.2824
2029	15.5093
2030	14.7361
2031	13.9630
2032	13.1898
2033	12.4167
2034	11.6436
2035	10.8704

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 19 in 2024 to about 11 deaths per 100 000 in 2035.

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Conclusion

Latvia has made significant progress in the reduction of maternal mortality. MMR dropped over the previous decades to levels below 30 per 100 000 live births. This signifies huge investments in the health sector and high quality of maternal health services during the antenatal, childbirth and post-partum periods. This study applies the double exponential smoothing model to project MMR for Latvia and the results indicate that MMR will decline from around 19 in 2024 to about 11 deaths per 100 000 live births by 2035. Hence, we encourage health authorities to relentlessly attend to local causes of maternal mortality and continue reporting severe maternal morbidities.

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