Western European Journal of Medicine and Medical Science
Volume 4, Issue 03, March 2026
https://westerneuropeanstudies.com/index.php/3
ISSN (E): 2942-1918 Open Access| Peer Reviewed
This article/work is licensed under CC Attribution-Non-Commercial 4.0

MATERNAL MORTALITY PROJECTION FOR MOLDOVA USING HOLT'S LINEAR METHOD

Smartson. P. NYONI[1], Thabani NYONI[2]
[1]Independent Researcher & Medical Doctor, Harare, Zimbabwe
[2]Independent Researcher & Health Economist, Harare, Zimbabwe

Abstract
This study uses annual time series data on MMR for Moldova 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 0.2 respectively based on minimum MSE. The results of the study indicate that MMR will decline from around 18.3 in 2024 to about 11.3 deaths per 100 000 live births by 2035. Therefore, we encourage authorities to attend to local factors associated with maternal mortality and continue routine surveillance of sever maternal morbidity.

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

Introduction

According to the World Health Organization, the Republic of Moldova in 2023 had an estimated population size of 3 067 070 inhabitants with a projected decrease of 23% to 2 351 809 by 2050. Life expectancy at birth (years) increased from 65.7 [65.4- 66] years in 2000 to 73.3 [73- 73.7] years in 2019. Since 2019, life expectancy has decreased to 69.6 [69.2- 69.9] years. The Republic of Moldova had 49 070 total deaths in 2021; 73% of deaths were from noncommunicable diseases NCDs) ; 24% were from communicable, maternal, perinatal and nutritional conditions and 4% were caused by injuries. The Policy Country Profile 2018-Moldova revealed that in 2020, maternal mortality rate stood at 12.3 deaths per 100 000 live births. This data indicates great improvements in the quality and accessibility of maternal health services across the country. The objective of this paper is to model and forecast MMR for Moldova using Holt's linear method. The findings of this paper will guide policy and allocation of resources to the maternal and child health program in order to further reduce preventable maternal deaths in the country.

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 whether postpartum	Prospective cohort study	Postpartum BMI increase was independently associated with new-onset dysglycemia. No independent

Western European Journal of Medicine and Medical Science
Volume 4, Issue 03, March 2026
https://westerneuropeanstudies.com/index.php/3
ISSN (E): 2942-1918 Open Access| Peer Reviewed
This article/work is licensed under CC Attribution-Non-Commercial 4.0

	changes in body mass index (BMI) independently predicted these outcomes.		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 cohort-study in women with Fabry disease showed an increase of pain burden during pregnancies and

Western European Journal of Medicine and Medical Science
Volume 4, Issue 03, March 2026
https://westerneuropeanstudies.com/index.php/3
ISSN (E): 2942-1918 Open Access| Peer Reviewed
This article/work is licensed under CC Attribution-Non-Commercial 4.0

		the Austrian Mother–Child Health Passport	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
Kabakchieva et al. (2022)	To investigate access-related barriers (availability, appropriateness, affordability, approachability, and acceptability) to maternity care in Romania, Bulgaria, and Moldova	cross- country study	Results show high rates of cesarean births (CB) and a low number of antenatal and postnatal care visits. Informal payments and use of personal connections are common practices
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

Western European Journal of Medicine and Medical Science
Volume 4, Issue 03, March 2026
https://westerneuropeanstudies.com/index.php/3
ISSN (E): 2942-1918 Open Access| Peer Reviewed
This article/work is licensed under CC Attribution-Non-Commercial 4.0

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 (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

Western European Journal of Medicine and Medical Science
Volume 4, Issue 03, March 2026
https://westerneuropeanstudies.com/index.php/3
ISSN (E): 2942-1918 Open Access| Peer Reviewed
This article/work is licensed under CC Attribution-Non-Commercial 4.0

			controlled were reported

Methodology

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

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

Smoothing equation

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

$0 < \alpha < 1$

Trend estimation equation

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

$0 < \beta < 1$

Forecasting equation

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

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

Western European Journal of Medicine and Medical Science
Volume 4, Issue 03, March 2026
https://westerneuropeanstudies.com/index.php/3
ISSN (E): 2942-1918 Open Access| Peer Reviewed
This article/work is licensed under CC Attribution-Non-Commercial 4.0

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 Moldova 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	Z
Included Observations	39
Smoothing constants	
Alpha (α) for data	0.900
Beta (β) for trend	0.200
Forecast performance measures	
Mean Absolute Error (MAE)	1.884765
Sum Square Error (SSE)	251.014516
Mean Square Error (MSE)	6.436270
Mean Percentage Error (MPE)	0.538057
Mean Absolute Percentage Error (MAPE)	6.149841

Residual Analysis for the Applied Model

Western European Journal of Medicine and Medical Science
Volume 4, Issue 03, March 2026
https://westerneuropeanstudies.com/index.php/3
ISSN (E): 2942-1918 Open Access| Peer Reviewed
This article/work is licensed under CC Attribution-Non-Commercial 4.0

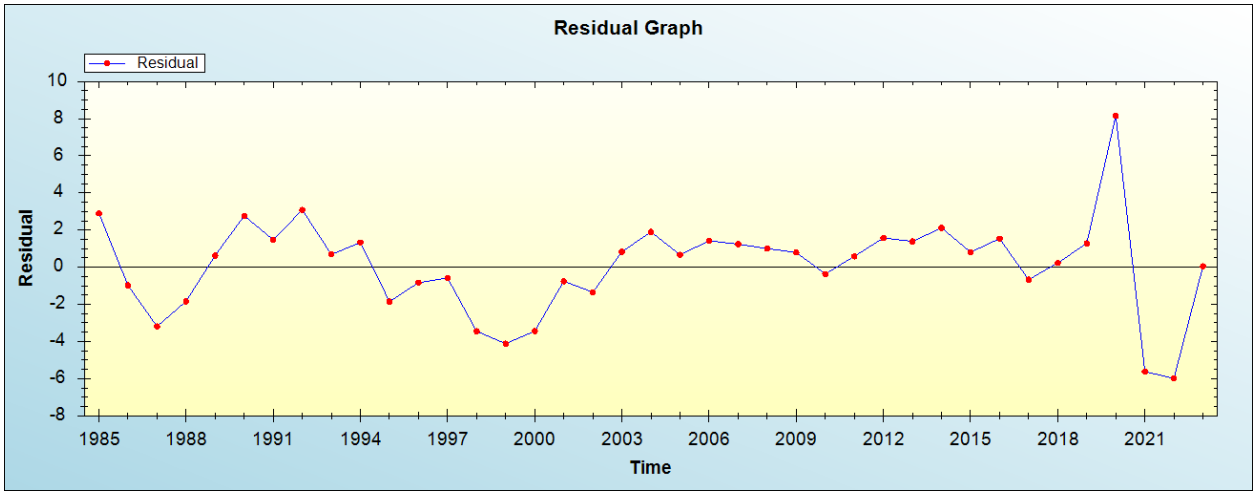


Figure 1: Residual analysis

In-sample Forecast for Z

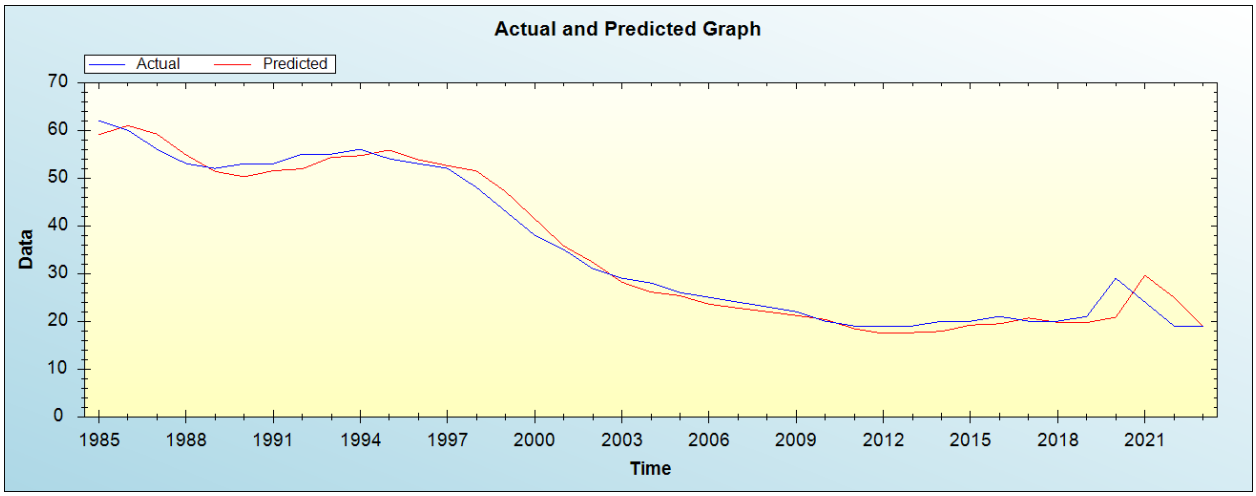


Figure 2: In-sample forecast for the Z series

Actual and Smoothed graph for Z series

Western European Journal of Medicine and Medical Science
Volume 4, Issue 03, March 2026
https://westerneuropeanstudies.com/index.php/3
ISSN (E): 2942-1918 Open Access| Peer Reviewed
This article/work is licensed under CC Attribution-Non-Commercial 4.0

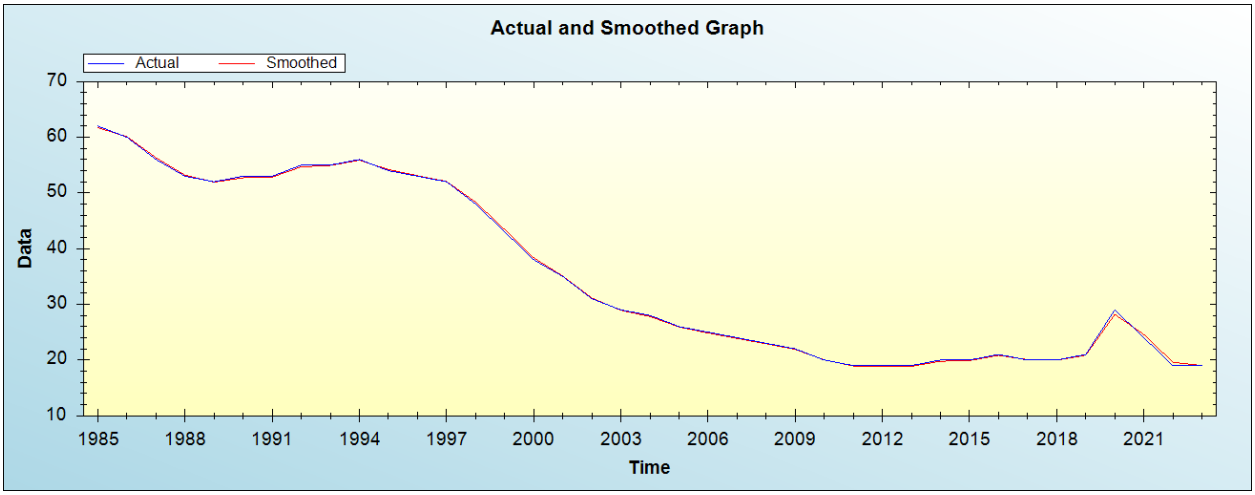


Figure 3: Actual and smoothed graph for Z series

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

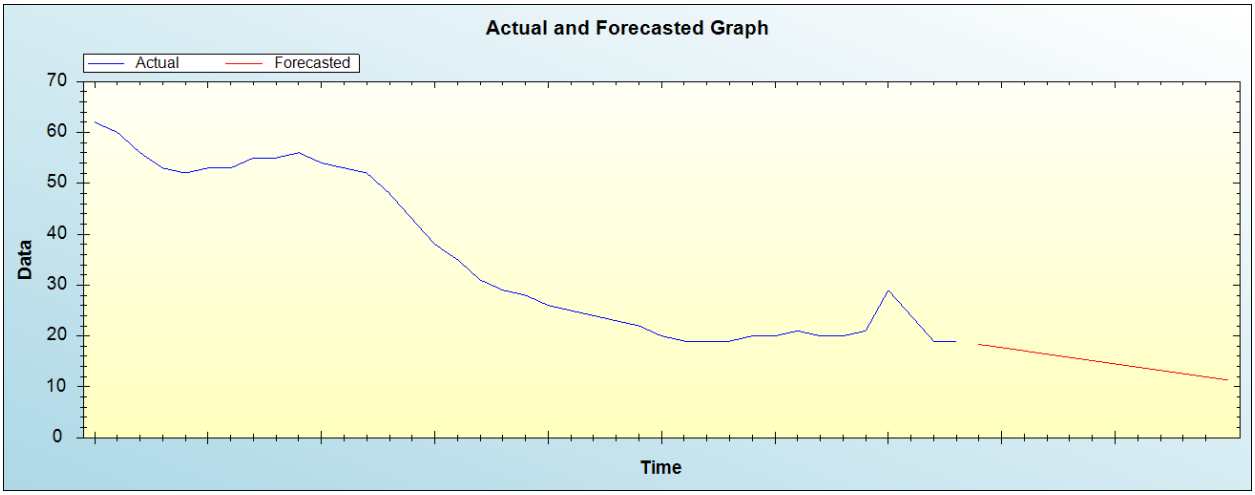


Figure 4: Out-of-sample forecast for Z: actual and forecasted graph

Out-of-Sample Forecast for Z: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Year	Forecasted MMR
2024	18.3545
2025	17.7141
2026	17.0737

Western European Journal of Medicine and Medical Science
Volume 4, Issue 03, March 2026
https://westerneuropeanstudies.com/index.php/3
ISSN (E): 2942-1918 Open Access| Peer Reviewed
This article/work is licensed under CC Attribution-Non-Commercial 4.0

2027	16.4333
2028	15.7928
2029	15.1524
2030	14.5120
2031	13.8716
2032	13.2312
2033	12.5907
2034	11.9503
2035	11.3099

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 18.3 in 2024 to about 11.3 deaths per 100 000 live births by 2035.

Recommendations & Conclusion

The Republic of Moldova has made significant strides in controlling maternal mortality as evidenced by low MMRs. Low MMR indicates significant improvements made across all sectors of the economy including the health sector. This paper applied Holt's linear approach to model and forecast MMR for Moldova and findings indicate that MMR will decline from around 18.3 in 2024 to about 11.3 deaths per 100 000 live births in 2035. Therefore, we implore the authorities to relentlessly address local causes of maternal mortality and conduct routine surveillance of severe maternal morbidities.

References

1. Diguisto, C., Saucedo, C., Kallianidis, A., van den Akker, T., Chauleur, C., Francois, M., Deneux-Tharaux, C., & Alexander, S. (2022). International comparison of maternal mortality in eight high-income European countries. *BJOG: An International Journal of Obstetrics & Gynaecology*, *129*(9), 1474–1481. https://doi.org/10.1111/1471-0528.17094
2. Haninger-Vacariu, M., Werther, E., Pollak, A., & Sunder-Plassmann, G. (2024). Pregnancy and delivery outcomes in women with Fabry disease: A retrospective cohort study. *Orphanet Journal of Rare Diseases*, *19*(1), Article 112. https://doi.org/10.1186/s13023-024-03112-9
3. Kabakchieva, M., Miteniece, E., Pavlova, M., Rechel, B., Zuza, I., Radu, I., & Groot, W. (2023). Barriers to access adequate maternal care in Romania, Bulgaria, and Moldova: A cross-country comparison. *Birth: Issues in Perinatal Care*, *50*(1), 205–214. https://doi.org/10.1111/birt.12681

Western European Journal of Medicine and Medical Science
Volume 4, Issue 03, March 2026
https://westerneuropeanstudies.com/index.php/3
ISSN (E): 2942-1918 Open Access| Peer Reviewed
This article/work is licensed under CC Attribution-Non-Commercial 4.0

4. Kornyicki, Á. M., & Fedor, A. R. (2024). Inequalities and differences in health status of pre- and perinatal periods in Hungarian long-term series analysis (1997–2019). *Children*, *11*(11), Article 1373. https://doi.org/10.3390/children11111373
5. Nunn, A., Shepherd, C. C. J., Glover, K., & Farrant, B. M. (2025). Key maternal characteristics and perinatal death rates among Aboriginal and Torres Strait Islander women in Victoria: A retrospective population-based cohort study. *The Australian & New Zealand Journal of Obstetrics & Gynaecology*, *65*(1), 45–54. https://doi.org/10.1111/ajo.13812
6. Schildberger, B., Zenzmaier, C., & König-Bachmann, M. (2017). Experiences of Austrian women with disabilities during pregnancy, childbirth and the puerperium: A qualitative study. *BMC Pregnancy and Childbirth*, *17*(1), Article 321. https://doi.org/10.1186/s12884-017-1517-5
7. Tsushima, A., Kasuga, Y., Miyakoshi, K., Saisho, Y., Ikenoue, S., & Tanaka, M. (2026). Impact of postpartum body mass index changes on long-term incidence of dysglycemia and dyslipidemia after gestational diabetes mellitus. *Journal of Diabetes Investigation*, *17*(2), 210–219. https://doi.org/10.1111/jdi.14321
8. Wami, M. S., Baji, P., Kovács, B., & Zsuga, J. (2022). Maternal and feto-neonatal outcomes associated with planned home births versus institutional births in Hungary: A retrospective cohort study. *BMC Pregnancy and Childbirth*, *22*(1), Article 512. https://doi.org/10.1186/s12884-022-04812-3
9. Yue, L., Zhang, Y., Wang, X., Liu, H., & Chen, Z. (2026). Antiphospholipid antibodies and adverse pregnancy outcomes in assisted reproductive technology and natural conception: An umbrella review. *Human Reproduction Update*, *32*(1), 88–104. https://doi.org/10.1093/humupd/dmae034