

Eurasian Scientific Herald 		Utilizing Forecasts Generated By The Double Exponential Smoothing Model To Inform Maternal Health Policy In Argentina	
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ABSTRACT		<i>This study uses annual time series data on MMR for Argentina 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 0.1 and 0.1 respectively based on minimum MSE. The results of the study indicate that MMR will continue on a downward trajectory and reach levels below 30 deaths per 100 000 live births by 2035. Therefore, we encourage authorities to adopt the 3-fold policy recommendations.</i>	
Keywords:		<i>Exponential smoothing, Forecasting, Maternal Mortality Ratio</i>	

Introduction

Death of women during pregnancy as a result of pregnancy related complications continues to attract global attention (WHO, 2024; Antsaklis & Antsaklis, 2023; WHO, 2012). Pregnant women should not die regardless of the medical condition. Efforts should be made during the antenatal, labor and delivery, and postnatal periods to detect all medical problems and attend to them timeously to eliminate all preventable maternal deaths. According to the World Health Organization, more than 800 women are dying every day due to pregnancy related complications (WHO, 2019). Maternal mortality is much more severe in low to middle income countries, where the overall deaths during pregnancy and labor have been calculated to account for ninety nine percent of the worldwide deaths, with the risk being ninety-seven times greater than in Europe or North America (Girum & Wasie, 2017). The etiology of above fifty percent of maternal

mortality cases are postpartum hemorrhage (27%), severe pre-eclampsia and eclampsia (14%), infections and sepsis during ante partum or postpartum period (10%), and intrapartum complications such obstruction and secondary arrest of labor especially in multiparous women (8%) (Say et al. 2014). In addition, complications associated with abortion, pre-existing medical conditions and infections (TB, HIV and malaria) are the leading indirect causes of maternal deaths. Argentina policy country profile 2018 revealed that in 2020, this reported maternal mortality ratio of 44.9 deaths per 100 000 live births, in 2022, neonatal mortality was 5.7 deaths per 1000 live births and under five mortality deaths in 2022 stood at 9.4 deaths per 1000 live births. The objective of this study is to model and forecast MMR for Argentina using the double exponential smoothing model. We expect the findings of this paper to detect future trends of MMR that will inform policy and allocation of resources to the

Maternal and Child health program in this country.

Literature Review

Author(s)	Objective(s)	Methodology	Key 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 weight change may help identify women at higher risk of subsequent metabolic abnormalities, particularly dysglycemia, in this high-risk population, although causal relationships cannot be inferred from this observational study
Yue et al. (2026)	to perform an umbrella review to summarize the current evidence to provide a reference for clinicians and future research	Systematic literature review	This review offers a thorough overview of the current evidence linking SLE, SS and APS to pregnancy and assisted reproductive outcomes. It identifies existing gaps and proposes

			future research directions
Cresswell et al. (2025)	To obtain updated evidence on causes of maternal death is needed to accelerate progress	Systematic review	Globally, the most common cause of maternal death was hemorrhage (27%; 80% uncertainty interval 22–32), followed by indirect obstetric deaths (23%, 18–30), and hypertensive disorders (16%, 14–19). The proportion of hemorrhage deaths varied substantially by region and was highest in sub-Saharan Africa and Western Asia and Northern Africa.
Quiroz-Acuña et al. (2025)	To assess maternal mortality trends in LAC women from 1997 to 2019, providing key insights to address this issue.	ecological observational time-series study	Despite overall progress, regional differences in maternal mortality persist across Latin America and the Caribbean. These variations highlight the importance of strengthening maternal health systems, improving access to skilled birth attendance, and ensuring quality prenatal and postnatal care
Silvana et al. (2025)	To describe the factors influencing the reduction of maternal mortality during the 2022–2024 management	Participatory Action Research (PAR) with a qualitative-quantitative analysis. Twelve meetings and interviews were	intercultural, comprehensive, and territory-based management of pregnancy and childbirth led to a reduction in

	period at Tartagal Hospital (HT)	conducted with the healthcare team, along with 10 validated surveys administered to obstetric inpatients (10/12/24), and an analysis of hospital databases	maternal mortality beginning in 2022. Teamwork and intersectoral collaboration optimized available resources, consolidating a sustainable and effective model for maternal health. However, the greatest challenge lies in maintaining and increasing funding to ensure the continuity of this policy
Nigenda and Serván-Mori (2024)	To discuss the relationship between the availability of human resources for health and the maternal mortality ratio for the period 1990–2021 in Latin America	used secondary data from a global source to show patterns in the relationship between these two aspects and identify gaps in the Latin American and Caribbean regions	Although variations in maternal mortality rate cannot be explained solely through the provision of health personnel, it is important to consider that it is critical to find new modalities on how human resources for health could integrate and create synergies with other resources to increase systems capacity to deliver care according to conditions in each country
Critto et al. (2022)	To examine the effects of a pandemic influenza virus on cause-specific maternal mortality time series, using	-conducted a population-based natural experiment from national vital records of maternal deaths between 1980 and 2017	Over this 38-year study, the MMR decreased by 58.6% (69.5 to 28.8 deaths/100,000 live births), transitioning from direct obstetric

	Argentinian vital statistics	-applied Join-point regression models	causes (67.0 to 21.1/100,000 live births; 68.4% decrease) to indirect causes (2.6 to 7.7/100,000 live births; 196.2% increase)
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Methodology

This study utilizes an exponential smoothing technique to model and forecast future trends of MMR for Argentina. 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 Argentina 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	0.100
Beta (β) for trend	0.100
Forecast performance measures	
Mean Absolute Error (MAE)	4.981988
Sum Square Error (SSE)	2248.260208
Mean Square Error (MSE)	57.647698
Mean Percentage Error (MPE)	-1.797453
Mean Absolute Percentage Error (MAPE)	9.248602

Residual Analysis for the Applied Model

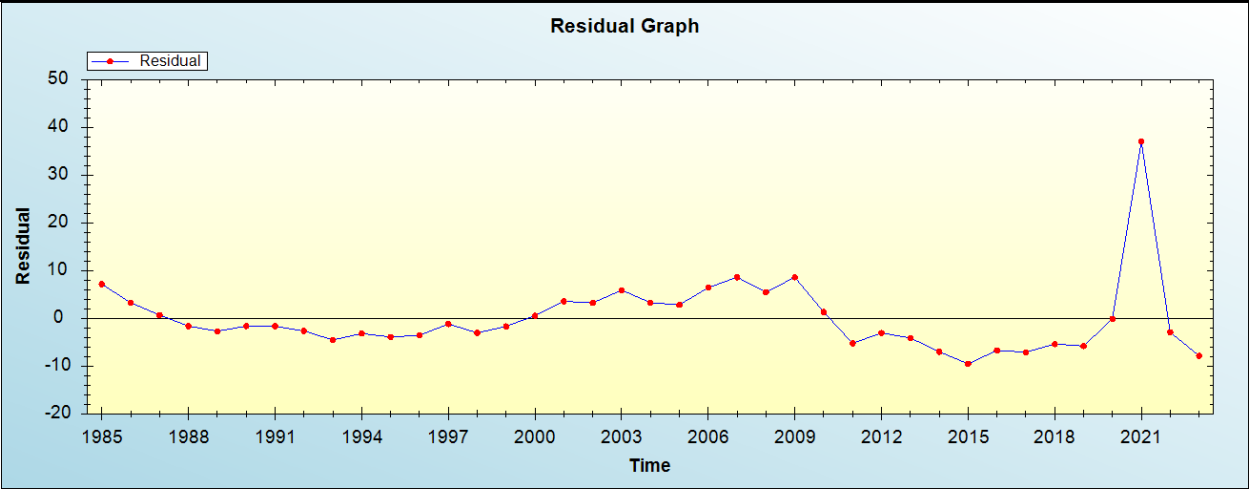


Figure 1: Residual analysis

In-sample Forecast for A

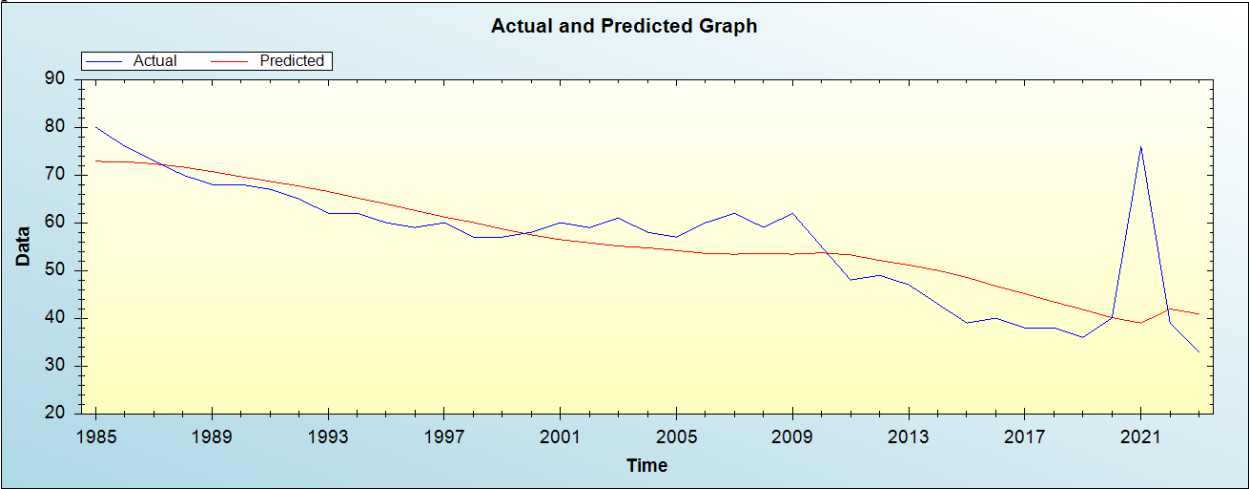


Figure 2: In-sample forecast for the A series

Actual and Smoothed graph for A series

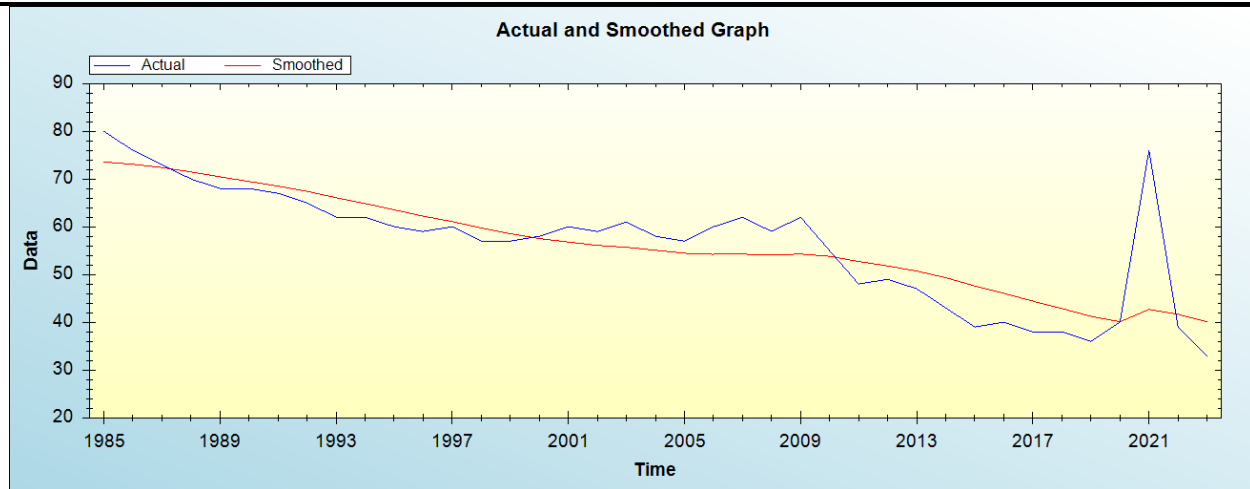


Figure 3: Actual and smoothed graph for A series

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

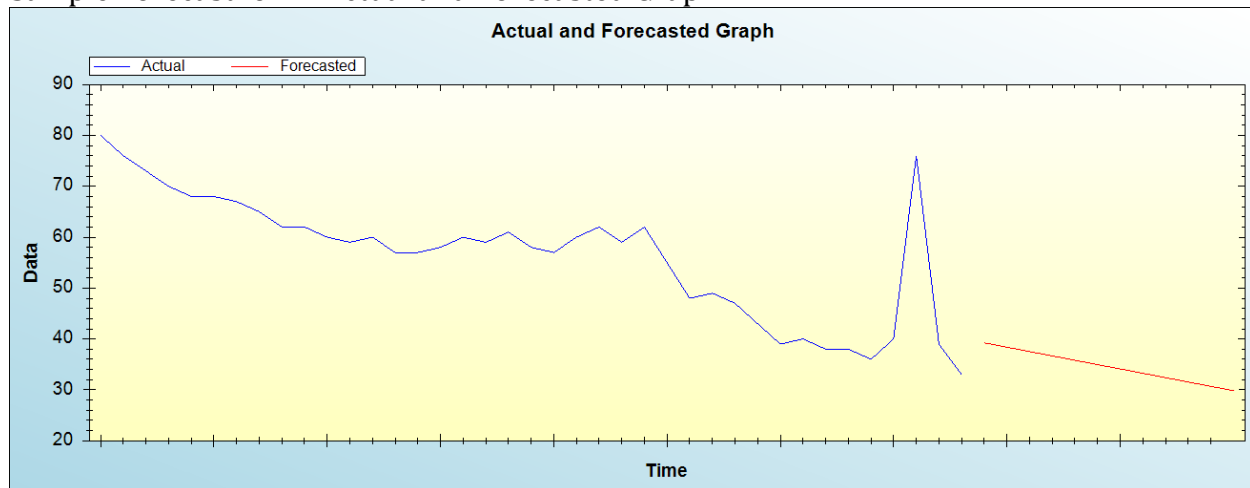


Figure 4: Out-of-sample forecast for A: actual and forecasted graph

Out-of-Sample Forecast for A: Forecasts only

Table 2: Tabulated out-of-sample forecasts

	Forecasted
2024	39.2365
2025	38.3827
2026	37.5290
2027	36.6752
2028	35.8215
2029	34.9677
2030	34.1140
2031	33.2602
2032	32.4065
2033	31.5527
2034	30.6990
2035	29.8452

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 trajectory and reach levels below 30 deaths per 100 000 live births by 2035.

Conclusion

This paper focused on forecasting MMR for Argentina using the double exponential smoothing technique. The findings of this paper highlighted that MMR will continue on a downward trajectory and reach levels below 30 deaths per 100 000 live births by 2035. Therefore, we encourage the Argentinian government to adopt the following policy prescriptions: (1) to carryout continuous quality improvement activities (2) improving access to skilled birth attendance, and ensuring quality prenatal and postnatal care and (3) to address local factors associated with maternal mortality.

References

1. Antsaklis, A., & Antsaklis, P. (2023). What is already done by different societies in reduction of maternal mortality? Are they successful at all? *Journal of Perinatal Medicine*, 51(2), 233–239. <https://doi.org/10.1515/jpm-2022-0402>
2. Cresswell, J. A., Ronsmans, C., Calvert, C., & Filippi, V. (2025). Causes of maternal death worldwide: A systematic review. *The Lancet Global Health*, 13(2), e215–e227.
3. Critto, M. E., Enriquez, Y., Bravo, M., & Koch, E. (2022). Impact of emerging virus pandemics on cause-specific maternal mortality time series: A population-based natural experiment in Argentina. *The Journal of Maternal-Fetal & Neonatal Medicine*, 35(25), 9831–9838. <https://doi.org/10.1080/14767058.2022.2058514>
4. Figar, S., Zingoni, P., & et al. (2025). Reduction of maternal mortality: Intercultural care for pregnancy and childbirth in Tartagal, Salta, Argentina. *medRxiv*. <https://doi.org/10.1101/2025.05.07.25326956>
5. Girmu, T., & Wasie, A. (2017). Correlates of maternal mortality in developing countries: An ecological study in 82 countries. *Maternal Health, Neonatology and Perinatology*, 3, Article 19. <https://doi.org/10.1186/s40748-017-0059-8>
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. Nigenda, G., & Serván-Mori, E. (2024). Availability of human resources for health and maternal mortality in Latin America and the Caribbean, 1990–2021. *Revista Panamericana de Salud Pública*.
8. Organization for Economic Co-operation and Development. (2018). *OECD reviews of health systems: Argentina 2018*. OECD Publishing.
9. Quiroz-Acuña, M., & et al. (2025). Trends in maternal mortality in Latin America and the Caribbean, 1997–2019: An ecological time-series analysis. *The Lancet Regional Health – Americas*.
10. Say, L., Chou, D., Gemmill, A., Tunçalp, Ö., Moller, A. B., & Daniels, J. (2014). Global causes of maternal death: A WHO systematic analysis. *The Lancet Global Health*, 2(6), e323–e333. [https://doi.org/10.1016/S2214-109X\(14\)70227-X](https://doi.org/10.1016/S2214-109X(14)70227-X)
11. 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*.
12. World Health Organization. (2012). *ICD-10: International statistical classification of*

- diseases and related health problems — Application to deaths during pregnancy, childbirth and the puerperium (ICD-MM)*. World Health Organization.
13. World Health Organization. (2019). *Trends in maternal mortality 2000 to 2017: Estimates by WHO, UNICEF, UNFPA, World Bank Group and the United Nations Population Division*. World Health Organization.
 14. World Health Organization. (2024). *Maternal mortality ratio (per 100 000 live births) – Indicator metadata (SDG 3.1.1)*. World Health Organization.
 15. 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.