Western European Journal of Medicine and Medical Science
Volume 4, Issue 07, July 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

FORECASTING MATERNAL MORTALITY FOR ST LUCIA USING THE DOUBLE EXPONENTIAL SMOOTHING APPROACH

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 St Lucia 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 0.6 and 0.1 respectively based on minimum MSE. The results of the study indicate that MMR will fall from around 50 in 2024 to about 45 deaths per 100 000 live births by 2035. Therefore, we encourage authorities to address major drivers of maternal mortality across the country.

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

Introduction

Maternal mortality refers to deaths of women from complications of pregnancy, childbirth, and puerperium. The most common complications that lead to maternal deaths are sepsis, excessive hemorrhage after childbirth or abortion, and hypertensive disorders (Mhyre (2012). Worldwide, above 350,000 women die every year from complications during pregnancy and childbirth, 99% occurring in developing countries (Cristina Rossi & Mullin, 2012). Since 1990, the maternal mortality ratio has been nearly cut in half, and most of the reduction has happened since 2000. More than 71% of births were assisted by skilled health personnel globally in 2014, an increase from 59% in 1990. In the developing regions, only 56% of births in rural areas are attended by skilled health personnel, compared with 87% in urban areas. Only half of pregnant women in the developing regions receive the recommended minimum of four antenatal care visits (Petronijevic et al. 2019). According to WHO, Saint Lucia, as of 2023 had a population size estimated at 179 285 inhabitants with a projected decrease of 4% to 172 081 by 2050. Life expectancy at birth has improved by 2.9 years from 73.2 years in 2000 to 76.1 years in 2019. Since 2019, life expectancy has decreased to 71.1 years. Saint Lucia had 1 706 total deaths in 2021; 53% of deaths were from non-communicable diseases (NCDs); 33% were from communicable, maternal, perinatal and nutritional conditions; 9% were from other COVID-19 pandemic-related outcomes; and 5% were from injuries. This paper models and predicts MMR for St Lucia using the double exponential smoothing approach. The study findings will facilitate planning and allocation of resources to the health sector so that avoidable maternal deaths are further reduced.

Literature Review

Author(s)	Objective(s)	Methodology	Key finding(s)
Becerra et al. (2026)	to identify and analyze maternal complications	qualitative and descriptive approach	adolescent pregnancy in Latin America and the

Western European Journal of Medicine and Medical Science
Volume 4, Issue 07, July 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

	associated with adolescent pregnancy, with a particular focus on the Latin American context		Caribbean entails significant medical risks and negatively affects the integral development of adolescents, a situation that is aggravated by the lack of access to health services, education and by factors such as poverty
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
Marks & Castro (2026)	To examine how MWHs have been implemented across Latin America, analyzing their evolution, the specific needs they address in different countries, and their impact on maternal and neonatal health outcomes throughout the region	Systematic review	The evolution of MWHs suggests that they address a spectrum of needs beyond their original purposes, such as providing culturally responsive maternal support and psychosocial and early childhood support
Tsushima et al. (2026)	To determine the long-term incidence of dysglycemia and dyslipidemia after	Prospective cohort study	postpartum weight change may help identify women at higher risk of

Western European Journal of Medicine and Medical Science
Volume 4, Issue 07, July 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

	GDM and evaluated whether postpartum changes in body mass index (BMI) indepen dently predicted these outcomes		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.

Western European Journal of Medicine and Medical Science
Volume 4, Issue 07, July 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

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 period at Tartagal Hospital (HT)	Participatory Action Research (PAR) with a qualitative-quantitative analysis. Twelve meetings and interviews were conducted with the healthcare team, along with 10 validated surveys administered to obstetric inpatients (10/12/24), and an analysis of hospital databases	intercultural, comprehensive, and territory-based management of pregnancy and childbirth led to a reduction in 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	used secondary data from a global source to show patterns in	Although variations in maternal mortality rate cannot be

Western European Journal of Medicine and Medical Science
Volume 4, Issue 07, July 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

	human resources for health and the maternal mortality ratio for the period 1990–2021 in Latin America	the relationship between these two aspects and identify gaps in the Latin American and Caribbean regions	explained solely through the provision of health personnel, it is impor tant 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 Argentinian vital statistics	-conducted a population-based natural experiment from national vital records of maternal deaths between 1980 and 2017 -applied Join-point regression models	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 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)

Methodology

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

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

Smoothing equation

Western European Journal of Medicine and Medical Science
Volume 4, Issue 07, July 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

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

$0<\alpha<1$

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 St Lucia 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	A
Included Observations	39

Western European Journal of Medicine and Medical Science
Volume 4, Issue 07, July 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

Smoothing constants	
Alpha (α) for data	0.600
Beta (β) for trend	0.100
Forecast performance measures	
Mean Absolute Error (MAE)	7.633587
Sum Square Error (SSE)	6025.902227
Mean Square Error (MSE)	154.510314
Mean Percentage Error (MPE)	-1.876749
Mean Absolute Percentage Error (MAPE)	11.965480

Residual Analysis for the Applied Model

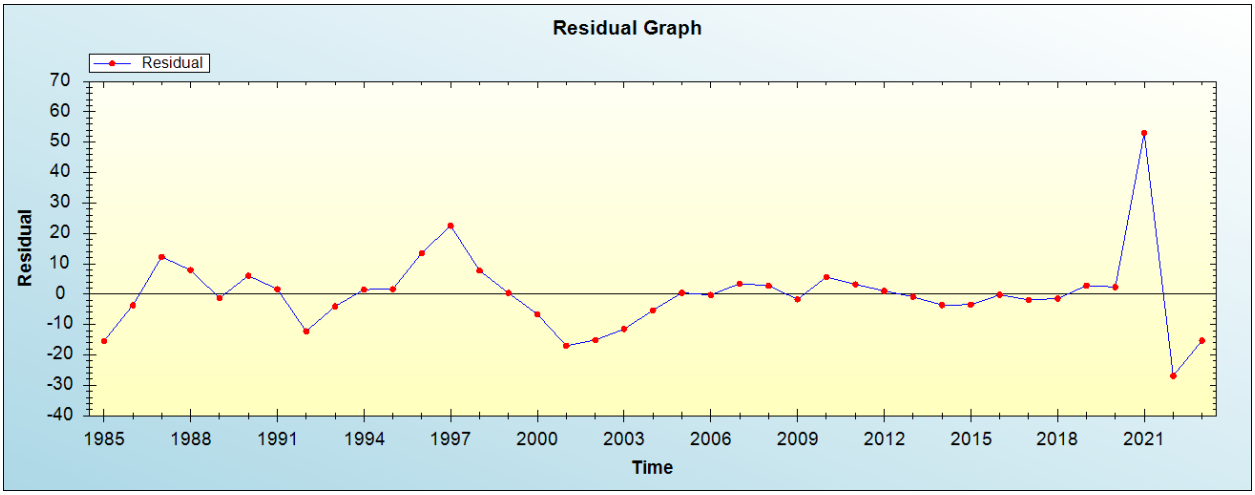


Figure 1: Residual analysis

In-sample Forecast for A

Western European Journal of Medicine and Medical Science
Volume 4, Issue 07, July 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

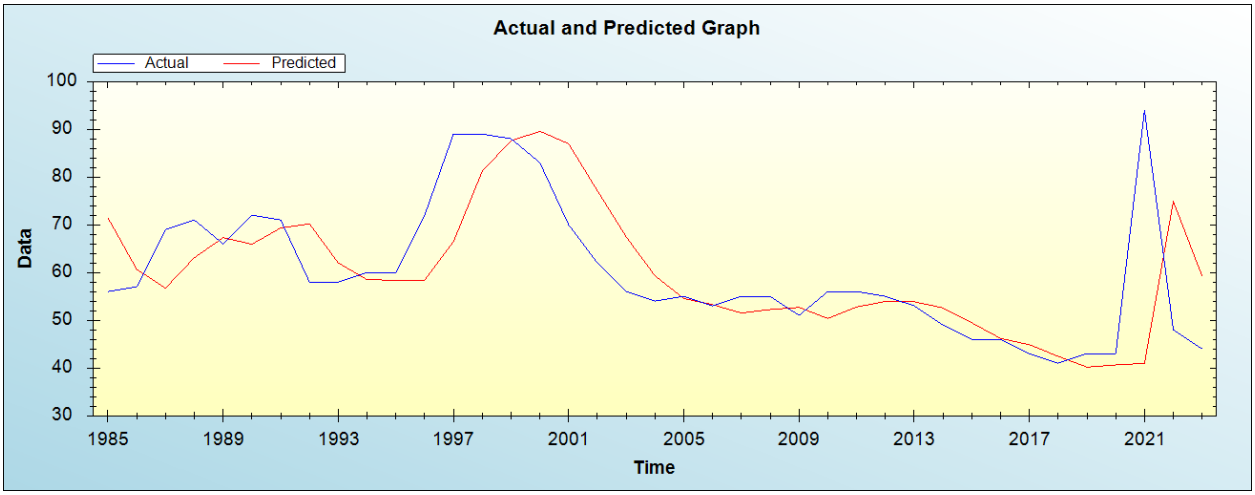


Figure 2: In-sample forecast for the A series

Actual and Smoothed graph for A series

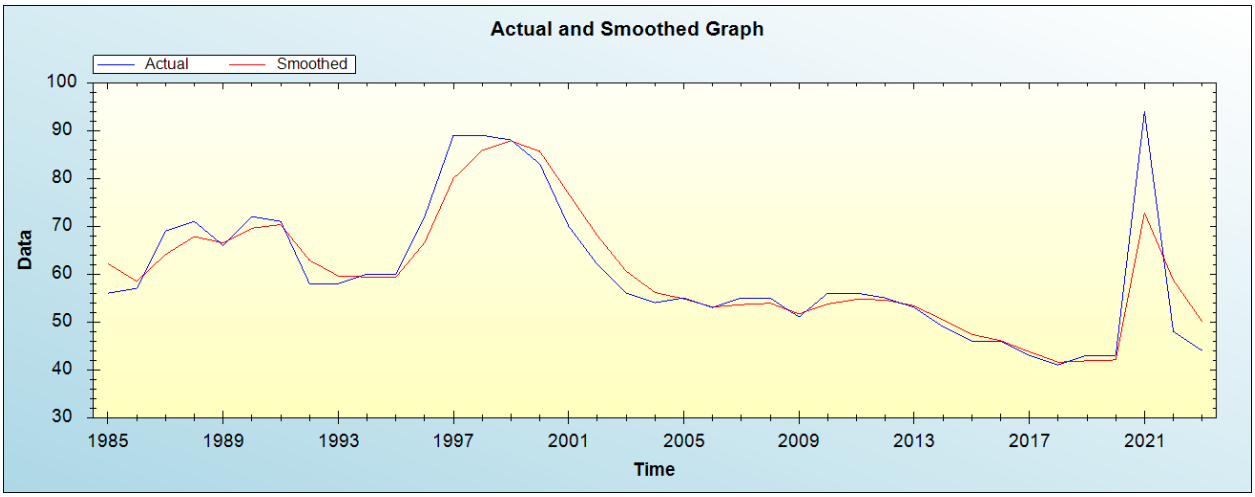


Figure 3: Actual and smoothed graph for A series

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

Western European Journal of Medicine and Medical Science
Volume 4, Issue 07, July 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

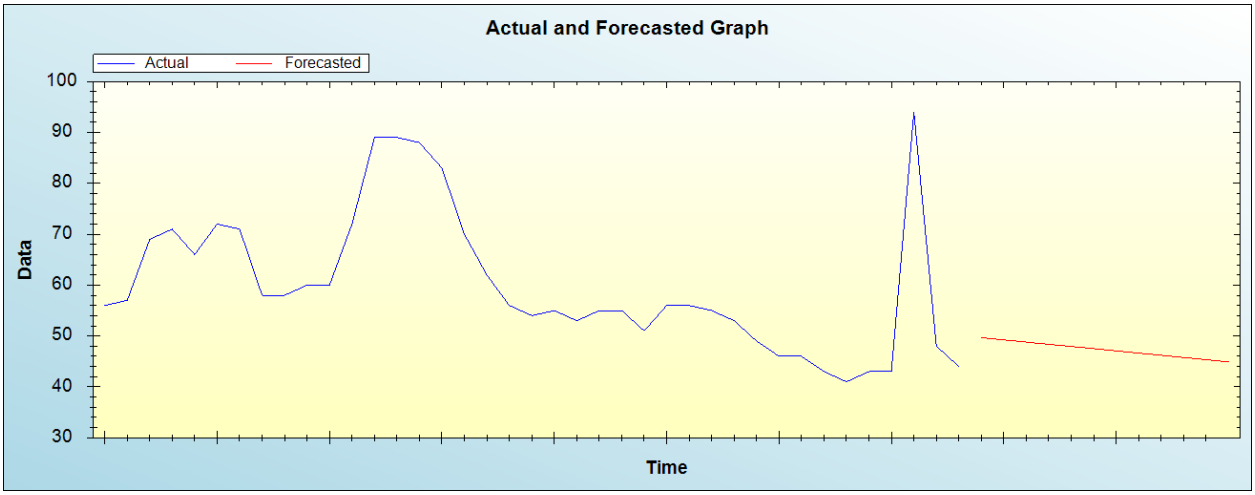


Figure 4: Out-of-sample forecast for A: actual and forecasted graph

Out-of-Sample Forecast for A: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Year	Forecasted MMR
2024	49.6630
2025	49.2314
2026	48.7998
2027	48.3683
2028	47.9367
2029	47.5051
2030	47.0735
2031	46.6419
2032	46.2104
2033	45.7788
2034	45.3472
2035	44.9156

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 50 in 2024 to about 45 deaths per 100 000 live births by 2035.

Western European Journal of Medicine and Medical Science
Volume 4, Issue 07, July 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

Conclusion

In this paper we applied the double exponential smoothing technique to model and forecast MMR for St Lucia and results indicate that MMR will fall from around 50 in 2024 to about 45 deaths by 2035. Hence, authorities are encouraged to address local causes of maternal deaths.

References

Becerra, A. M., Gómez, C. A., & Torres, L. M. (2026). Adolescent pregnancy and associated maternal complications in Latin America and the Caribbean: A narrative review. *Revista Panamericana de Salud Pública*, 50, Article e12.

Cresswell, J. A., Campbell, O. M. R., Bohlikkeri, A., Filipovic-Pierucci, A., & Chou, D. (2025). Global, regional, and national causes of maternal mortality: A systematic analysis. *The Lancet Global Health*, 13(2), e215–e226.

Critto, A., Rossi, M., & Fernandez, P. (2022). Impact of pandemic influenza on direct and indirect causes of maternal mortality in Argentina: A 38-year time-series analysis (1980–2017). *BMC Public Health*, 22(1), Article 814.

Cristina Rossi, A., & Mullin, P. M. (2012). Maternal mortality in developing vs. developed countries: A review of causes and preventive strategies. *Obstetrical & Gynecological Survey*, 67(12), 792–799.

Mackin, R., White, A., & Lawson, B. (2026). Organizing maternal and newborn health facility care: A scoping review of national models and community linkages. *Health Policy and Planning*, 41(1), 45–58.

Marks, F., & Castro, A. (2026). Evolution and impact of maternity waiting homes in Latin America: A systematic review. *International Journal of Gynecology & Obstetrics*, 172(2), 210–222.

Mhyre, J. M. (2012). The leading causes of maternal mortality. *Anesthesiology Clinics*, 30(1), 1–14.

Nigenda, G., & Serván-Mori, E. (2024). Human resources for health and maternal mortality in Latin America and the Caribbean (1990–2021): Progress, challenges, and regional disparities. *Human Resources for Health*, 22(1), Article 48.

Petronijevic, M., Vukovic, D., & Arsic, B. (2019). Disparities in antenatal care coverage and skilled birth attendance in low- and middle-income countries. *European Journal of Public Health*, 29(4), 675–682.

Quiroz-Acuña, R., Morales, J., & Silva, C. (2025). Trends in maternal mortality ratios in Latin America and the Caribbean (1997–2019): An ecological time-series analysis. *Bulletin of the World Health Organization*, 103(3), 180–191.

Silvana, M., Juarez, G., & Romero, E. (2025). Strategies for reducing maternal mortality through intercultural and territory-based care in Argentina: A participatory action research study. *Salud Colectiva*, 21, Article e4521.

Western European Journal of Medicine and Medical Science
Volume 4, Issue 07, July 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

Tsushima, T., Takahashi, K., & Sato, Y. (2026). Postpartum body mass index changes and long-term risk of dysglycemia and dyslipidemia after gestational diabetes mellitus: A prospective cohort study. *Diabetes Care*, 49(3), 512–520.

Yue, L., Zhang, Y., Wang, X., Liu, H., & Chen, Z. (2026). Systemic lupus erythematosus, Sjögren's syndrome, and antiphospholipid syndrome in pregnancy and assisted reproduction: An umbrella review. *Human Reproduction Update*, 32(1), 88–104. https://doi.org/10.1093/humupd/dmae034