



PREDICTION OF MATERNAL MORTALITY FOR SAMOA USING THE DOUBLE EXPONENTIAL SMOOTHING TECHNIQUE

Smartson. P. NYONI 1,

Thabani NYONI 2

1Independent Researcher & Medical Doctor, Harare, Zimbabwe

2Independent Researcher & Health Economist, Harare, Zimbabwe

Abstract

This study uses annual time series data on MMR for Samoa 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 hover around 100 deaths per 100 000 live births throughout the out of sample period. Therefore, we encourage authorities to address local causes of maternal mortality and direct more resources towards the implementation of quality improvement strategies.

Keywords: Exponential smoothing, Forecasting, Maternal Mortality Ratio

Introduction

Nearly 800 women die every day from avoidable causes related to pregnancy or childbirth (WHO, 2023). Obstetric bleeding, gestational hypertension, and maternal infection are responsible for over 50% of maternal deaths worldwide (Khan et al. 2006). In Sub-Saharan Africa, 65% of maternal deaths from hemorrhage occur following delivery (Campbell et al. 2006; Li et al, 1996). Maternal mortality affects low-middle countries more than the developed countries. According to the WHO, at the global level, the maternal mortality ratio in 2020 was estimated at 233 per 100,000 live births (WHO, 2020). However, during the recent decades, a substantial decline of maternal mortality ratio at the global level was noted, with a reduction of 34.3% between 2000 and 2020, an



average rate of reduction of 2.9% per year (WHO, 2023; WBG, 2023; WHO, 2020). According to WHO, Samoa had a population size of 216 663 inhabitants in 2023, with a projected increase of 26% to 272 726 by 2050. Life expectancy at birth has improved by 0.4 years from 69.6 [69- 70.3] years in 2000 to 70 [69.5- 70.7] years in 2019. Since 2019, life expectancy has improved to 70.3 [69.6- 71] years. Samoa had 1 427 total deaths in 2021; 83% of deaths were from noncommunicable diseases (NCDs); 11% were from communicable, maternal, perinatal and nutritional conditions; 6% were from injuries; and 0% were from other COVID-19 pandemic-related outcomes. The objective of this paper is to model and forecast MMR for Samoa using the double exponential smoothing technique. The study findings will assist in the crafting of maternal and child health policies and implementation of appropriate strategies to eliminate all preventable maternal deaths.

Author(s)	Objective(s)	Methodology	Key finding(s)
Becerra et al. (2026)	to identify and analyze maternal complications associated with adolescent pregnancy, with a particular focus on the Latin American context	qualitative and descriptive approach	adolescent pregnancy in Latin America and the 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	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



Modern American Journal of Medical and Health Sciences

ISSN (E): 3067-803X

Volume 2, Issue 5, May 2026

Website: usajournals.org

This work is Licensed under CC BY 4.0 a Creative Commons Attribution 4.0 International License.

	on maternal and neonatal health outcomes throughout the region		and psychosocial and early childhood support
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	Participatory Action Research (PAR) with a	intercultural, comprehensive, and territory-based



Modern American Journal of Medical and Health Sciences

ISSN (E): 3067-803X

Volume 2, Issue 5, May 2026

Website: usajournals.org

This work is Licensed under CC BY 4.0 a Creative Commons Attribution 4.0 International License.

	of maternal mortality during the 2022–2024 management period at Tartagal Hospital (HT)	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	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 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 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)
Fa'alili-Fidow et al. (2016)	to identify positive and effective mechanisms of advice and support that would improve the experiences of pregnancy for mothers, and improve health outcomes for mothers and babies in Samoa	qualitative approach	A lack of funding and transportation were identified as barriers to implementing a sustainable program to help pregnant women



Hill et al. (2009)	To assess the feasibility of measuring maternal mortality in countries lacking accurate birth and death registration through national population censuses by a detailed evaluation of such data for three Latin American countries	Applied established demographic techniques	The PRMRs for Honduras (2001), Nicaragua (2005) and Paraguay (2002) were 168, 95 and 178 per 100 000 live births, respectively. Surprisingly, evaluation of the data for Nicaragua and Paraguay showed overreporting of adult deaths, so a downward adjustment of 20% to 30% was required
--------------------	--	--	---

Methodology

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

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

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 Samoa 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
Smoothing constants	
Alpha (α) for data	0.900
Beta (β) for trend	0.100
Forecast performance measures	
Mean Absolute Error (MAE)	4.154257
Sum Square Error (SSE)	1947.606160
Mean Square Error (MSE)	49.938619
Mean Percentage Error (MPE)	0.195520
Mean Absolute Percentage Error (MAPE)	3.527222



Residual Analysis for the Applied Model

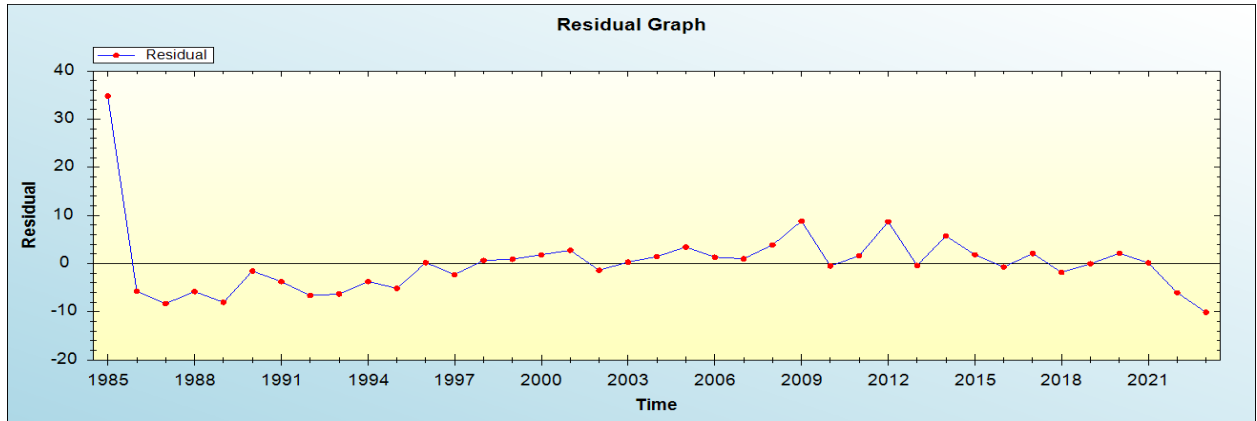


Figure 1: Residual analysis

In-sample Forecast for A

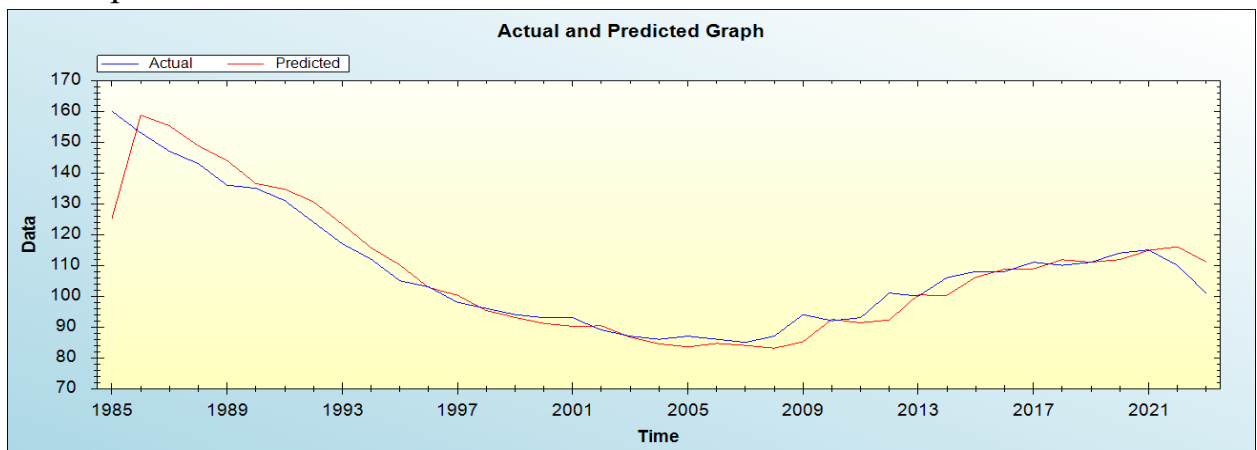


Figure 2: In-sample forecast for the A series

Actual and Smoothed graph for A series

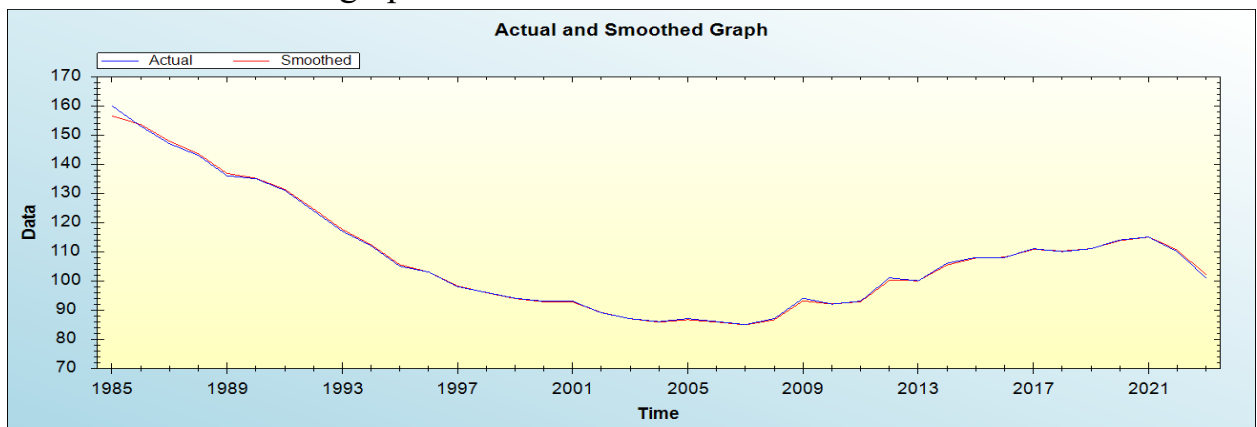


Figure 3: Actual and smoothed graph for A series



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

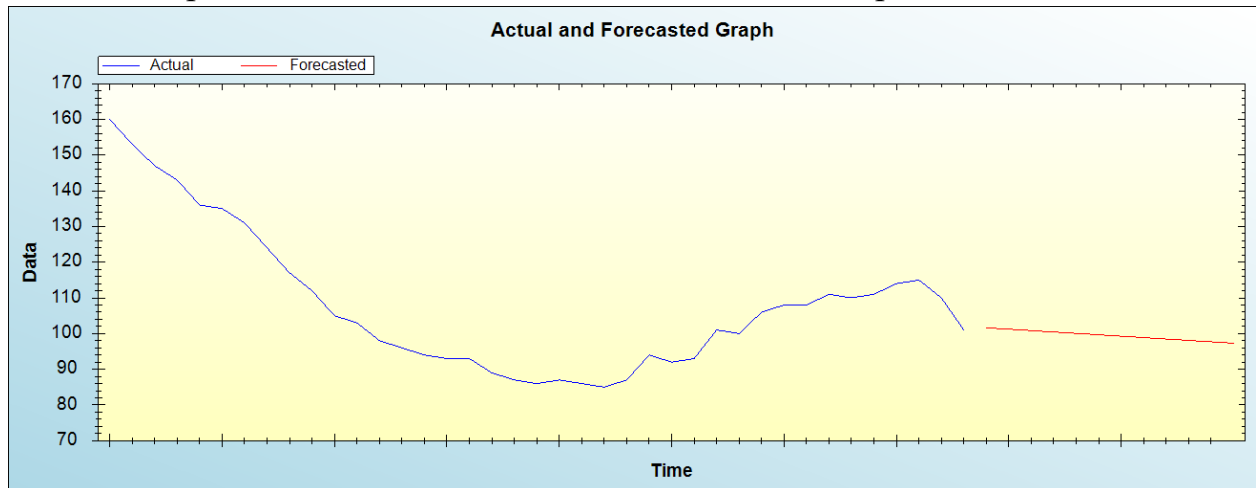


Figure 4: Out-of-sample forecast for A: actual and forecasted graph

Out-of-Sample Forecast for A: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Year	Forecasted MMR
2024	101.6199
2025	101.2275
2026	100.8351
2027	100.4427
2028	100.0503
2029	99.6579
2030	99.2655
2031	98.8731
2032	98.4807
2033	98.0883
2034	97.6959
2035	97.3035

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 hover around 100 deaths per 100 000 live births over the out of sample period.



Recommendations & Conclusion

In this study we demonstrated the application of the double exponential smoothing technique to model and forecast MMR for Samoa and findings suggest that MMR will hover around 100 deaths per 100 000 live births over the out of sample period. Hence, we implore authorities to continue addressing local causes of maternal deaths and direct more resources towards implementation of quality improvement strategies.

References

1. WHO (2023). Trends in maternal mortality 2000 to 2020: estimates by Who, UNICEF, Unfpa, World Bank Group and UNDESA/Population Division. Geneva: World Health Organization; 2023. Licence: CCBY-NC SA3.0IGO.
2. WHO (2020). Maternal Mortality. Available: <https://www.who.int/news-room/fact-sheets/detail/Maternal-mortality>.
3. WBG (2023). Maternal mortality ratio (modeled estimate, per 100,000 live births) 2023. World Bank Open Data. Available: <https://data.worldbank.org>
4. Khan K.S., Wojdyla D., Say L., Gülmezoglu A.M. and Van Look P.F (2006). WHO analysis of causes of maternal death: a systematic review. The lancet, 367(9516), pp.1066-1074.
5. Campbell O.M., Graham W.J and Lancet Maternal Survival Series steering group (2006). Strategies for reducing maternal mortality: getting on with what works. The lancet, 368(9543), pp.1284-1299.
6. Li X.F., Fortney J.A., Kotelchuck M. and Glover, L.H (1996). The postpartum period: the key to maternal mortality. International Journal of Gynecology & Obstetrics, 54(1), pp.1-10.
7. WHO (2024). SAMOA Health at a glance.