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PROJECTION OF MATERNAL MORTALITY FOR CUBA USING THE SINGLE EXPONENTIAL SMOOTHING MODEL

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Abstract
This study uses annual time series data on MMR for Cuba from 1985 to 2023 to predict future trends of MMR over the period 2024 to 2035. The study utilizes single exponential smoothing model. The optimal value of the smoothing constants α is 0.1 based on minimum MSE. The results of the study indicate that MMR will hover around 53 deaths per 100 000 live births over the out of sample period. Therefore, we encourage authorities to address local causes of preventable maternal deaths and continue routine surveillance of severe maternal morbidities.

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

Introduction

Since the 1959 revolution, Cuba has made tremendous achievements in the health sector. It has one of the highest physician densities worldwide, with 8.4 doctors per 1,000 population compared to just 2.6 in the US, 3.3 in France, 0.2 in sub-Saharan Africa, and 1.2 globally (World Bank, n.d). This success story was due to the expansion of medical education and neighborhood-based primary care teams who provide continuous preventive care and education. According to the World Health Organization, Infectious diseases dominated pre-revolution period, but now non-communicable diseases (NCDs) are the leading cause of mortality accounting for 84% of Cuban deaths, indicating an epidemiological transition (WHO, 2018). As a result, the Cuban government changed its focus towards addressing morbidity related to NCDs. The response was characterized by enhanced community based NCD screening, prevention, and management. Cuba has also made significant strides in controlling maternal and child mortality. World Bank data showed that in 2019, Cuba reported an under-5 mortality rate of 5.5 per 1,000 live births and a maternal mortality ratio of 36 per 100,000 live births, outperforming many Latin American and Caribbean nations. The objective of this paper is to model and forecast MMR for Cuba using the single exponential smoothing model. The results of this paper will inform policy and allocation of resources to the health sector.

Literature Review

Author(s)	Objective(s)	Methodology	Key finding(s)
Mackin et al. (2026)	to understand how levels of MNH care are organized	Scoping review	Three or four levels of MNH facility care were most

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	in different country contexts		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

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			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

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			Caribbean. These variations highlight the importance of strengthening maternal health systems, improving access to skilled birth attendance, and ensuring quality prenatal and postnatal care
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 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

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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)
Fernández González et al. (2021)	to describe the behavior of the maternal deaths burden due to direct causes in Cuba, between 2005 and 2018	descriptive study of annual series, cross-sectional. The universe was the total of direct maternal deaths (N = 463). The mortality ratio, years of life potentially lost due to mortality, the trend, the percentage and the average were calculated	the causes with the greatest impact on life expectancy were complications related to the puerperium, other hemorrhages and ectopic pregnancy; but the women who died at younger ages were from abortion and puerperal infection. Puerperal infections, placental disorders, and other complications

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			tended to increase over time
Santana Espinosa et al. (2018)	To describe the Cuban experience in the National Maternal–Child Health Program, as well as its main achievements, challenges, and lessons learned		Among the most relevant results up to 2015 are the reduction of infant mortality rate and under-five mortality rate to 4.3 and 5.7 deaths per 1000 live births, more than 10 prenatal check-ups per delivery; 5.3% of low birth weight; 99.9% of institutional births; and being the first country to validate the elimination of and to reduce maternal mortality, adolescent fertility rate, and voluntary abortion.
Bragg et al. (2012)	To assess maternal and child healthcare in Cuba, details the system of community-based regional maternity homes, and outlines specific recommendations for the US	Based on observations during a visit to Cuba, and supplemental research on international health expenditures and health indicators	Cuba utilizes community-based regional maternity homes to provide comprehensive care for women with high-risk pregnancies. This effective

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		such as infant and maternal mortality, this paper details maternal and child health in Cuba	strategy of investing in maternal health by safeguarding pregnancies has lowered infant and maternal mortality rates significantly

Methodology

This study utilizes an exponential smoothing technique to model and forecast future trends of MMR for Cuba. 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 single exponential smoothing technique because it is an appropriate technique for modeling data without a trend and seasonal pattern

The simple exponential smoothing model is specified as follows;

$Y(t)=\beta(t)+\varepsilon(t)$

Where $\beta(t)$ is a constant at time t, $\varepsilon(t)$ is a stochastic error term

Y(t) is the actual value of the time series variable at time t

The forecast equation is then expressed as follows:

$$F_{t+1}= \alpha Y_t + (1-\alpha) F_t$$

Where F_t is the forecast value of variable Y at time t

F_{t+1} is the forecast value of variable Y at time t+1

α is the smoothing constant

Data Issues

This study is based on annual MMR in Cuba 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	Y

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Included Observations	39
Smoothing constant	
Alpha (α)	0.100
Forecast performance measures	
Mean Absolute Error (MAE)	10.659161
Sum Square Error (SSE)	19523.984463
Mean Square Error (MSE)	500.614986
Mean Percentage Error (MPE)	-14.223588
Mean Absolute Percentage Error (MAPE)	18.337851

Residual Analysis for the Applied Model

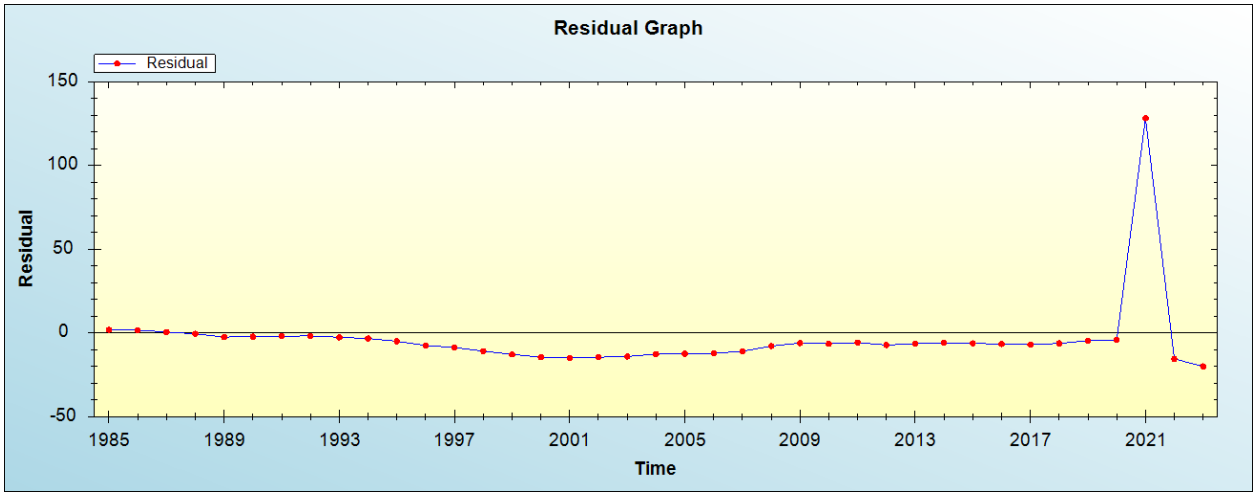


Figure 1: Residual analysis

In-sample Forecast for Y

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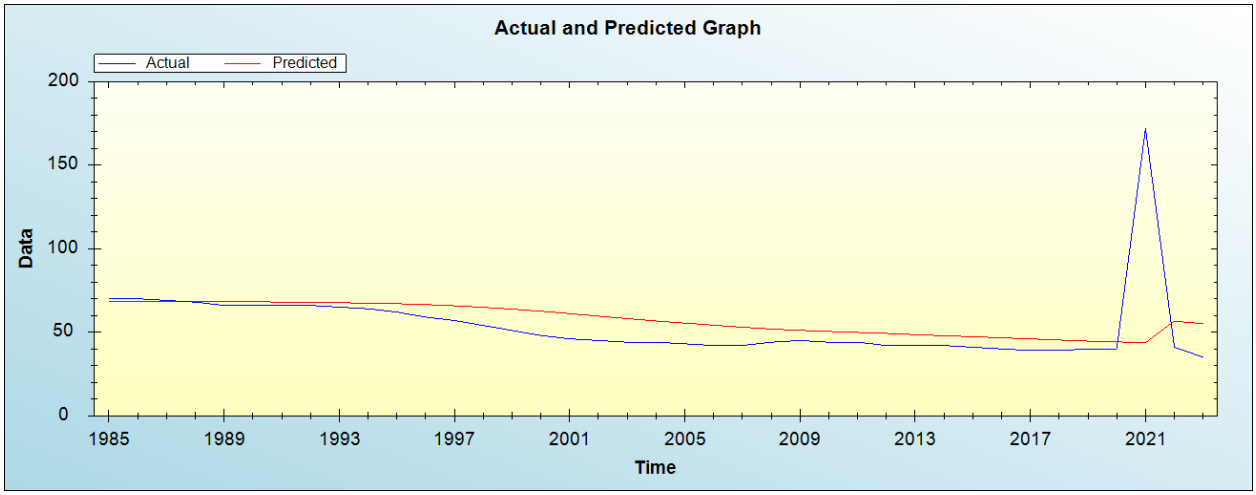


Figure 2: In-sample forecast for the Y series

Actual and Smoothed graph for Y series

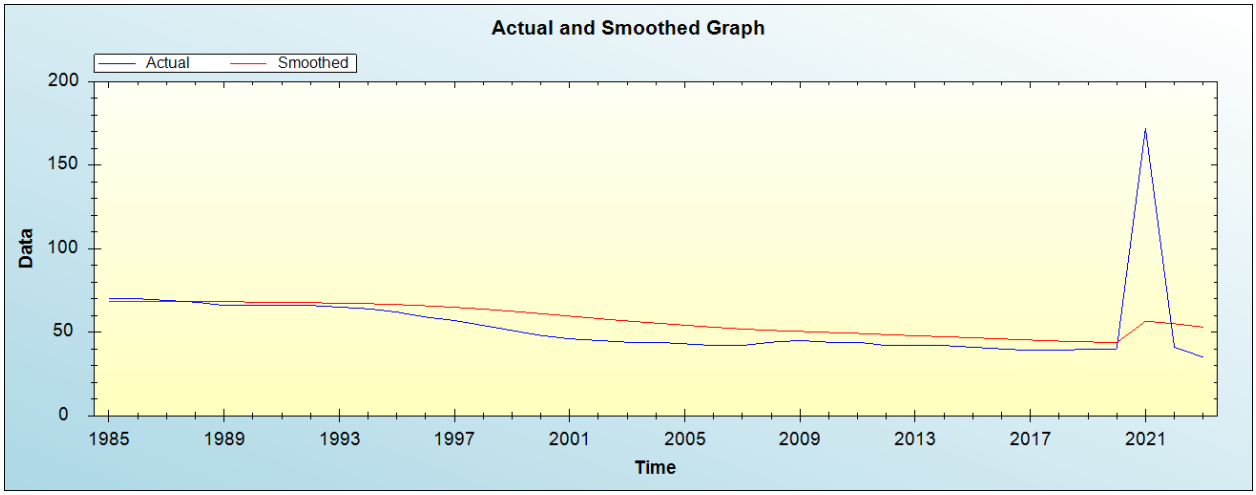


Figure 3: Actual and smoothed graph for Y series

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

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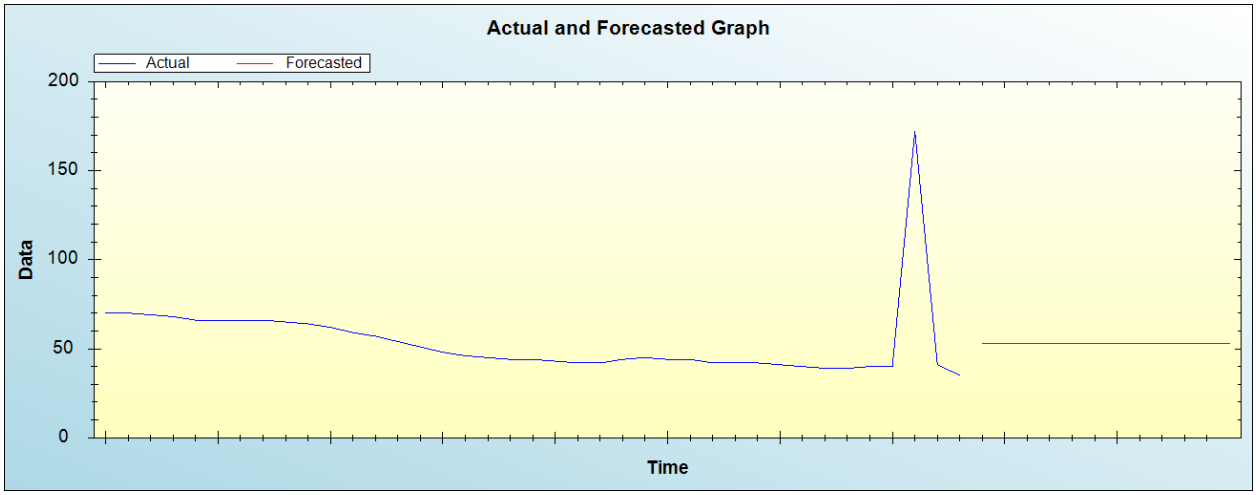


Figure 4: Out-of-sample forecast for Y: actual and forecasted graph

Out-of-Sample Forecast for Y: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Year	Forecasted MMR
2024	53.0345
2025	53.0345
2026	53.0345
2027	53.0345
2028	53.0345
2029	53.0345
2030	53.0345
2031	53.0345
2032	53.0345
2033	53.0345
2034	53.0345
2035	53.0345

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

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Conclusion

This study uses the single exponential smoothing method to forecast MMR for Cuba and results indicate that MMR will hover around 53 deaths per 100 000 live births over the out of sample period. Therefore, we encourage health authorities to address local causes of maternal deaths and improve on surveillance of severe maternal morbidities.

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