

# Forecasting Future Trends of Under Five Mortality Rate for Lebanon Using Double Exponential Smoothing

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**Abstract - This study uses annual time series data on under five mortality rate (U5MR) for Lebanon from 1960 to 2020 to predict future trends of U5MR over the period 2021 to 2030. Residuals and forecast evaluation criteria indicate that the applied model is stable in forecasting U5MR. Holt's linear exponential smoothing model was applied to project U5MR. The optimal values of smoothing constants  $\alpha$  and  $\beta$  are 0.9 and 0.4 respectively based on minimum MSE. The results of the study indicate that annual U5MR will continue to fall throughout the out of sample period. Therefore, we encourage the health authorities in Lebanon to address all the health challenges that significantly contribute to under five mortality.**

**Keywords:** Exponential smoothing, Forecasting, U5MR

## I. INTRODUCTION

Many countries around the globe are experiencing the effects of climate change such as drought, hunger, flooding and extreme weather conditions. The economic collapse and growing unemployment poses a threat to humanity (UN, 2016; UN, 2015). The global health challenges are increasing at an alarming rate raising concerns over the capability of all UN member states to solve these problems due to dwindling funds, shortage of staff and co-existence of other challenges such as wars, inequalities, poor governance and poor infrastructure. The United Nations' 3<sup>rd</sup> sustainable development goal (SDG3) was designed to solve all major health problems without discrimination. The health section of the global action plan is top political priority and therefore deserves all partners to unite and encourage a collaborative approach. The death of pregnant mothers and under five children must not be allowed to continue unchecked. Ensuring good health and promotion of well-being for all at all stages is the focus of SDG 3 (UN, 2020; UNICEF, 2019; WHO, 2019; UNICEF, 2018). In line with agenda 2030 for sustainable development, this study applies the Holt's linear exponential smoothing method to model and forecast future trends of under-five mortality rate for Lebanon. The results are expected to help in planning and allocation of resources in order to end all avoidable under five deaths in the country.

## II. LITERATURE REVIEW

Schuermans *et al.* (2021) conducted a retrospective cohort study in Haiti to determine the prevalence of maternal death, stillbirth and low birth weight in women with (pre-) eclampsia and complicated pregnancies or deliveries in Centre de Références des Urgences Obstétricales, an obstetric emergency hospital in Port-au-Prince, Haiti, and identified the main risk factors for these adverse pregnancy outcomes. The study included pregnant women admitted to Centre de Référence des Urgences Obstétricales between 2013 and 2018 using hospital records. Risk factors investigated were age group, type of pregnancy (singleton, multiple), type of delivery and use of antenatal care services. The findings showed that of all admissions, 10 991 (34.9%) were women with (pre-) eclampsia and the main predictors of adverse pregnancy outcomes were not attending antenatal care, low birth weight and caesarian section in patients with complicated pregnancy. A prospective, population-based observational study was carried out by Aziz *et al.* (2020) to compare pregnancy outcomes in Pakistan to other low-resource countries and explore factors that might help explain these differences. The research included all pregnant women and their pregnancy outcomes in defined geographic communities in six low-middle income countries (India, Pakistan, Democratic Republic of Congo, Guatemala, Kenya, and Zambia). Study staff enrolled women in early pregnancy and followed them up soon after delivery and at 42 days to ascertain delivery, neonatal, and maternal outcomes. The Pakistani pregnancy outcomes were found to be much worse than those in the other GN sites. Reasons for these poorer outcomes likely include that the Pakistani sites' reproductive-aged women are largely poorly educated, under-nourished, anemic, and deliver a high percentage of preterm and low-birth weight babies in settings of often inadequate maternal and newborn care. Nath *et al.* (2020) examined the effect of extreme prematurity and early neonatal deaths on infant mortality rates in England. Authors used aggregate data on all live births, stillbirths and linked infant deaths in England in 2006–2016 from the Office for National Statistics. Infant mortality decreased from 4.78 deaths/1000 live births in 2006 to 3.54/1000 in 2014 (annual decrease of 0.15/1000) and increased to 3.67/1000 in 2016 (annual increase of 0.07/1000). This rise was driven by increases in deaths at 0–6 days of life. Gage & Bauhoff (2020) assessed the impact of PBF on early neonatal health outcomes and associated health care utilization and quality in Burundi, Lesotho, Senegal, Zambia and Zimbabwe. Authors utilized data from Demographic and Health Surveys and Multiple Indicator Cluster Surveys and applied difference-in-differences analysis to estimate the effect of PBF projects supported by the World Bank on early neonatal mortality and low birth weight and

concluded that PBF had no impact on early neonatal health outcomes in the five African countries studied and had limited and variable effects on the utilization and quality of neonatal health care.

### III. METHODOLOGY

This study utilizes an exponential smoothing technique to model and forecast future trends of under-five mortality rate in Lebanon. 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.

$$N_t = \mu_t + b_t t + \varepsilon_t$$

Smoothing equation

$$L_t = \alpha N_t + (1-\alpha)(L_{t-1} + b_{t-1})$$

Trend estimation equation

$$T_t = \beta (L_t - L_{t-1}) + (1-\beta)b_{t-1}$$

Forecasting equation

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

$N_t$  is the actual value of time series at time t

$L_t$  is the exponentially smoothed value of time series at time t

$\alpha$  is the exponential smoothing constant for the data

$\beta$  is the smoothing constant for trend

$f_{t+h}$  is the h step ahead forecast

$T_t$  is the trend estimate

#### Data Issues

This study is based on annual under five mortality rate in Lebanon for the period 1960 – 2020. The out-of-sample forecast covers the period 2021 – 2030. All the data employed in this research paper was gathered from the World Bank online database.

### IV. FINDINGS OF THE STUDY

#### Exponential smoothing Model Summary

Table 1: ES model summary

Variable	N
Included Observations	61 (After Adjusting Endpoints)
Smoothing constants	
Alpha ( $\alpha$ ) for data	0.900
Beta ( $\beta$ ) for trend	0.400
Forecast performance measures	
Mean Absolute Error (MAE)	0.262147
Sum Square Error (SSE)	14.537141
Mean Square Error (MSE)	0.238314
Mean Percentage Error (MPE)	0.483616
Mean Absolute Percentage Error (MAPE)	0.857638

Residual Analysis for the Applied Model

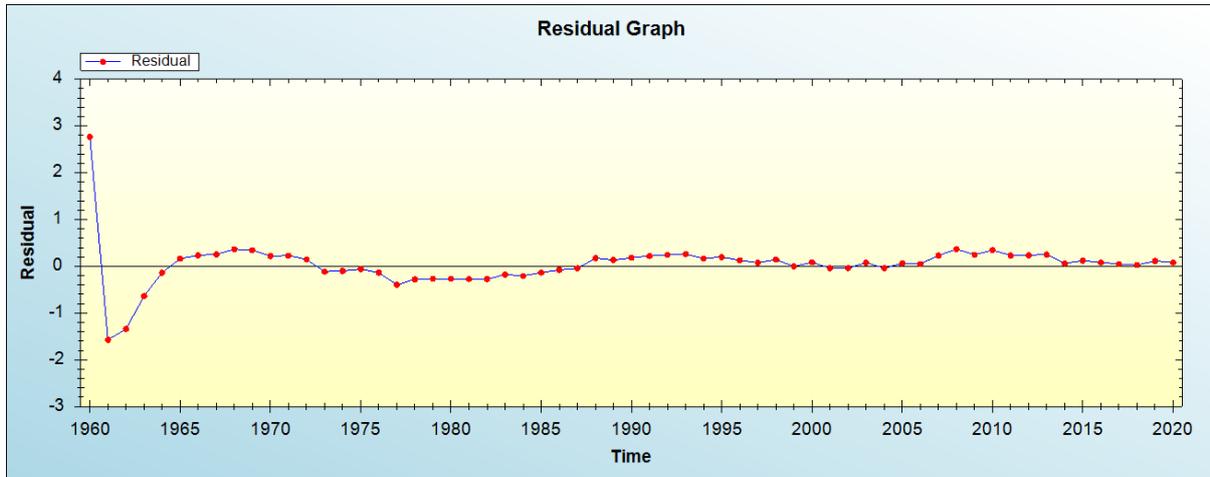


Figure 1: Residual analysis

In-sample Forecast for N

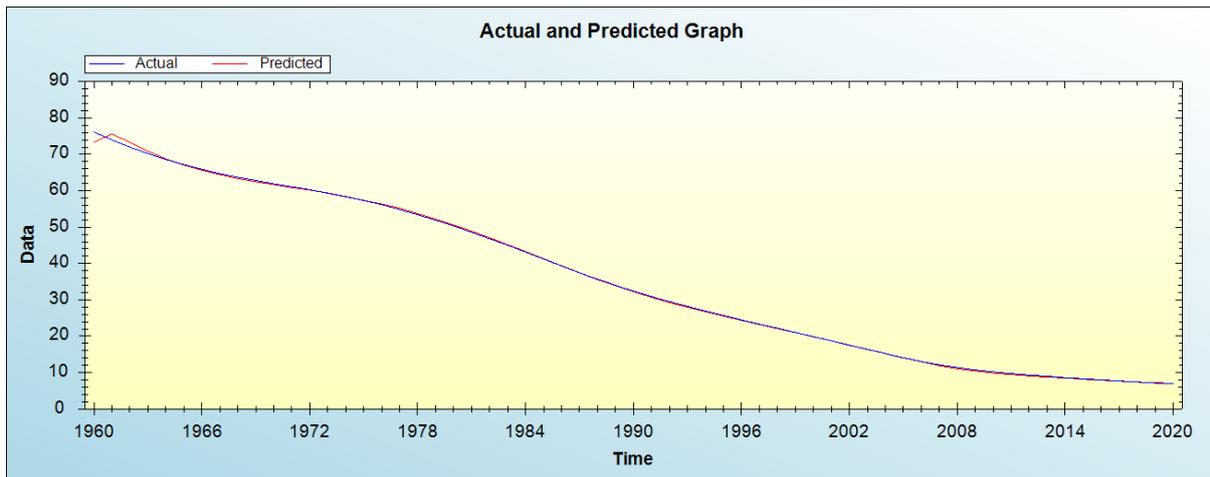


Figure 2: In-sample forecast for the N series

Actual and smoothed graph for N

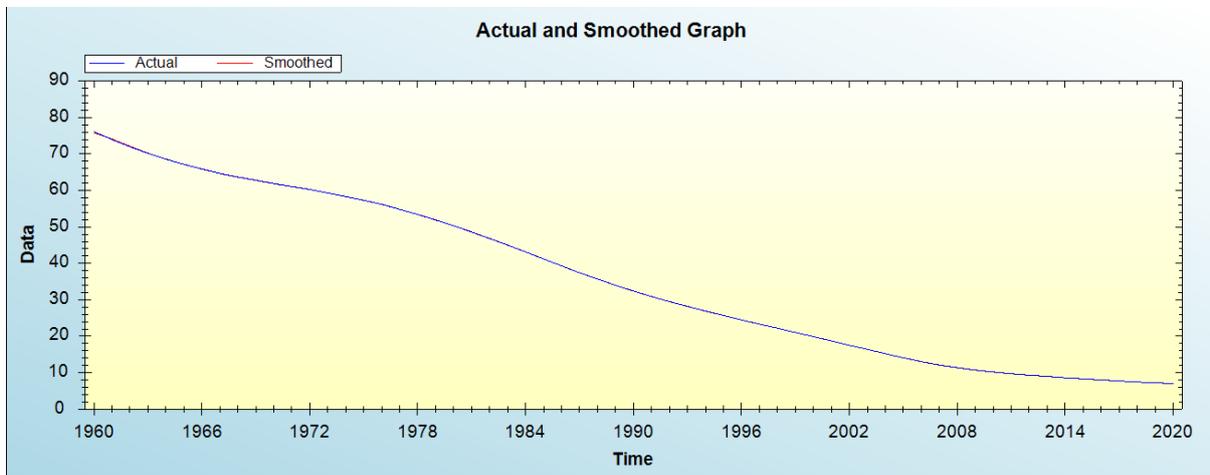


Figure 3: Actual and smoothed graph for N

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

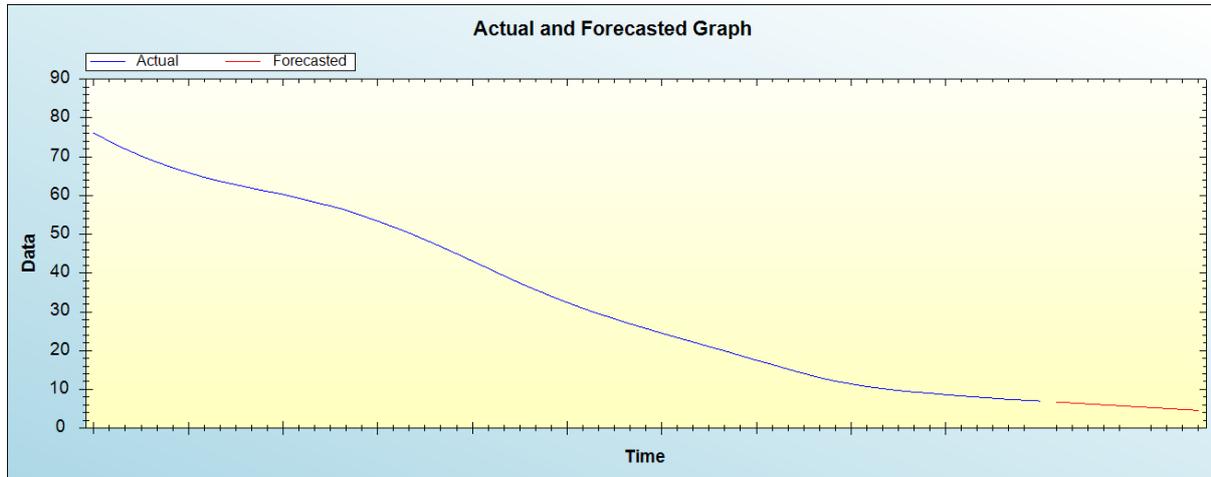


Figure 4: Out-of-sample forecast for N: actual and forecasted graph

Out-of-Sample Forecast for N: Forecasts only

Table 2: Tabulated out-of-sample forecasts

2021	6.7502
2022	6.5086
2023	6.2671
2024	6.0255
2025	5.7840
2026	5.5425
2027	5.3009
2028	5.0594
2029	4.8179
2030	4.5763

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 U5MR will continue to fall throughout the out of sample period.

### V. POLICY IMPLICATION & CONCLUSION

Lebanon is currently facing serious challenges that negatively impact on population health. The government is committed to solving all these challenges as agreed at the UN general assembly in September 2015 where the agenda 2030 for sustainable development was drafted. The country reported a downward trend of under-five mortality rate over the past decades. This study applied Holt’s linear method to project future trends of under-five mortality rate in Lebanon and the results of the study indicated that annual U5MR will continue to fall throughout the out of sample period. Therefore, we encourage the health authorities in Lebanon to address all the challenges that significantly contribute to under five mortality.

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