

Tracking the Future Path of Under Five Mortality Rate for Congo Using Double Exponential Smoothing Model

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Abstract - This study uses annual time series data on under five mortality rate (U5MR) for Congo from 1960 to 2020 to predict future trends of U5MR over the period 2021 to 2030. Residuals and model evaluation criteria of the applied model indicate that the model is stable in forecasting U5MR. Holt's linear exponential smoothing model was applied in this study to forecast U5MR for Congo. The optimal values of smoothing constants α and β are 0.9 and 0.3 respectively based on minimum MSE. Model projections indicate that annual U5MR will continue to decline over the out of sample period. Hence, we implore the government to channel more resources to maternal and child health program activities with special attention being given to capacitating healthcare facilities and improving working conditions of healthcare workers particularly in the rural areas.

Keywords: Exponential smoothing, Forecasting, U5MR.

I. INTRODUCTION

Every UN member state made a commitment to implement the 17 objectives of the agenda 2030 for sustainable development (UN, 2016; UN, 2015). By the end of 2030, each country should have managed to address its main problems affecting its citizens. Top of the list should be poverty reduction and solving all health challenges. Maternal, neonatal and under five mortality remains a public health challenge for many developing countries in Sub-Saharan Africa and South Central Asia (Lawn *et al.* 2016). Congo has witnessed fertility transition over the past decades reporting a decline in total fertility rate from 6.3 births per woman in 1975 to 4.5 births per woman in 2020 (Worldometer, 2020). The country recorded a downward trend of Infant and under five mortality over the past decades. IMR declined from 134 infant deaths per 1000 live births in 1950 to 31 infant deaths per 1000 live births in 2020 (Worldometer, 2020). By the end of 2030, the country is expected to have reduced under five mortality to as low as 25 deaths per 1000 live births (UN, 2020; UNICEF, 2019; WHO, 2019; UNICEF, 2018). The aim of this study is to forecast future trends of under-five mortality rate for Congo using double exponential smoothing (Holt). The findings of this study will guide child health policies, planning and allocation of resources in order to end all avoidable deaths among under five children.

II. LITERATURE REVIEW

Garcia *et al.* (2020) described changes over time in the use of childbirth care in Egypt, focusing on location and sector of provision (public versus private) and the content of immediate postpartum care. The authors used five Demographic and Health Surveys conducted in Egypt between 1995 and 2014 to explore national and regional trends in childbirth care. The study findings suggested that Egypt achieved large increases in the percentage of women delivering in facilities and with skilled birth attendants. However, most women and newborns did not receive essential elements of high quality immediate postpartum care. 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. Another study by Masaba & Phetoe (2020) described the trends of neonatal mortality within the two sub-Saharan countries. The study concluded that in 2018, the neonatal mortality rate for Kenya was 19.6 deaths per 1000 live births. The neonatal mortality rate had fallen gradually from 35.4 deaths per 1000 live births in 1975. On the other hand, South Africa had its neonatal mortality rate fall from 27.9 deaths per 1000 live births in 1975 to 10.7 deaths per 1000 live births in 2018. Iriondo *et al.* (2020) developed and validated different mortality predictive models, using Spanish data, to be applicable to centers with similar morbidity and mortality. Infants born alive, admitted in NICU, and registered in the SEN1500 database, were included. Multivariable regression models were used for the different time periods. The study revealed that using dynamic models to predict individual mortality can improve outcome estimations. Development of models in the prenatal period, first 24 hours, and during hospital admission, cover key stages of mortality prediction in preterm infants.

III. METHODOLOGY

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

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

Smoothing equation

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

Trend estimation equation

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

Forecasting equation

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

V_t is the actual value of time series at time t

L_t is the exponentially smoothed value of time series 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

T_t is the trend estimate

Data Issues

This study is based on annual under five mortality rate in Congo 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	V
Included Observations	61 (After Adjusting Endpoints)
Smoothing constants	
Alpha (α) for data	0.900
Beta (β) for trend	0.300
Forecast performance measures	
Mean Absolute Error (MAE)	2.717000
Sum Square Error (SSE)	1821.312273
Mean Square Error (MSE)	29.857578
Mean Percentage Error (MPE)	0.148601
Mean Absolute Percentage Error (MAPE)	2.549217

Residual Analysis for the Applied Model

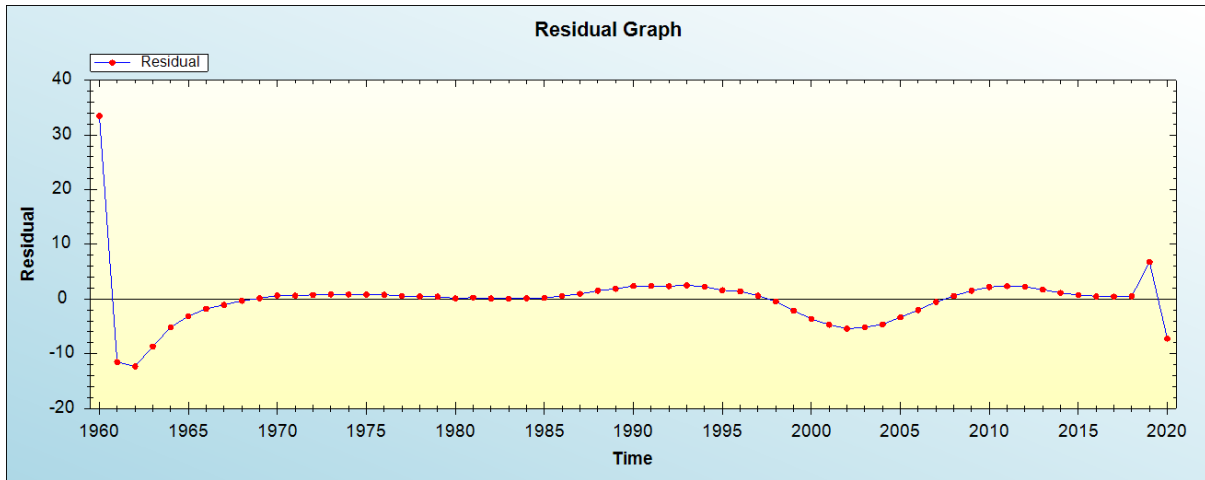


Figure 1: Residual analysis

In-sample Forecast for V

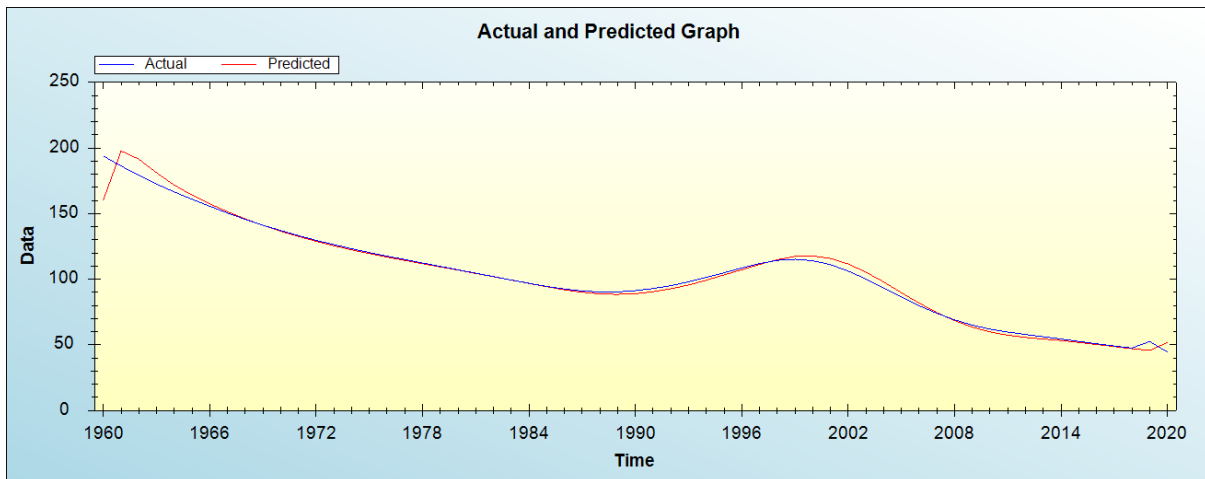


Figure 2: In-sample forecast for the V series

Actual and Smoothed Graph for V series

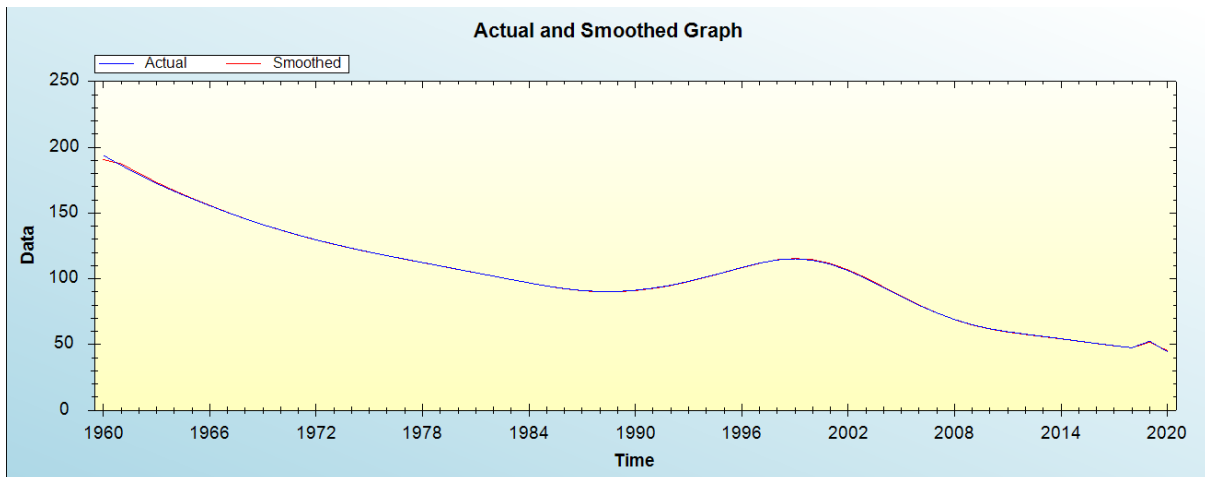


Figure 3: Actual and smoothed V series

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

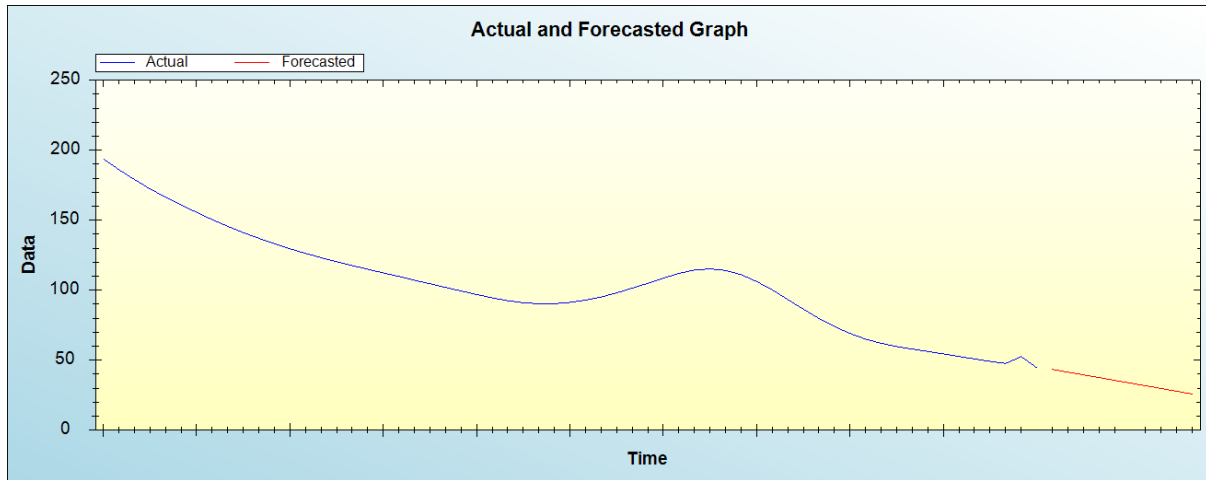


Figure 4: Out-of-sample forecast for V: actual and forecasted graph

Out-of-Sample Forecast for V: Forecasts only

Table 2: Tabulated out-of-sample forecasts

2021	43.3697
2022	41.4176
2023	39.4655
2024	37.5135
2025	35.5614
2026	33.6093
2027	31.6572
2028	29.7051
2029	27.7530
2030	25.8009

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 decline over the out of sample period.

V. POLICY IMPLICATION & CONCLUSION

Sustainable development goals (SDGs) were designed to facilitate the process of solving all the major problems affecting people around the world. Robust measures must be put in place by all UN member states to curb under five mortality. The root causes of mortality among under five children must be identified and quickly addressed to alleviate suffering and death. This study utilizes the Holt’s linear exponential smoothing method to predict under five mortality in Congo. The results of the study indicate that annual U5MR will continue to decline over the out of sample period. Therefore, we encourage health authorities in Congo to allocate more resources to the maternal and child health (MNCH) program with special attention being given to capacitating healthcare facilities and improving working conditions for healthcare workers particularly in the rural areas.

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