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Analysis of Under Five Mortality Rate for Sub-Saharan Africa Using the Holt's Linear Method

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***Abstract* - This study uses annual time series data on under five mortality rate (U5MR) in Sub-Saharan Africa (SSA) from 1990 to 2020 to predict future trends of U5MR over the period 2021 to 2030. Residuals and forecast evaluation criteria indicate that the applied Holt's linear exponential smoothing model is stable in forecasting U5MR.Optimal values of smoothing constants α and β are 0.9 and 0.4 respectively based on minimum MSE. Forecast results revealed that annual U5MR will continue to decline over the out of sample period. Therefore, we encourage authorities in Sub-Saharan Africa to allocate more resources to maternal and child health programs to ensure availability of medical supplies and healthcare professionals at all levels of healthcare. There is need to identify and address factors that significantly contribute to mortality among under five children.**

Keywords: Exponential smoothing, Forecasting, U5MR.

I. INTRODUCTION

Under five mortality remains a public health problem especially in developing countries (UNICEF, 2018; Basu & Mckeey, 2010). The era of sustainable development goals (SDGs) has created an opportunity for Sub-Saharan Africa and South Asia to address this problem (UN, 2016; UN, 2015). Low and middle income countries are expected to incorporate sustainable development goals into their national plans and Budgets. They should utilize available resources to address all health challenges in their countries. Tracking progress on SDGs will facilitate policy formation, planning and allocation of resources (UN, 2020; UNICEF, 2019; WHO, 2019; UNICEF, 2018). In line with the agenda 2030 for sustainable development, this study applies the Holt's linear exponential smoothing technique to forecast future trends of under-five mortality in Sub-Saharan Africa. The findings will guide regional policies and resource mobilization so as to end all preventable under five deaths by 2030.

II. LITERATURE REVIEW

Duration modelling was utilized by Tiruneh *et al.* (2021) to assess the pooled estimate of infant mortality rate (IMR), time to death, and its associated factors in SSA using the recent demographic and health survey dataset between 2010 and 2018. The study concluded that the most common cause of infant death is a preventable bio-demographic factor. Juarez *et al.* (2020) conducted a quality improvement study to increase the detection of neonatal complications by lay midwives in rural Guatemala, thereby increasing referrals to a higher level of care. A quality improvement team in Guatemala reviewed drivers of neonatal health services provided by lay midwives. Improvement interventions included training on neonatal warning signs, optimized mobile health technology to standardize assessments and financial incentives for providers. The primary quality outcome was the rate of neonatal referral to a higher level of care. It was found that structured improvement interventions, including mobile health decision support and financial incentives, significantly increased the detection of neonatal complications and referral of neonates to higher levels of care by lay midwives operating in rural home-based settings in Guatemala.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.Yet a similar study by Gayawan *et al*. (2016) examined the residual geographical variations in infant and child mortality and how the different categories of the risk factors account for the spatial inequality in West African countries. The study pooled data for 10 of the countries extracted from Demographic and Health Surveys and used the spatial extension of discrete-time survival model to examine how the variables exert influence on infant and child mortality across space. Inference was Bayesian based on the computational efficient MCMC technique. They found different geographical patterns for infant and child mortality. In the case of children under five,

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demographic factors inherent to the mother and child as well as maternal status variables when explained away a good part of the huge variations observed in the crude rates.

III. METHODOLOGY

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

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

Smoothing equation

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

Trend estimation equation

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

Forecasting equation

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

G_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 Sub-Saharan Africa for the period 1990 – 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	G
Included Observations	31 (After Adjusting Endpoints)
Smoothing constants	
Alpha (α) for data	0.900
Beta (β) for trend	0.400
Forecast performance measures	
Mean Absolute Error (MAE)	1.236110
Sum Square Error (SSE)	116.446438
Mean Square Error (MSE)	3.756337
Mean Percentage Error (MPE)	0.191601

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Mean Absolute Percentage Error (MAPE)	0.858780

Residual Analysis for the Applied Model

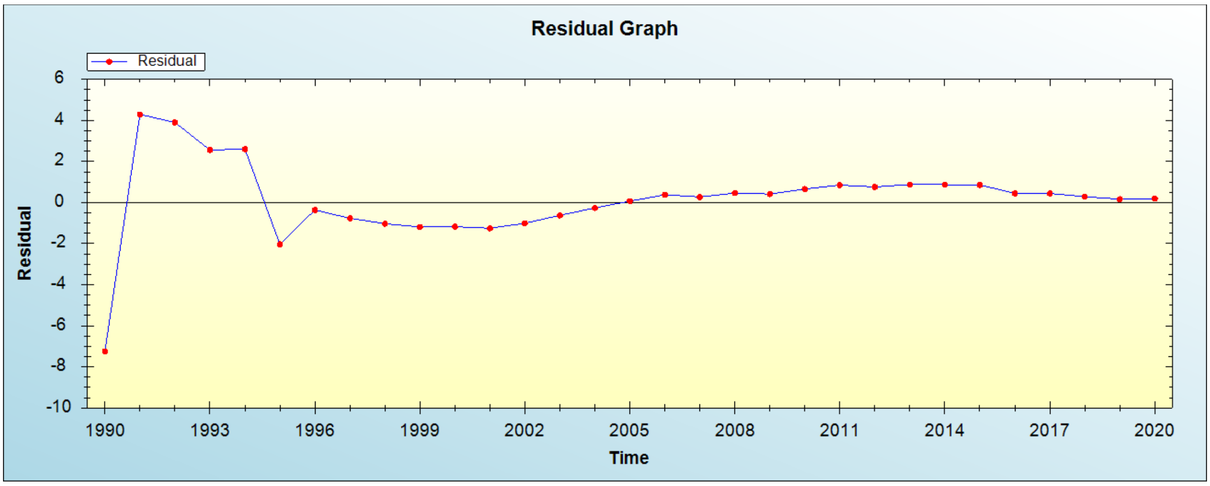

Figure 1: Residual analysis

In-sample Forecast for G

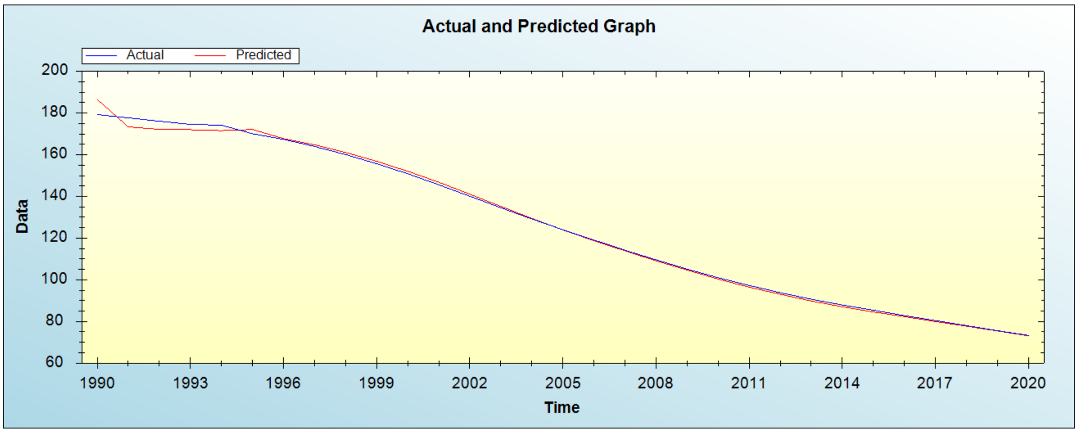

Figure 2: In-sample forecast for the G series

Actual and Smoothed graph for G series

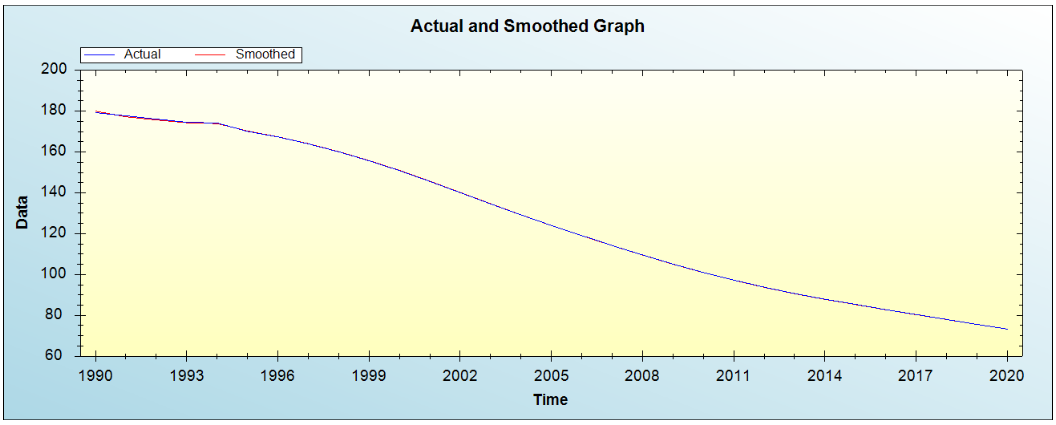

Figure 3: actual and smoothed graph for G series

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

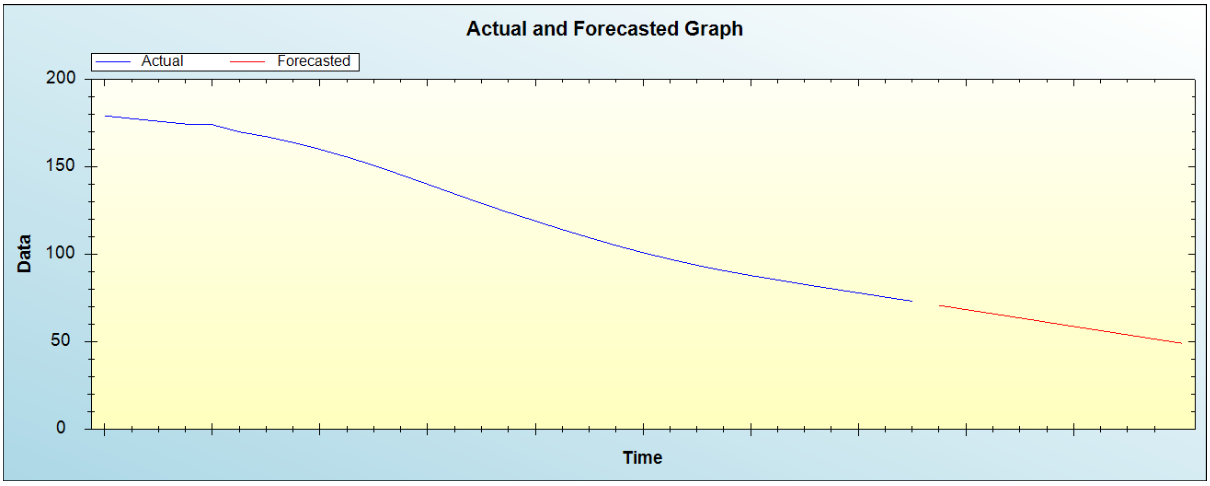

Figure 4: Out-of-sample forecast for G: actual and forecasted graph

Out-of-Sample Forecast for G: Forecasts only

Table 2: Tabulated out-of-sample forecasts

2021	70.8726
2022	68.4647
2023	66.0568
2024	63.6489
2025	61.2410
2026	58.8331
2027	56.4252
2028	54.0173
2029	51.6094
2030	49.2014

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

Under five mortality has declined over the decades across the globe as a result effective health interventions that are being implemented. Sub-Saharan Africa and Asia bear the greatest part of the burden. There are numerous challenges that affect the success of the maternal and child health (MNCH) program such as shortage of healthcare workers, long distances to medical facilities, and dilapidated health infrastructure. This study applied the Holt's linear method to predict future trends of under-five mortality rate in Sub-Saharan Africa (SSA).Forecast results indicate thatannual U5MR will continue to decline over the out of sample period. Therefore, we encourage authorities in SSA to allocate more resources to the maternal and child health programs to ensure availability of medical supplies and healthcare professionals.

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