Estimation of Under Five Mortality Rate for Carbo Verde Using Double Exponential Smoothing Model

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Abstract - **This study uses annual time series data on under five mortality rate (U5MR) for Carbo Verde 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 under five mortality. The Holt's linear exponential smoothing model was applied in this study. The optimal values of smoothing constants α and β are 0.9and 0.5 respectively based on minimum MSE. The study findings revealed that annual U5MR will continue to decline over the out of sample period. Therefore, we encourage authorities in Carbo Verde to continue providing resources to the maternal and child health programs to ensure adequate medical staff and medical supplies at all levels of the health delivery system.**

Keywords: Exponential smoothing, Forecasting, U5MR.

I. INTRODUCTION

The 3rd sustainable development goal (SDG-3) focuses on ensuring healthy lives and promotion of well-being for all at all at every stage of life (UN, 2020; UNICEF, 2019; WHO, 2019; UNICEF, 2018; UN, 2016; UN, 2015). Its mandate is to solve various health challenges which include sexual and reproductive health. Many adolescent girls and young women continue to have unwanted pregnancies, unsafe abortions and bad obstetric outcomes (WHO, 2014). Several new cases of gender based violence and sexual abuse of adolescent girls and women are being reported during this COVID-19 pandemic (Mittal & Singh, 2020). About 17million adolescent girls give birth each year and most of them are in low and middle income countries (WHO, 2014; Ganchimeg et al, 2014).Sub Saharan Africa and Asia continue to report high absolute numbers of maternal and under five mortality (UNICEF, 2018; Basu & Mckeey, 2010). By the end of 2030 every country should have managed to substantially reduce neonatal and under five mortality to levels as low as 12 neonatal deaths per 1000 live births and 25 under five deaths per 1000 live births (UNICEF, 2019). The study proposes the Holt's linear exponential smoothing model to forecast future trends of under-five mortality rate in Carbo Verde. The study findings are expected to guide child health policy making, planning and allocation of resources to the MNCH program in order to end all preventable under five deaths by 2030.

II. LITERATURE REVIEW

Adjei *et al*. (2021) investigated the effect of community-, household- and individual-level factors on the risk of neonatal mortality in two districts in Ghana. The longitudinal study used the Kintampo Health and Demographic Surveillance System as a platform to select 30,132 neonatal singletons with 634 deaths. Multilevel cox frailty model was used to examine the effect of community-, household- and individual-level factors on the risk of neonatal mortality. The conclusion from the study was that there is risk of neonatal mortality at the individual- and household-levels in the Kintampo Districts. A cross-sectional study carried out by Edem *et al*. (2020) examined the health practices, care-seeking behavior, and referral of sick out-born neonates to a district and regional hospital in the Upper West Region of Ghana. The study findings suggested that socio-cultural factors strongly influence health seeking behavior and the health outcome of neonates in this setting. Sougou & Diouf (2020) conducted a secondary analysis of the 2017 DHS for Senegal to analyze the factors associated with neonatal deaths in Senegal in 2017. The study found out that significant predictors of neonatal mortality were newborns with a low birth weight < 2500 g, newborns who are considered "very small" by their mother at birth and birth by caesarean section. A study done by Damian *et al*. (2019) showed that estimates from both global metrics and institutional reporting, although widely divergent, indicate South Africa has not achieved MDG 4a and 5a goals but made a significant progress in reducing maternal and neonatal mortality. A cross-sectional study was conducted Burundi by Moise (2018) to describe the main causes of hospitalization and mortality in children during the neonatal period and at ages 1 to 59 months, for boys and girls, and to assess the total annual (2010) burden of under-five morbidity and mortality in hospitals using hospitalization records from 21 district hospitals. The study findings indicated that human malarial infections continue to be the main cause of hospitalization and mortality among under-five children in Burundi. Rhoda *et al*. (2018) reviewed estimates of the NMR and etiology of neonatal deaths, and outlined how the mortality from preventable causes of death could be reduced. The study concluded that high-impact interventions, providing an adequate number of appropriately trained healthcare providers and a more active role played by ward-based community health workers and district clinical specialist teams was necessary to curb neonatal deaths.

III. METHODOLOGY

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

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

Smoothing equation

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

Trend estimation equation

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

Forecasting equation

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

H_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 Carbo Verde 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	H
Included Observations	61 (After Adjusting Endpoints)
Smoothing constants	
Alpha (α) for data	0.900
Beta (β) for trend	0.500
Forecast performance measures	
Mean Absolute Error (MAE)	1.416025
Sum Square Error (SSE)	437.110555
Mean Square Error (MSE)	7.165747
Mean Percentage Error (MPE)	0.367920
Mean Absolute Percentage Error (MAPE)	2.005744

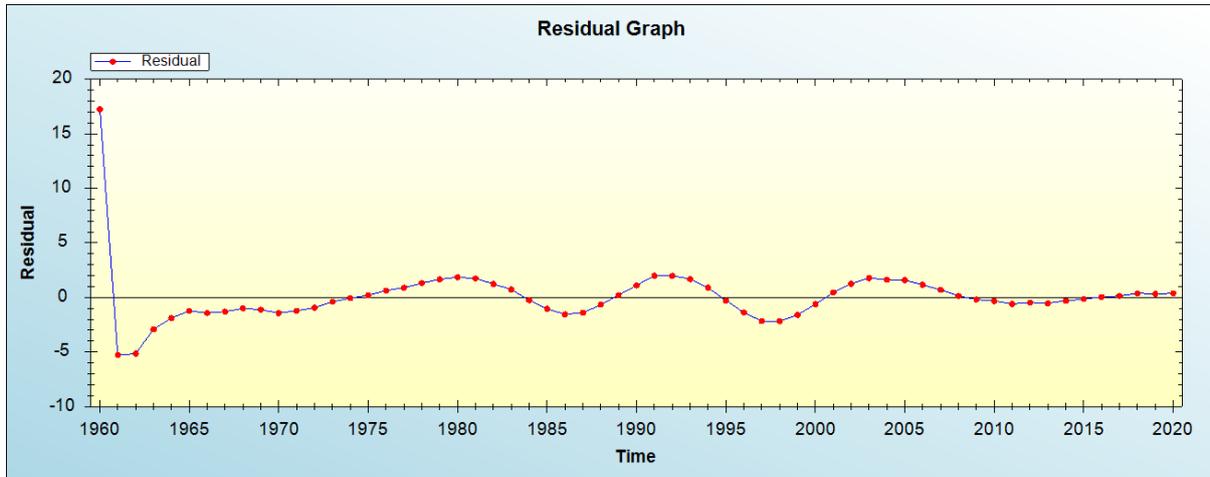Residual Analysis for the Applied Model
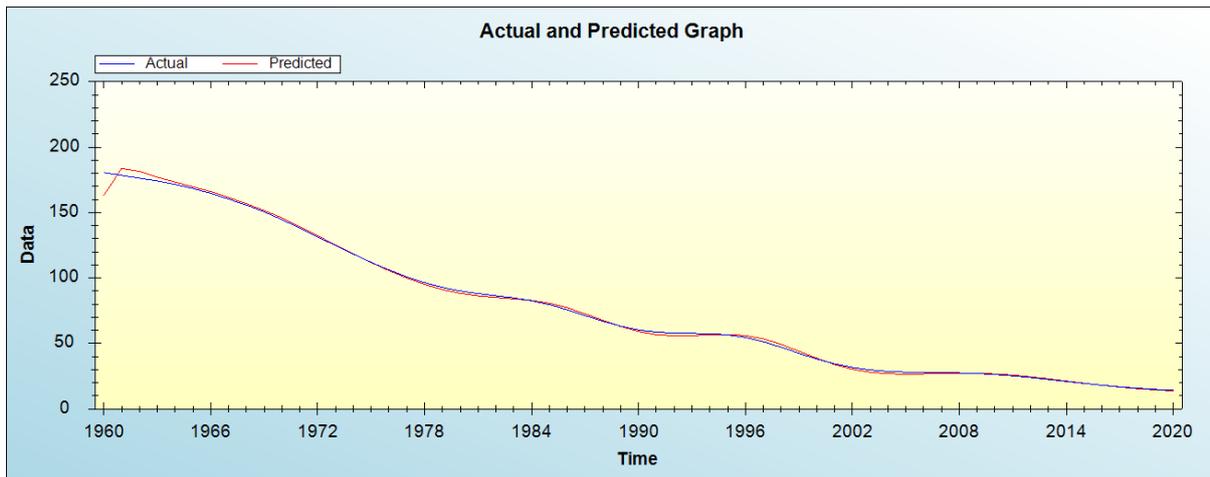

Figure 1: Residual analysis

In-sample Forecast for H

Figure 2: In-sample forecast for the H
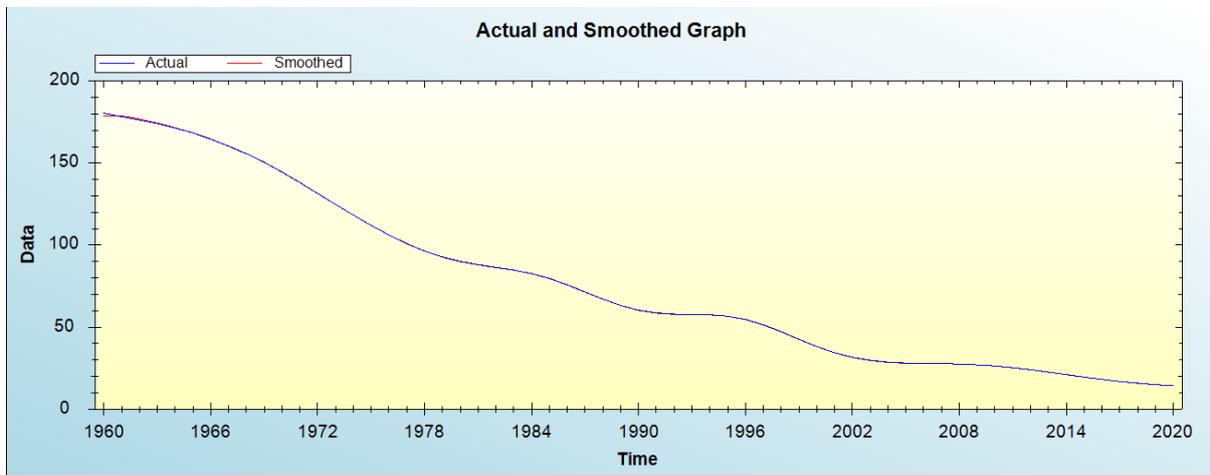
Actual and Smoothed Graph for H

Figure 3: Actual and smoothed graph for H series

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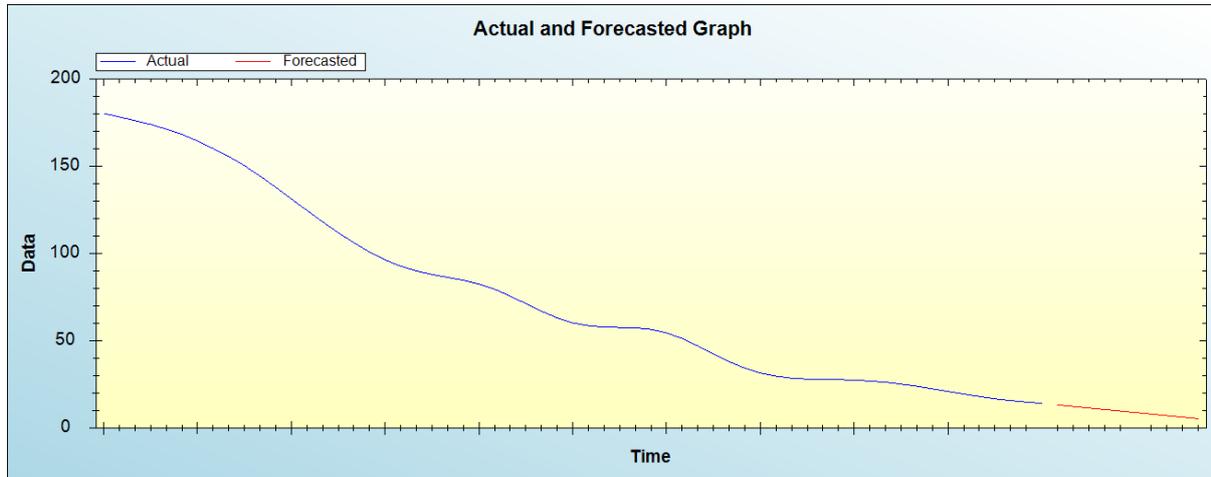Out-of-Sample Forecast for H: Actual and Forecasted Graph

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

Out-of-Sample Forecast for H: Forecasts only

Table 2: Tabulated out-of-sample forecasts

2021	13.2863
2022	12.4108
2023	11.5352
2024	10.6596
2025	9.7840
2026	8.9084
2027	8.0328
2028	7.1572
2029	6.2816
2030	5.4060

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

The 3rd sustainable development goal (SDG3) is a priority especially in developing countries which are facing numerous challenges that include poverty, hunger, climate change effects and civil conflicts. Under five mortality will remain a public health challenge as long as all these issues are not addressed once and for all. This study applied the Holt's linear method to predict future trends of under-five mortality rate in Carbo Verde and the findings revealed that annual U5MR will continue to decline over the out of sample period. Therefore, we encourage authorities in Carbo Verde to continue providing resources to the maternal and child (MNCH) program to ensure adequate medical staff and medical supplies at every level of the healthcare delivery system.

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