Yemen is Trailing behind in the Reduction of under Five Mortality: Evidence From the Holt's Linear Method

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Abstract - **This study uses annual time series data on under five mortality rate (U5MR) for Yemen from 1960 to 2020 to predict future trends of U5MR over the period 2021 to 2030. Residuals and model evaluation statistics indicate that that the applied Holt's linear exponential smoothing model is stable in forecasting under five mortality rate. Optimal values of smoothing constants α and β are 0.9 and 0.3 respectively based on minimum MSE. The double exponential smoothing model projections revealed that annual U5MR will remain high over the out of sample period. Therefore, health authorities in Yemen must address all the major challenges that hinder successful implementation of the maternal and child health program in order to improve child survival across the country.**

Keywords: Exponential smoothing, Forecasting, U5MR.

I. INTRODUCTION

In September 2015 all 193 UN member states signed an agreement that binds all member countries to ensure peace and security, and end all forms of human rights violations (UN, 2016, UN, 2015). Certain regions and countries across the globe are continuously suffering from the devastating effects of war and human rights abuses (UN, 2015). The health component of the 2030 Agenda for sustainable development is seriously under threat in conflict zones where women and children end up bearing the greater part of the negative impacts of war. Yemenis one classical example of a conflict zone which is defined by massive displacement of thousands of people and the resultant humanitarian crisis requires urgent responses from global partners (OCHA, 2019; Al-Mekhlafi, 2018; Burki, 2015). The conflict has led to the destruction of infrastructure and aggravating existing problems such as poverty, poor health, shortage of basic human needs like water, food and medical supplies (El Bcheraoui *et al.* 2018; Eshaq *et al.* 2017; Qirbi & Ismail, 2017). The crisis in Yemen has negatively impacted on the quality of maternal and child health programs (Eze *et al.* 2020). Despite these challenges Yemen is expected to meet the set SDG 3 targets by 2030. SDG3 target 3.2 is directed towards substantially reducing neonatal and under five mortality to as low as 12 neonatal deaths per 1000 live births and 25 under five deaths per 1000 live births by 2030 (UN, 2020; UNICEF, 2019; WHO, 2019; UNICEF, 2018).This research is conducted in line with Vision 2030, to model and forecast future trends of under-five mortality rate for Yemen using the Holt's linear exponential smoothing model. We expect the findings to inform child health policies, decision making and allocation of resources to the MNCH programs activities in the country to effectively prevent under five deaths.

II. LITERATURE REVIEW

Jawad *et al.* (2021) utilized regression analysis to assess the association between conflict and maternal and child health globally. Data for 181 countries (2000–2019) from the Uppsala Conflict Data Program and World Bank were analyzed using panel regression models. The study findings revealed that armed conflict is associated with substantial and persistent excess maternal and child deaths globally. Eze *et al.* (2020) conducted a retrospective study in Yemen to examine morbidities & outcomes of a neonatal intensive care unit in a complex humanitarian conflict setting, Hajjah for the period 2017-2018. A 2-year retrospective study of admissions into the Neonatal Intensive Care Unit (NICU) in Al-Gomhoury Hospital Hajjah, Northwest Yemen was conducted. Data was analyzed with IBM SPSS® version 25.0 statistical software using descriptive/inferential statistics. The study findings indicated that preterm newborns bear disproportionate burden of neonatal morbidity and mortality in this setting which is aggravated by difficulties in accessing early neonatal care. A cross-sectional study in Ghana was conducted by Annan & Asiedu (2018) who used the logit logistic model to assess the maternal, neonatal, and health system related factors that influence neonatal deaths in the Ashanti Region, Ghana. The study concluded that there was a high number of neonatal deaths which were mainly as a result of by birth asphyxia, infections, congenital anomalies and respiratory distress syndrome. Dejong *et al.* (2017) utilized Countdown to 2015 (Millennium Development Goals) health indicators to provide an up-to-date review and analysis of the best available data on Syrian refugees in Jordan, Lebanon and Turkey and internally displaced within Syria and explored data challenges in this conflict setting. The study obtained data from electronic databases and relevant stakeholders. The study revealed that in Syria, the infant mortality rate and under-five mortality rate increased, and coverage of antenatal care (one visit with a skilled attendant), skilled birth attendance and vaccination (except for DTP3 vaccine) declined. The number of Syrian refugee women attending more than four antenatal care visits was low in Lebanon and in non-camp settings in Jordan.

III. METHODOLOGY

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

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

Smoothing equation

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

Trend estimation equation

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

Forecasting equation

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

Y_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 Yemen 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	Y
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)	3.294029
Sum Square Error (SSE)	4150.206277
Mean Square Error (MSE)	68.036168
Mean Percentage Error (MPE)	0.622900
Mean Absolute Percentage Error (MAPE)	1.675902

Residual Analysis for the Applied Model
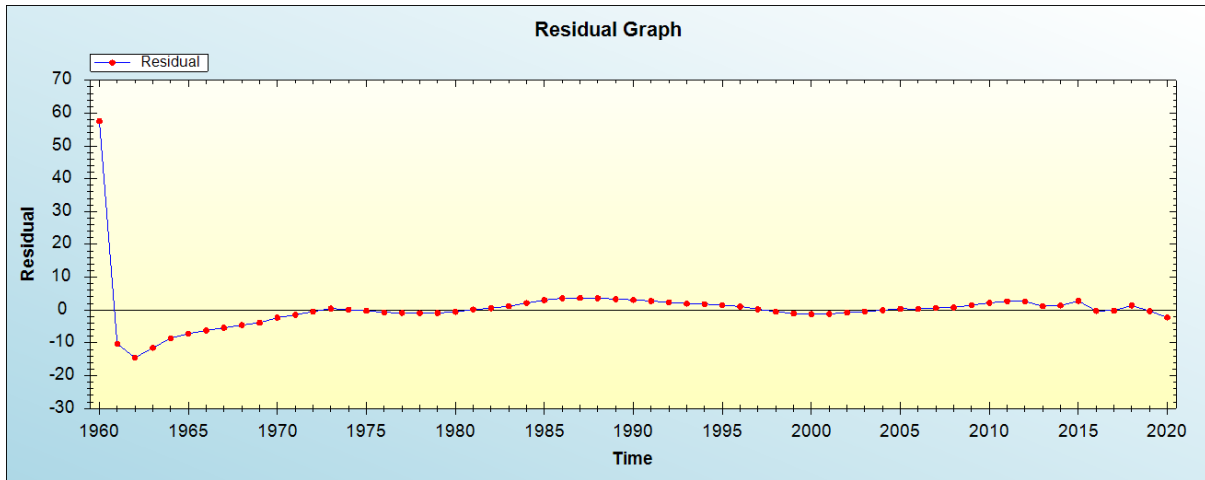

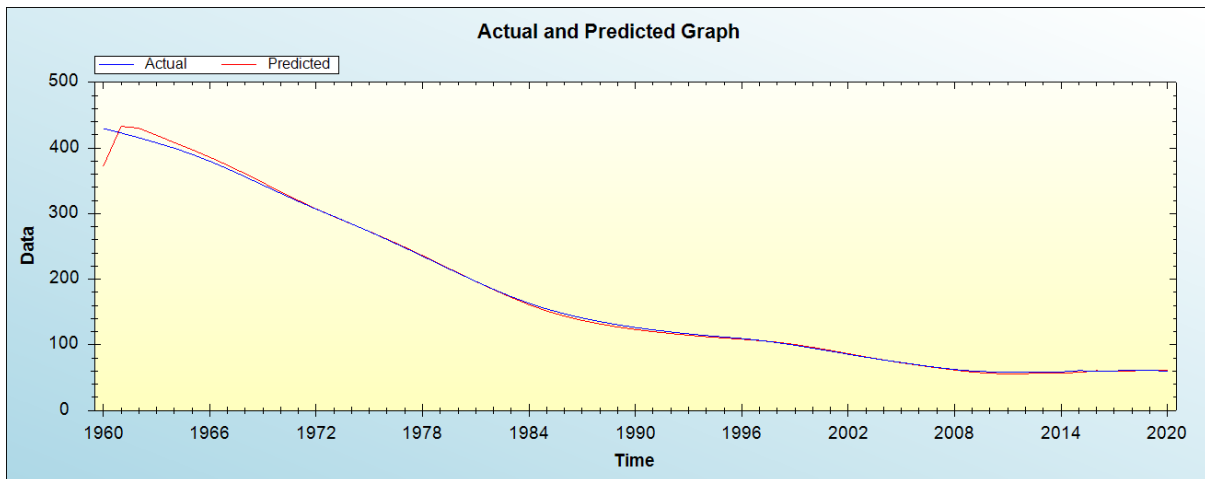Figure 1: Residual analysis

In-sample Forecast for Y

Figure 2: In-sample forecast for the Y series
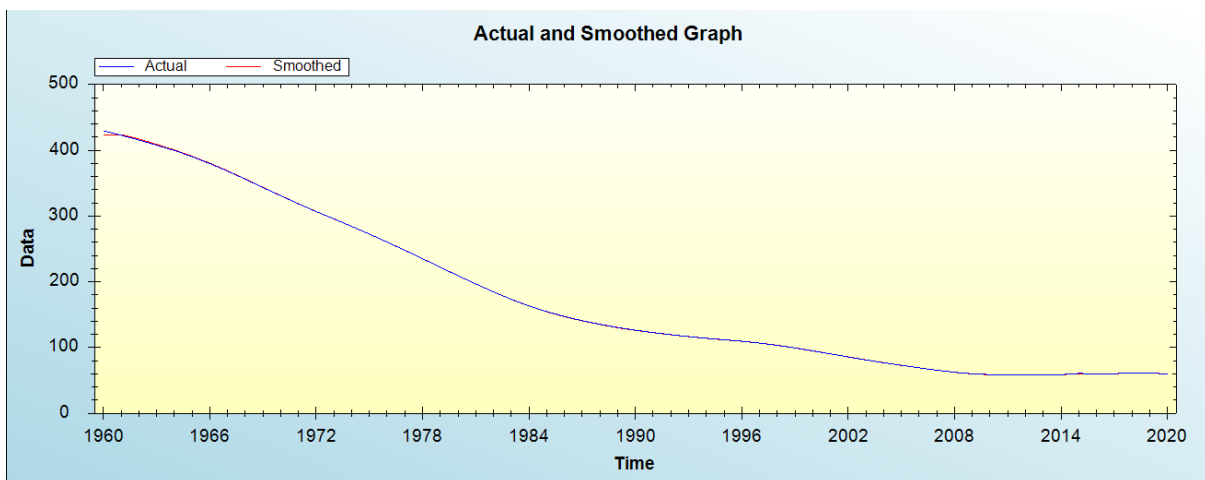
Actual and Smoothed graph Y series

Figure 3: Actual and smoothed graph for Y series

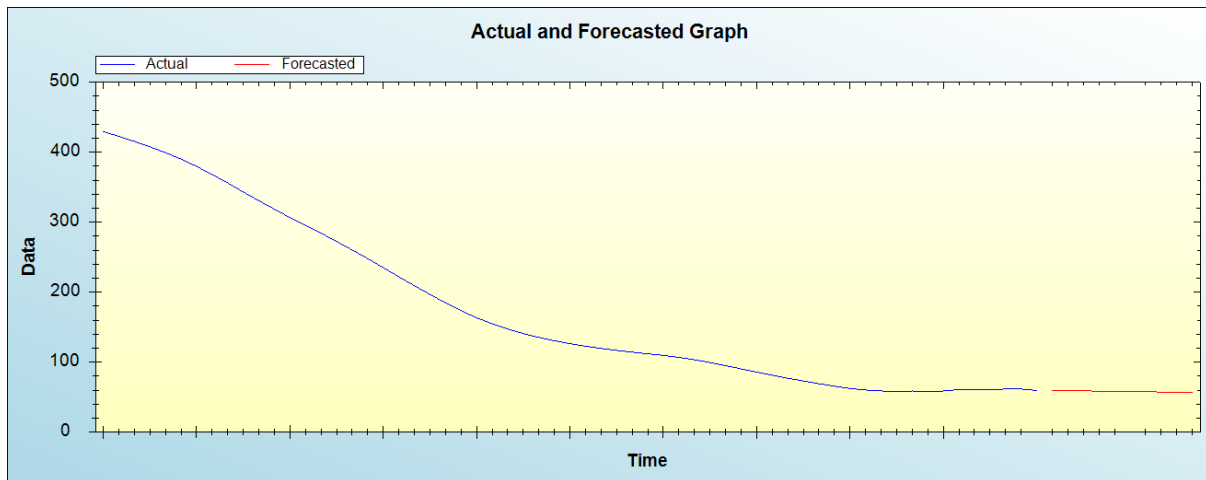Out-of-Sample Forecast for Y: Actual and Forecasted Graph

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

2021	59.5098
2022	59.1974
2023	58.8850
2024	58.5727
2025	58.2603
2026	57.9479
2027	57.6355
2028	57.3231
2029	57.0108
2030	56.6984

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 remain high over the out of sample period.

V. POLICY IMPLICATION & CONCLUSION

The persistence of war in Yemen is a cause for concern and negatively affecting the success of the maternal and child health program. Poverty, hunger and destruction of health infrastructure is a major setback for achieving all the set targets under SDG3. This study applied Holt's linear method to project under five mortality rate and forecast results indicate thatannual U5MR will remain high over the out of sample period. Therefore, health authorities in Yemen must address the various challenges that hinder the successful implementation of the maternal and child health program.

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