

Tracking Future Trends of Under Five Mortality Rate in Bahrain Using Double Exponential Smoothing Model

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Abstract - This study uses annual time series data on under five mortality rate (U5MR) for Bahrain from 1960 to 2020 to predict future trends of U5MR over the period 2021 to 2030. Residuals and model evaluation statistics 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 0.1 respectively based on minimum MSE. The Holt's linear model projections suggest that annual U5MR will continue to drop throughout the out of sample period. Hence, health authorities should relentlessly provide funding to the maternal and child health program in order to maintain this desirable trend of under-five mortality.

Keywords: Exponential smoothing, Forecasting, U5MR.

I. INTRODUCTION

Although several developing countries are struggling to solve all the global health problems, it is quite encouraging to see them reporting downward trends of neonatal and under five mortality (World Bank, 2020). Developing countries are currently facing multiple challenges in the implementation of the global action plan such as lack of adequate resources, governance and accountability issues, political conflicts, climate change, and mass exodus of skilled labor force due to poor remuneration and working conditions (UN, 2016; UN, 2015). Maternal and child health is not immune to these problems. Reduction of maternal, neonatal and under five mortality is a huge task that requires assistance from global partners and other stakeholders. The decline in under five mortality is remarkable however the decline of neonatal mortality is slower hence more resources should be allocated towards addressing neonatal mortality. By end of 2030, all countries should have achieved the set SDG 3 target 3.2 of reducing neonatal and under five mortality to levels as low as 12 deaths per 1000 live births and 25 deaths per 1000 live births respectively (UN, 2020; UNICEF, 2019; WHO, 2019; UNICEF, 2018). This study proposes Holt's linear exponential smoothing model to forecast future trends of under-five mortality rate for Bahrain. We expect study findings to assist in planning and allocation of resources to MNCH program activities in order to keep under five mortality under control.

II. LITERATURE REVIEW

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. A cross-sectional study was conducted in Indonesia by Irawaty *et al.* (2020) to analyze the causes of infant mortality in rural Indonesia and suggested strategies for its reduction by utilizing data from the 2017 Indonesian Demographic and Health Survey (IDHS) dataset for children. Infant mortality is associated with intermediate social determinants such as birth order, birth weight, and breastfeeding status. Socio-demographic factors such as the educational status of mothers, wealth quintile, the smoking habit of the mother, age of mother at first delivery, and sex of the baby are also related to infant mortality. The study concluded the most crucial factors in rural Indonesia were the age of first-time mothers. A descriptive study was carried out by McNamara *et al.* (2018) to reveal intrapartum fetal deaths and unexpected neonatal deaths in Ireland from 2011 to 2014. Anonymised data pertaining to all intrapartum fetal deaths and unexpected neonatal deaths for the study time period was obtained from the national perinatal epidemiology centre. The findings of the study indicated that the corrected intrapartum fetal death rate was 0.16 per 1000 births and the overall unexpected neonatal death rate was 0.17 per 1000 live births. Bandeira *et al.* (2016) described Portugal's achievements in the maternal and child health program. The study highlighted that the joint venture of pediatricians and obstetricians with adequate top-down government commissions for maternal and child health for the decision making by health administrators and a well-defined schedule of preventive and managerial measures in the community and in hospitals, registry of special diseases and training of medical personnel are the most likely explanations for this success.

III. METHODOLOGY

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

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

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 Bahrain 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	0.100
Forecast performance measures	
Mean Absolute Error (MAE)	4.512066
Sum Square Error (SSE)	10285.783966
Mean Square Error (MSE)	168.619409
Mean Percentage Error (MPE)	3.918972
Mean Absolute Percentage Error (MAPE)	7.291701

Residual Analysis for the Applied Model

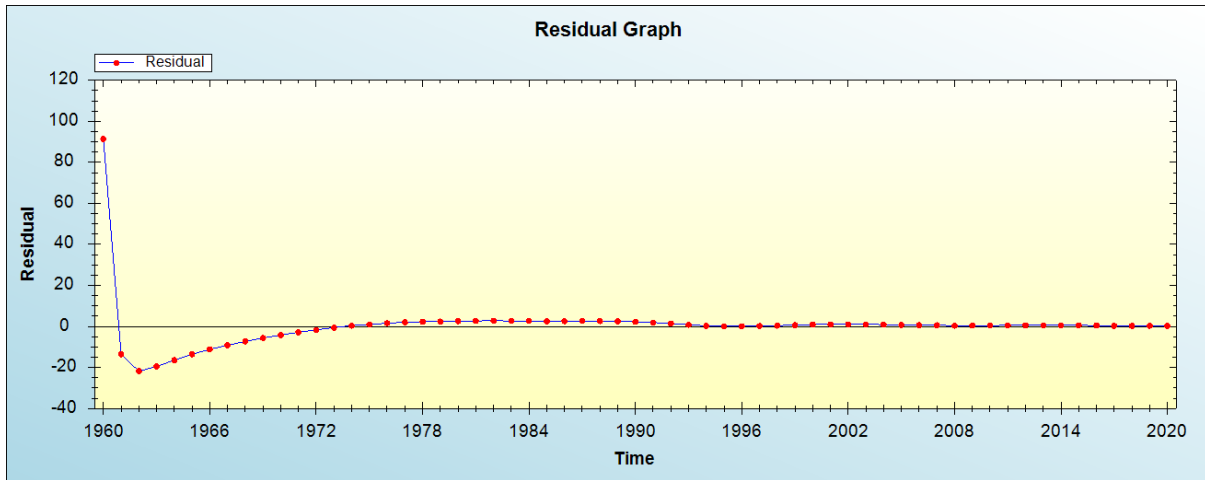


Figure 1: Residual analysis

In-sample Forecast for H

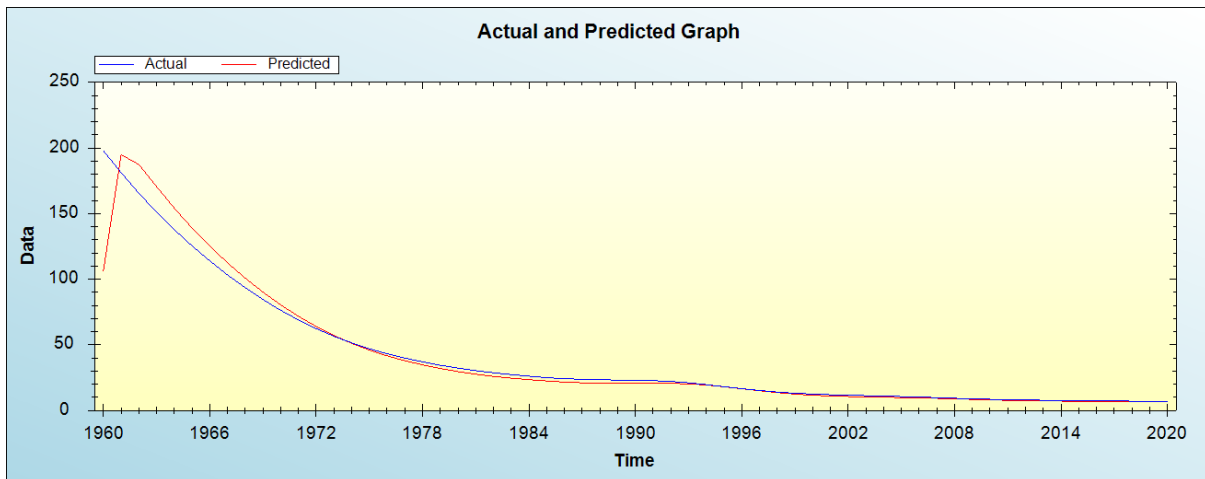


Figure 2: In-sample forecast for the H series

Actual and smoothed graph for H

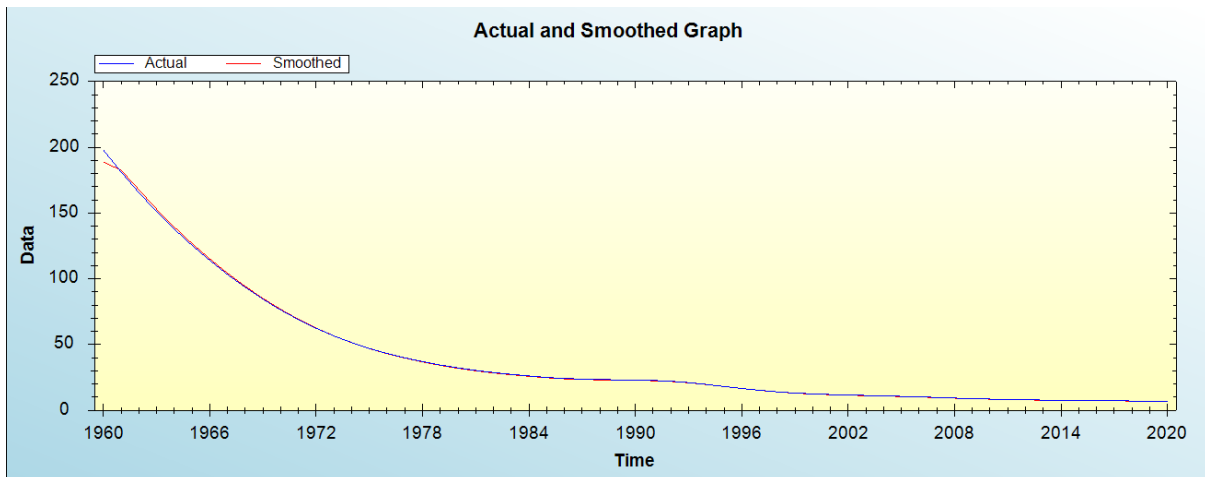


Figure 3: Actual and smoothed graph for H

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

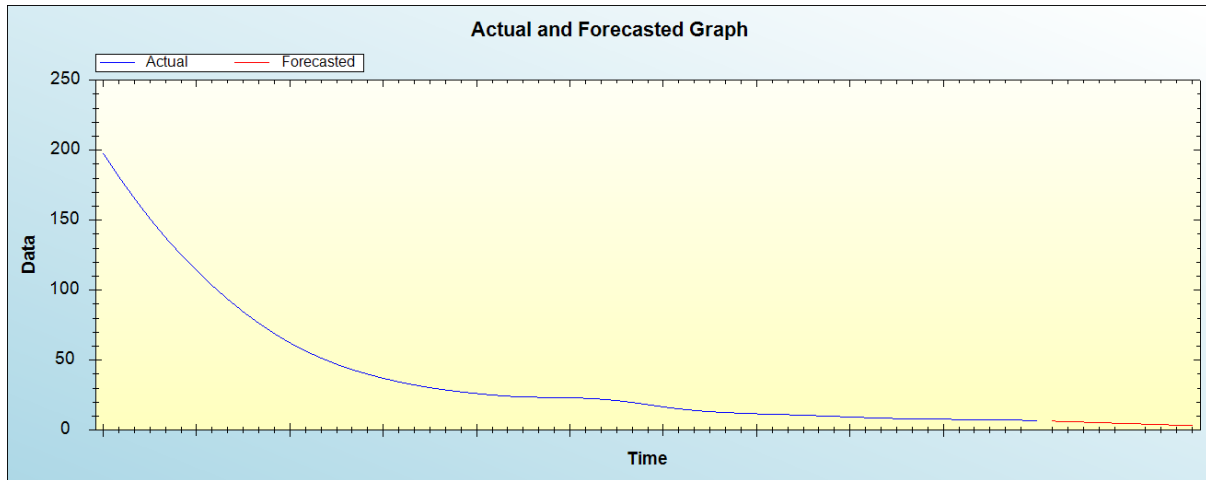


Figure 4: Out-of-sample forecast for H: actual and forecasted graph

Out-of-Sample Forecast for H: Forecasts only

Table 2: Tabulated out-of-sample forecasts

2021	6.4142
2022	6.0502
2023	5.6862
2024	5.3222
2025	4.9581
2026	4.5941
2027	4.2301
2028	3.8661
2029	3.5021
2030	3.1380

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 drop throughout the out of sample period.

V. POLICY IMPLICATION & CONCLUSION

Bahrain has made tremendous progress towards achieving all the set SDG targets by 2030. The decrease in maternal and under five mortality that has been witnessed over the years is clear evidence of the country’s commitment to the fulfilment of Agenda 2030 for sustainable development. This study applied the double exponential smoothing model to forecast future trends of under-five mortality rate in Bahrain. The Holt’s linear model projections suggest that annual U5MR will continue to drop throughout the out of sample period. Therefore, we encourage the government to continuously fund maternal and child programs to maintain this desirable path.

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