

Analysing Under Five Mortality Rate for South Africa Using Double Exponential Smoothing (HOLT)

¹Dr. Smartson. P. NYONI, ²Thabani NYONI

¹ZICHIRE Project, University of Zimbabwe, Harare, Zimbabwe

²Independent Researcher & Health Economist, Harare, Zimbabwe

Abstract - This study uses annual time series data on under five mortality rate (U5MR) for South Africa from 1974 to 2020 to predict future trends of U5MR over the period 2021 to 2030. Residuals and model evaluation criteria indicate 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 decline over the out of sample period. Therefore, we encourage the South African government to address all the challenges that affect the quality of maternal and child healthcare services in the country.

Keywords: Exponential smoothing, Forecasting, U5MR.

I. INTRODUCTION

Sustainable development goals (SDGs) were constructed by all 193 UN member countries in September 2015 after realizing the weaknesses of the Millennium development goals (MDGs). This set of 17 objectives and 169 targets outlined the desired path to ending all forms of poverty, hunger, human rights violations, inequalities, unemployment challenges, educational needs, and health challenges across the globe (UN, 2016; UN, 2015). Many countries are making significant progress towards achieving the set targets by 2030 and this shows great political leadership commitment in various countries. The South African government has made tremendous progress towards achieving the sustainable development goal 3, target 3.2 of reducing neonatal and under five mortality rate to at least 12 neonatal deaths per 1000 live births and 25 under five deaths per 1000 live births in every country by 2030 (UN, 2020; UNICEF, 2019; WHO, 2019; UNICEF, 2018). The country has recorded a downward trend in neonatal and under five mortality rates over the past decades, however more combined effort is required to reduce the absolute number of neonatal deaths (World Bank, 2019; Dorrington, 2016; Velaphi & Rhoda, 2012).

The objective of this paper is to model and forecast future trends of under-five mortality rate for the Republic of South Africa using the Holt's linear exponential smoothing technique and the findings will inform child health policies, planning and allocation of resources with the aim of ending all preventable under five deaths in the country.

II. LITERATURE REVIEW

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. 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. A study conducted in Zimbabwe by Nyoni & Nyoni (2020) analyzed monthly time series data on neonatal death cases at Chitungwiza Central Hospital (CCH) from January 2013 to December 2018 using Box-Jenkins SARIMA models and found out that there will be a slow but steady decrease in neonatal deaths at CCH over the out-of-sample period. Another study by Nyoni & Nyoni, 2020 applied the Box-Jenkins ARIMA methodology to forecast neonatal deaths in Zimbabwe using annual time series data on neonatal deaths in Zimbabwe from 1966 to 2018. The ARIMA (8, 2, 0) was found to be the optimal model. The study findings revealed that the numbers of neonatal deaths per year would decline sharply over the next 25 years. 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. In a 2018 review paper, Rhoda *et al* 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 South 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.

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

Smoothing equation

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

Trend estimation equation

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

Forecasting equation

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

K_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 South Africa for the period 1974– 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	K
Included Observations	47 (After Adjusting Endpoints)
Smoothing constants	
Alpha (α) for data	0.900
Beta (β) for trend	0.300
Forecast performance measures	
Mean Absolute Error (MAE)	2.849731
Sum Square Error (SSE)	1293.586873
Mean Square Error (MSE)	27.523125
Mean Percentage Error (MPE)	0.537925
Mean Absolute Percentage Error (MAPE)	3.885701

Residual Analysis for the Applied Model

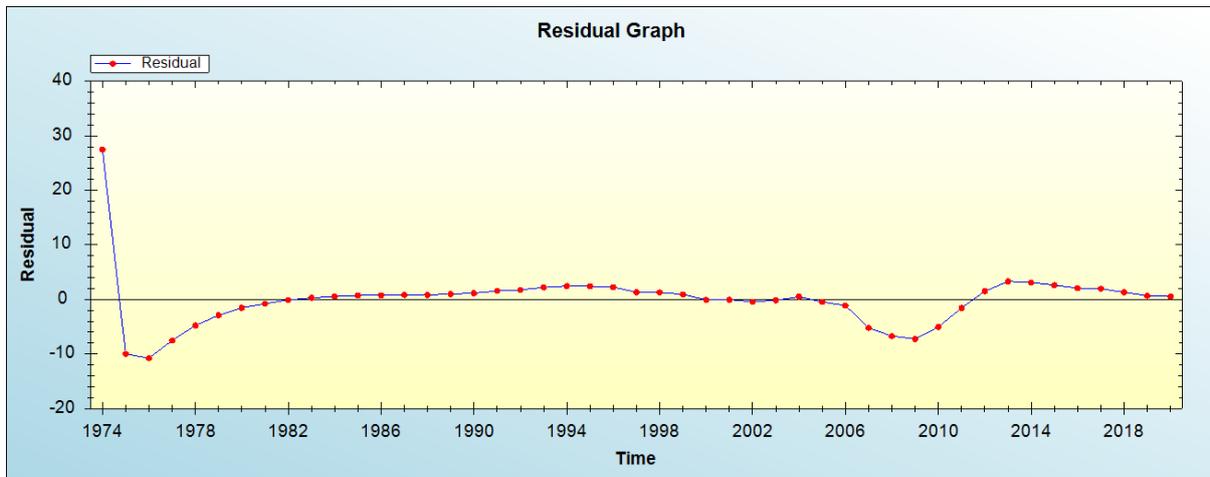


Figure 1: Residual analysis

In-sample Forecast for K

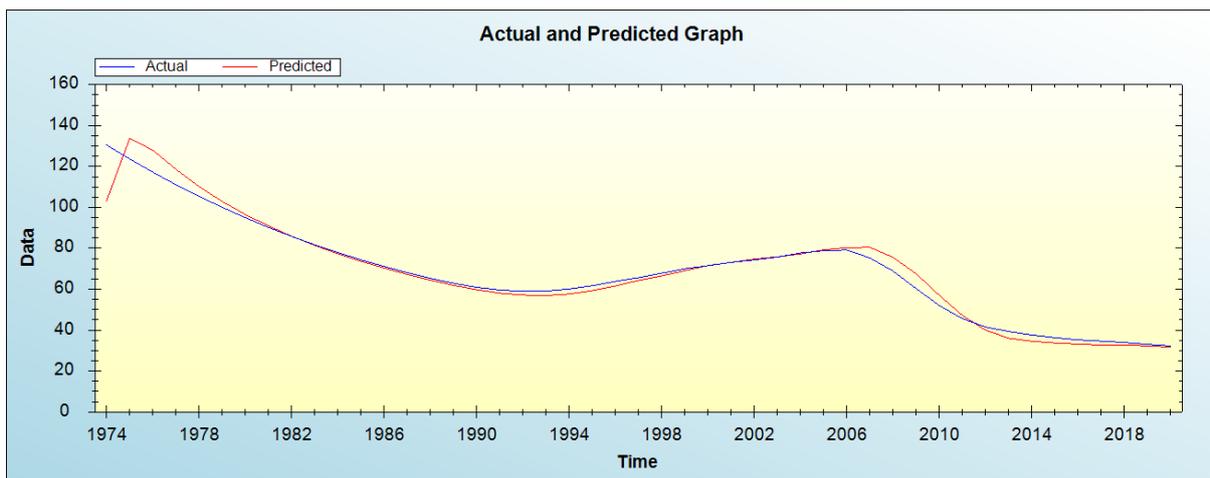


Figure 2: In-sample forecast for the K series

Actual and Smoothed graph for K series

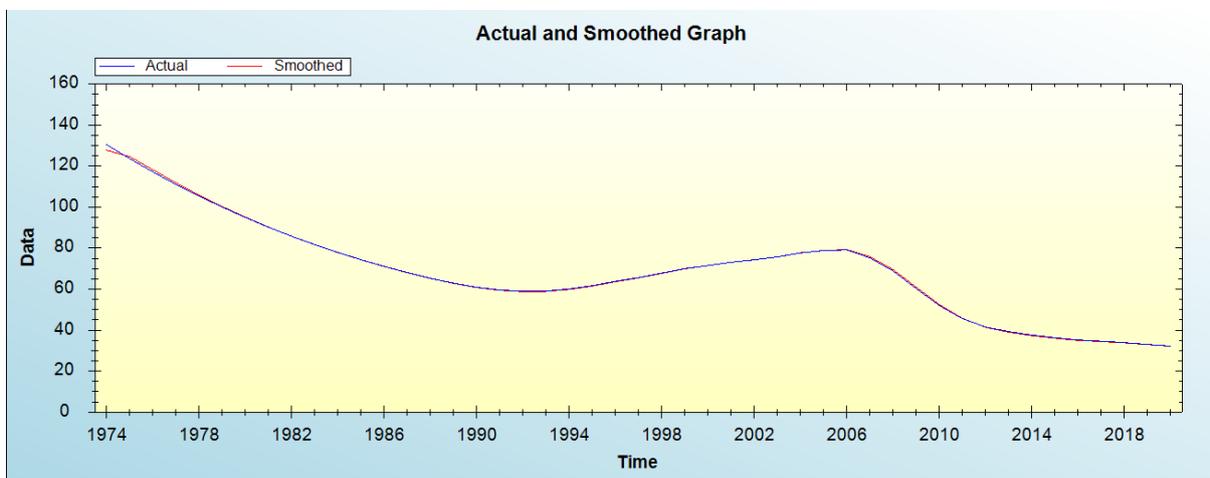


Figure 3: Actual and smoothed graph for K series

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

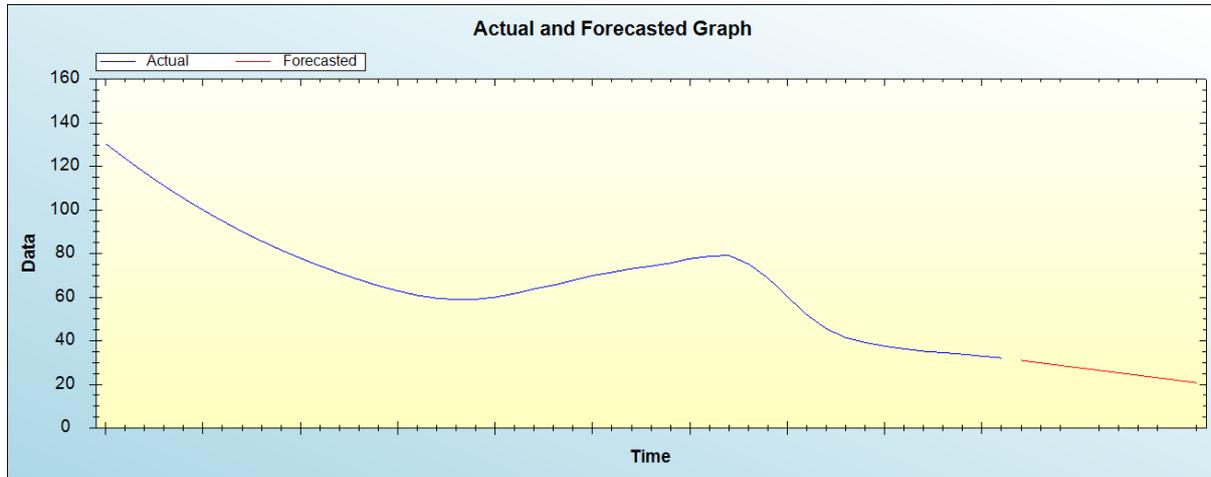


Figure 4: Out-of-sample forecast for K: actual and forecasted graph

Out-of-Sample Forecast for K: Forecasts only

Table 2: Tabulated out-of-sample forecasts

2021	31.0143
2022	29.8834
2023	28.7526
2024	27.6218
2025	26.4909
2026	25.3601
2027	24.2293
2028	23.0984
2029	21.9676
2030	20.8368

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 decline over the out of sample period.

V. POLICY IMPLICATION & CONCLUSION

The South African government has made significant progress towards achieving the set targets under SDG3. SDG3 target 3.2 aims at the substantial reduction of under-five mortality to levels as low as 25 deaths per 1000 live births by 2030. Over the past decades, South Africa has reported a decline in under five and neonatal mortality rates. This study applied Holt’s linear method to forecast under five mortality rate and the projections revealed that annual U5MR will decline over the out of sample period. Therefore, the South African government must address all the challenges that affect the quality of maternal and child healthcare services in the country.

REFERENCES

- [1] UNICEF. (2019). Levels and trends in child mortality: report 2019. Estimates developed by the UN Inter-agency Group for child mortality estimation. New York: UNICEF.
- [2] United Nations. (2015). transforming our world: The 2030 agenda for sustainable development, A/RES/70/1. New York: UN General Assembly.
- [3] World Bank (2019). Mortality rate, under 5.
- [4] UN (2020) sustainable development goals. <https://www.un.org/sustainabledevelopment/development-agenda>
- [5] UNICEF (2018). Every Child alive. New York: UNICEF
- [6] World Health Organization (WHO) (2019). SDG 3: Ensure healthy lives and promote wellbeing for all at all ages.
- [7] United Nation. Transforming our world: The 2030 agenda for sustainable development 2016.

- [8] Velaphi S., and Rhoda N (2012). Reducing neonatal deaths in South Africa – are we there yet, and what can be done? *S Afr J Child Health*, 6, 3:67-71. <https://doi.org/10.1186/1471>
- [9] Dorrington RE., Bradshaw D., Laubscher R., and Nannan N (2016). Rapid Mortality Surveillance Report 2015. Cape Town: South African Medical Research Council. <http://www.mrc.ac.za/bod/RapidMortalitySurveillanceReport2015.pdf>

Citation of this Article:

Dr. Smartson. P. NYONI, Thabani NYONI, “Analysing Under Five Mortality Rate for South Africa Using Double Exponential Smoothing (HOLT)” Published in *International Research Journal of Innovations in Engineering and Technology - IRJIET*, Volume 6, Issue 7, pp 470-474, July 2022. Article DOI <https://doi.org/10.47001/IRJIET/2022.607104>
