

# Estimating Future Trends of Under Five Mortality Rate for Bolivia Using Holt's Linear Method

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**Abstract** - This study uses annual time series data on under five mortality rate (U5MR) for Bolivia from 1960 to 2020 to predict future trends of U5MR over the period 2021 to 2030. Residuals and forecast evaluation criteria of the applied model indicate that the model is stable in forecasting under five mortality rate. The optimal values of smoothing constants  $\alpha$  and  $\beta$  are 0.9 and 0.2 respectively based on minimum MSE. The Holt's linear model projections revealed that annual U5MR will continue to drop throughout the out of sample period. Therefore we encourage authorities in Bolivia to channel more resources to maternal and child health (MNCH) programs particularly primary healthcare so as to attend to all the factors that contribute to under five mortality.

**Keywords:** Exponential smoothing, Forecasting, U5MR.

## I. INTRODUCTION

Sustainable development goals (SDGs) refers to the 17 objectives enshrined in the agenda 2030 for sustainable development document (UN, 2016; UN, 2015). There are 169 targets attached to the 17 thematic areas to help all UN member states to accelerate their efforts to address all the major burning global issues. SDGs appear to be very ambitious goals however, with commitment and unified effort, countries will be able to solve most of the challenges that affect their populations. Sexual and reproductive health is a critical component of health and sustainable development (UN, 2020; UNICEF, 2019; WHO; 2019; UNICEF, 2018; Starrs *et al.* 2018). Many developing countries are experiencing adverse maternal, neonatal and child health outcomes such as abortions, HIV infections and pregnancy related adverse outcomes aggravated by sexual and gender based violence (Glasier *et al.* 2006; Eczati *et al.* 2002). Investing in reproductive health and spending in this sector is associated with positive maternal and child health outcomes (Borghi *et al.* 2006; Adam, 2004; Ensor, 2005; Jowett, 2000). The aim of this study is to model and project under five mortality rate for Bolivia using the Holt's linear method. We expect study findings to assist in policy making, planning and allocation of resources to MNCH programs so as to end all preventable under five deaths in the country.

## II. LITERATURE REVIEW

An interrupted time series analysis was done by MacDonald *et al.* (2021) to determine if the new maternity unit brought about improvements in maternal and neonatal outcomes using data collected between July 2016 and October 2019 including 20 months before the opening of the maternity unit and 20 months after. The researchers examined maternal neonatal outcomes such as physiological (vaginal) births, caesarean birth, postpartum hemorrhage (PPH), maternal deaths, stillbirths and undesirable outcomes (eclampsia, PPH, perineal laceration, postpartum infection, maternal death or stillbirth). The results showed that the new maternity unit led to an upward trend in caesarean births yet an overall reduction in all undesirable maternal and neonatal outcomes. Raymondville *et al.* (2020) conducted a convergent, mixed methods study to assess barriers and facilitators to facility based childbirth at Hôpital Universitaire de Mirebalais (HUM) in Mirebalais, Haiti. A secondary analyses of a prospective cohort of pregnant women seeking antenatal care at HUM was performed and quantitatively assessed predictors of not having a facility-based childbirth at HUM. The study also prospectively enrolled 30 pregnant women and interviewed them about their experiences delivering at home or at HUM. It was found that living further from the hospital, poverty and household hunger were associated with not having a facility-based childbirth. Primigravid women were more likely to have a facility-based childbirth. 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. A study by Souza *et al.* (2019) investigated the determinants of neonatal mortality in Foz do Iguassu in Brazil. The authors analyzed all neonatal deaths that occurred in Foz do Iguassu from 2012 to 2016. Birth and mortality data were extracted from two national

governmental databases (SINASC and SIM). It was found that high rate of neonatal death in Foz do Iguassu is strongly associated with newborn characteristics and not associated with maternal socio-demographic characteristics.

### III. METHODOLOGY

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

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

#### Smoothing equation

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

#### Trend estimation equation

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

#### Forecasting equation

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

$V_t$  is the actual value of time series at time t

$L_t$  is the exponentially smoothed value of time series at time t

$\alpha$  is the exponential smoothing constant for the data

$\beta$  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 Bolivia 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	V
Included Observations	61 (After Adjusting Endpoints)
Smoothing constants	
Alpha ( $\alpha$ ) for data	0.900
Beta ( $\beta$ ) for trend	0.200
Forecast performance measures	
Mean Absolute Error (MAE)	1.251027
Sum Square Error (SSE)	551.079261
Mean Square Error (MSE)	9.034086
Mean Percentage Error (MPE)	0.772518
Mean Absolute Percentage Error (MAPE)	1.152099

Residual Analysis for the Applied Model

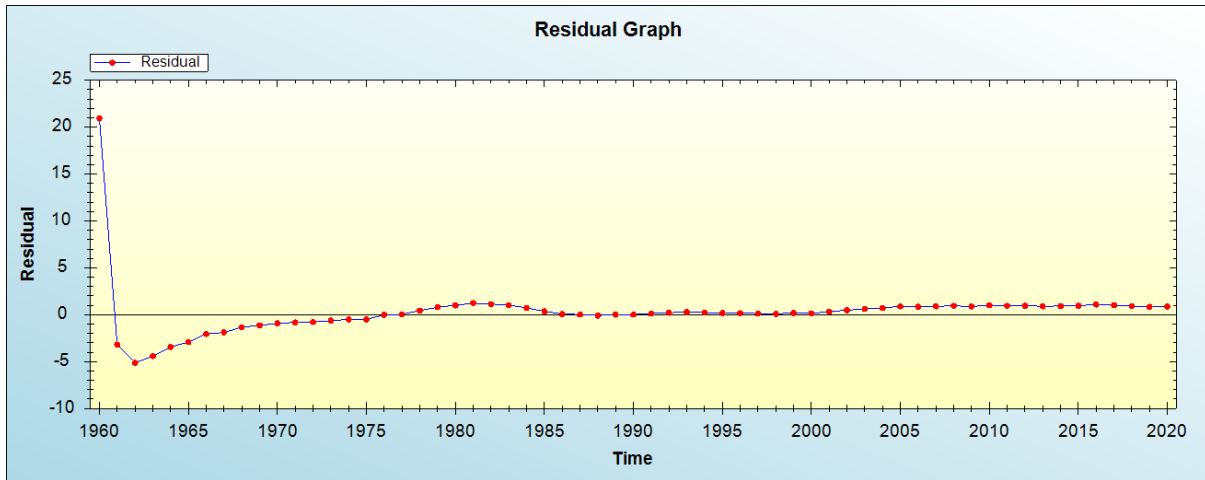


Figure 1: Residual analysis

In-sample Forecast for V

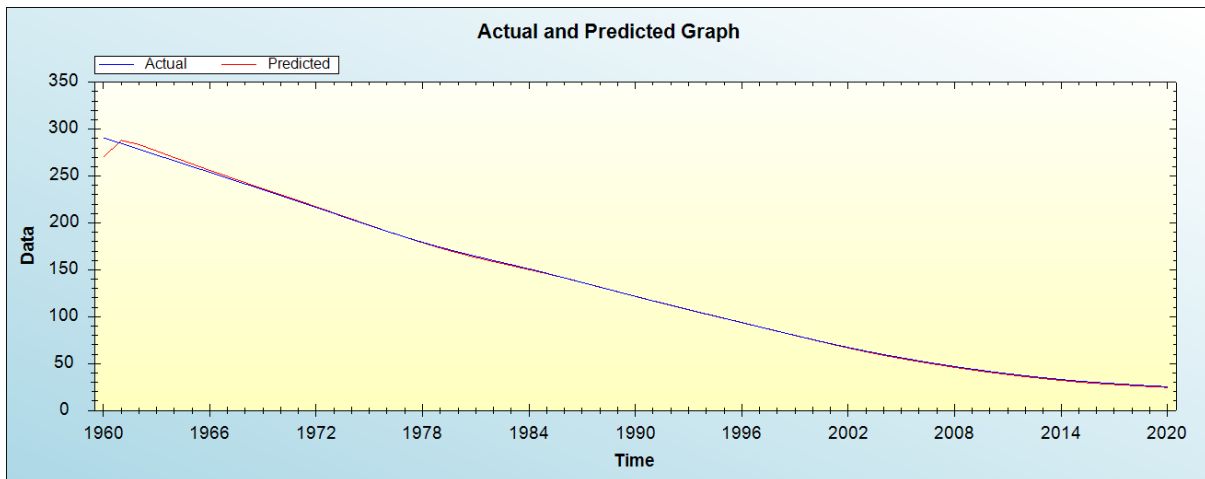


Figure 2: In-sample forecast for the V series

Actual and Smoothed V series

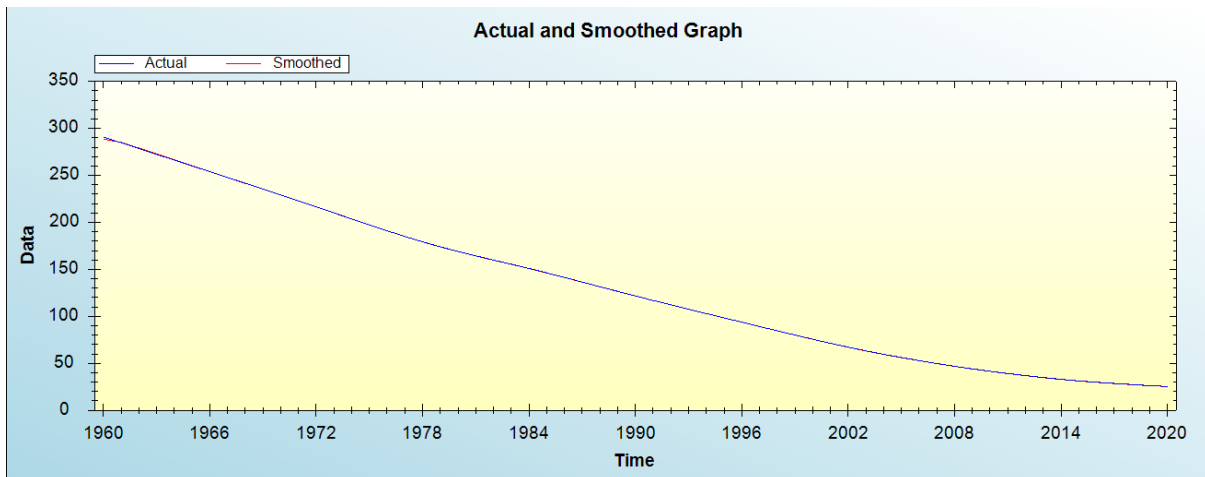


Figure 3: Actual and smoothed V series

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

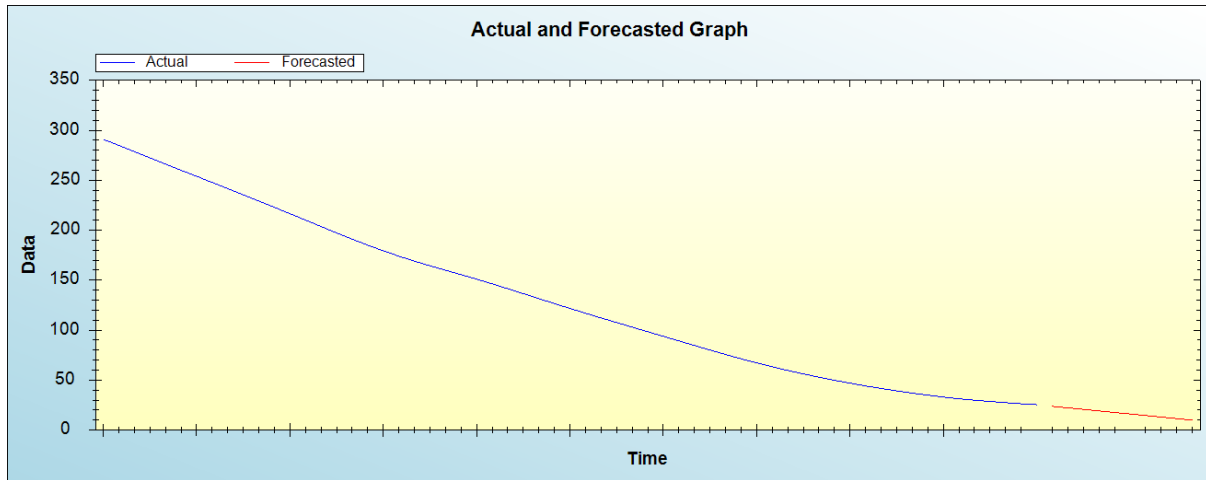


Figure 4: Out-of-sample forecast for V: actual and forecasted graph

Out-of-Sample Forecast for V: Forecasts only

Table 2: Tabulated out-of-sample forecasts

2021	23.7701
2022	22.2287
2023	20.6873
2024	19.1459
2025	17.6045
2026	16.0631
2027	14.5217
2028	12.9803
2029	11.4389
2030	9.8974

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

Many countries are working tirelessly in the quest to achieve the set targets for sustainable development goals (SDGs). Most countries have witnessed a downward trend in under five mortality rate over the past 2 decades due to investments in health, sustainable agriculture, and innovative strategies in various fields. In this study we applied the Holt’s linear exponential smoothing model to forecast future trends of under-five mortality rate in Bolivia. The model projections indicate that annual U5MR will continue to drop throughout the out of sample period. Therefore we encourage authorities in Bolivia to channel more resources to primary health care and attend to all the factors that contribute to mortality among under five children.

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**Citation of this Article:**

Dr. Smartson. P. NYONI, Thabani NYONI, “Estimating Future Trends of Under Five Mortality Rate for Bolivia Using Holt’s Linear Method” Published in *International Research Journal of Innovations in Engineering and Technology - IRJIET*, Volume 6, Issue 7, pp 126-130, July 2022. Article DOI <https://doi.org/10.47001/IRJIET/2022.607025>

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