

# Forecasting Future Trends of Adolescent Fertility for Lesotho Using Holt's Linear Method

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**Abstract** - This research article uses annual time series data of adolescent fertility rate for Lesotho from 1960 to 2020 to predict future trends of adolescent fertility rate over the period 2021 to 2030. The study utilizes Holt's linear exponential smoothing model. The optimal values of smoothing constants  $\alpha$  and  $\beta$  are 0.9 and 0.8 respectively based on minimum MSE. The results of the study indicate that annual adolescent fertility will decline but still remain high throughout the out of sample period. Therefore, we encourage authorities in Lesotho to establish adolescent friendly clinics which are adequately resourced to address adolescent health issues, enforce laws that protect the sexual and reproductive rights of women and girls, and allocate more funding towards youth empowerment projects to enable youths to contribute towards economic growth and development of this country.

**Keywords:** Exponential smoothing, Forecasting, adolescent fertility rate.

## I. INTRODUCTION

Unintended pregnancy and HIV are the most important public health challenges affecting adolescents' worldwide (Aventin *et al.* 2021). In 2019, around 170,000 adolescents aged 10–19 years around the world were newly infected with HIV (UNICEF, 2020). Lesotho has the second-highest HIV prevalence in the world, estimated in 2019 at 23 percent among 15–49 year olds and 10 percent and 5 percent among 15–24 year old women and men respectively (UNAIDS, 2019). Furthermore, approximately 50 percent of sexually active adolescents in Lesotho report that they do not regularly use condoms (UNICEF, 2016). Teenage conception is another problem affecting adolescents around the world. The leading cause of morbidity and mortality among adolescents in developing regions is adolescent pregnancy (Ganchimeg *et al.* 2014). Literature indicates that pregnancy during this stage tend to be associated with complications such as hypertensive disorders, antepartum hemorrhage, anemia, preterm delivery, prolong delivery, birth trauma and low birth weight (Noori *et al.* 2022; Ahinkorah *et al.* 2021; Harrington *et al.* 2021; Kaforau *et al.* 2021; Geda, 2019; Wado *et al.* 2019; UNICEF, 2019; Ganchimeg *et al.* 2014). Lesotho DHS 2014 revealed that 1 in 4 women marry before 18 years of age and the median age of first intercourse is 18.5 years. Approximately 6% of the population is sexually active before the age of 15 years. Ninety eight percent of the population had access to contraceptive information and the unmet need for contraception among all women in the country was 6.1%. This unmet need was higher in adolescents than adults and was seen in both married (18%) and unmarried (24.2%) female adolescents (Ministry of Health/Lesotho, 2015). As with unintended adolescent pregnancy, rates of marriage are higher among girls in rural areas (24.9% vs. 13.8% urban), and among those who are the poorest and have the lowest levels of schooling (Lesotho multiple indicator cluster survey 2018). Previous studies have highlighted health service-related barriers such as long waiting times, negative health care provider attitudes, and lack of privacy and confidentiality, making adolescents reluctant to access services (Jonas *et al.* 2017). Misconceptions about contraceptives causing adverse side effects in youth have also been reported as a barrier to them accessing SRH services (Self *et al.* 2018).

The purpose of this paper is to forecast future trends of adolescent fertility for Lesotho using the double exponential smoothing technique. Findings of this study will depict future trends of adolescent fertility in the out of sample period. This is anticipated to inform national policies, planning and allocation of resources to teenage pregnancy prevention programs.

## II. METHODOLOGY

This study utilizes an exponential smoothing technique to model and forecast future trends of adolescent fertility rate in Lesotho. 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.

Holt's linear method is specified as follows:

Model equation

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

Smoothing equation

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

$$0 < \alpha < 1$$

Trend estimation equation

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

$$0 < \beta < 1$$

Forecasting equation

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

$H_t$  is the actual value of adolescent fertility rate at time  $t$

$\varepsilon_t$  is the time varying **error term**

$\mu_t$  is the time varying mean (**level**) term

$\rho_t$  is the time varying **slope term**

$t$  is the trend component of the time series

$L_t$  is the exponentially smoothed value of adolescent fertility rate 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

$b_t$  is the trend estimate at time  $t$

$b_{t-1}$  is the trend estimate at time  $t-1$

**Data Issues**

This study is based on annual adolescent fertility rate in Lesotho 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.

**III. FINDINGS OF THE STUDY**

Exponential smoothing Model Summary

Table 1: ES model summary

Variable	H
Included Observations	61
Smoothing constants	
Alpha ( $\alpha$ ) for data	0.900
Beta ( $\beta$ ) for trend	0.800
Forecast performance measures	
Mean Absolute Error (MAE)	0.143509
Sum Square Error (SSE)	5.961227
Mean Square Error (MSE)	0.097725
Mean Percentage Error (MPE)	0.000544
Mean Absolute Percentage Error (MAPE)	0.157861

Residual Analysis for the Applied Model

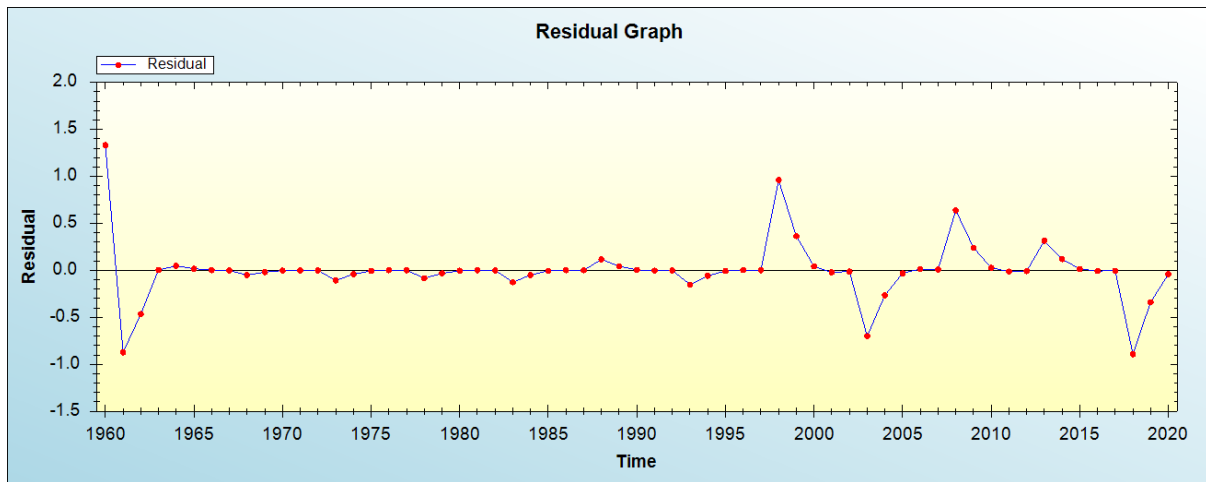


Figure 1: Residual analysis

In-sample Forecast for H

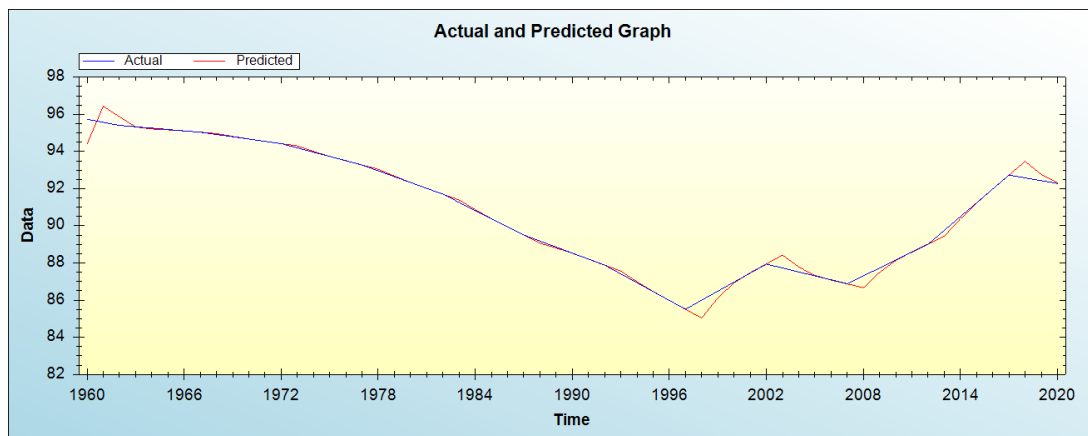


Figure 2: In-sample forecast for the H series

Actual and Smoothed graph for H series

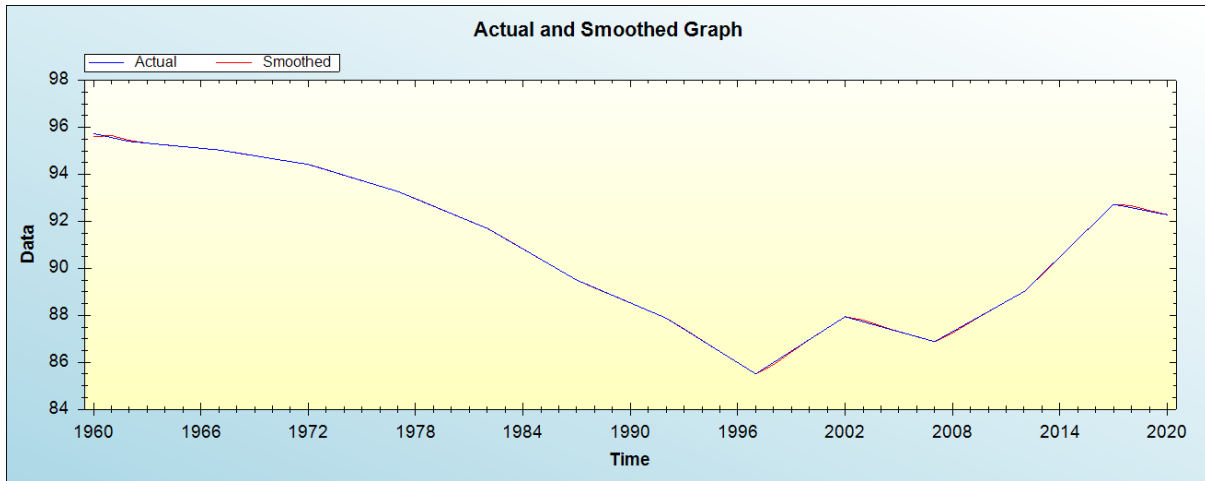


Figure 3: Actual and smoothed graph for H series

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

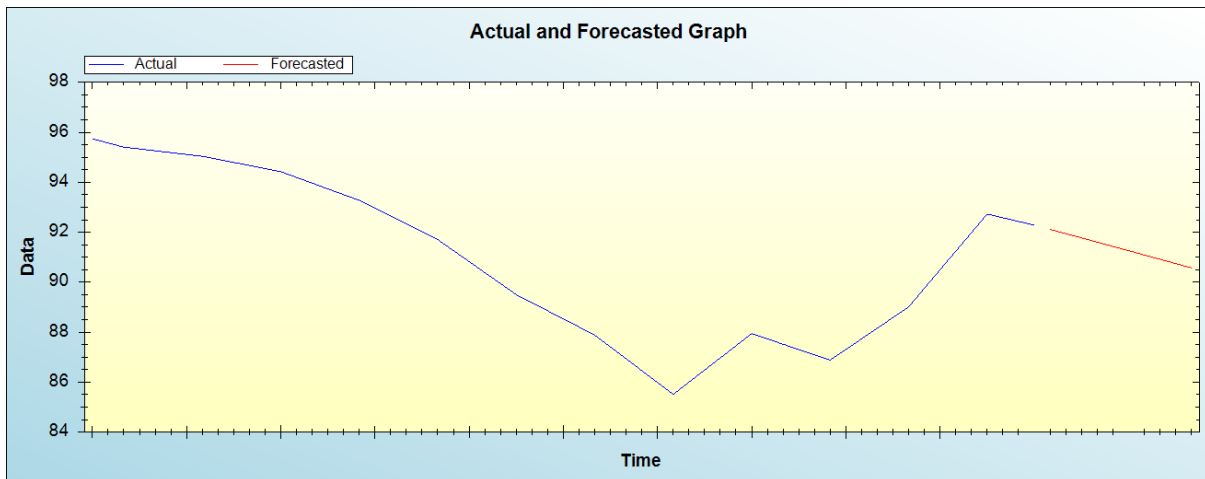


Figure 4: Out-of-sample forecast for H: actual and forecasted graph

Out-of-Sample Forecast for H: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Year	Predicted adolescent fertility rate
2021	92.1151
2022	91.9443
2023	91.7735
2024	91.6027
2025	91.4319
2026	91.2611
2027	91.0903
2028	90.9195
2029	90.7487
2030	90.5779

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 adolescent fertility rate will decline but remain high throughout the out of sample period.

#### IV. POLICY IMPLICATION & CONCLUSION

Unintended pregnancy is an important public health challenge affecting adolescents worldwide. In Lesotho, teenage pregnancy remains a huge problem. Adolescent birth rates have been increasing during the period 1997-2020. Pregnancy rates are higher among teenage girls in the rural areas than those in urban areas. Risk factors for pregnancy among teenagers include poverty, lower educational level, long waiting times, negative health care provider attitudes, and lack of privacy and confidentiality, making adolescents reluctant to access services and misconceptions about contraceptives causing adverse side effects. This study applied Holt's double exponential smoothing technique to forecast future trends of adolescent fertility for Lesotho. Forecast results indicated that adolescent fertility will continue to decline but remain high throughout the out of sample period. Therefore, we encourage the government to establish adolescent friendly clinics which are adequately resourced to address adolescent health issues, enforce laws that protect the sexual and reproductive rights of women and girls, and allocate more funding towards youth empowerment projects to enable youths to contribute towards economic growth and development of this country.

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