International Research Journal of Innovations in Engineering and Technology (IRJIET)

ISSN (online): 2581-3048

Volume 7, Issue 2, pp 486-491, February-2023

https://doi.org/10.47001/IRJIET/2023.702081

Assessing the Feasibility of Ending Adolescent Births in Yemen Using the Double Moving Average Method

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***Abstract* - Tracking future trends of various health phenomena is very crucial for policy-making and allocation of adequate resources to public health interventions. This research paper utilizes annual time series data on adolescent fertility rate for Yemen from 1960 to 2020 to predict future trends of adolescent fertility rate over the period 2021 to 2030. The model evaluation criteria indicate that the applied Double moving average model (DMA) is stable in forecasting for adolescent fertility rate. The results of the study indicate that annual adolescent fertility will continue to fall throughout the out of sample period. Therefore, we implore authorities in Yemen to scale up campaigns against sexual abuse of women and girls, enforce laws that safeguard sexual and reproductive health rights of women and girls and offer affordable and accessible adolescent health services.**

Keywords: Double moving average, Forecasting, adolescent fertility rate.

I. INTRODUCTION

Adolescence pregnancy is a worldwide problem that has immediate and long term consequences to the mother, her baby and family (Althabe *et al.* 2015; Ganchimeg *et al.* 2014; Malabarey *et al.* 2012). Previous literature has revealed adverse outcomes of teenage pregnancy such as maternal mortality, hypertensive disorders, mental disorders, anemia, preterm delivery and low birth weight (Amjad *et al.* 2019; Grønvik & Fossgard, 2018; Neal *et al.* 2016; Kirbas *et al.* 2016). Limited resource settings and poverty are strongly linked to adolescent pregnancy and child birth as highlighted in studies done in the past (Birhanu *et al.* 2019; Islam *et al.* 2017). Conflicts and war create an environment which is not conducive for adolescent health as many teenage girls become victims of war and terror in conflict affected regions. Sexual and physical abuse of women and children is of major concern. Destruction of important infrastructure becomes a major drawback to the achievement of universal health coverage including the provision of quality and affordable sexual and reproductive health services (El Bcheraoui *et al.* 2018; Eshaq *et al.* 2017; Qirbi & Ismail, 2017). A good example of such conflicts is the armed conflict in Yemen which has been recognized as one of the worst humanitarian crisis in our life time (OCHA, 2019; Al-Mekhlafi, 2018; Burki, 2015). In Yemen, the proportion of married teenagers among all married women declined from 13.7 percent in 2005 to 7 percent in 2013 while 17percent of teenagers were married in 2013 (MOPH&P *et al.* 2015; Bin, 2005). The country has high maternal and infant mortality rates of 365 per 100 000 live births and 75 deaths per 1000 live births respectively (MoPH & P, 2014).

The aim of this paper is to forecast adolescent fertility for Yemen using the double moving average method (DMA). The findings are expected to highlight the future burden of adolescent births in the out of sample period. This will guide policy, planning and allocation of resources to teenage pregnancy prevention programs.

II. LITERATURE REVIEW

Author(s)	Study area	Topic	methodology	Main finding(s)
Al-Jermmy et al.(2022)	Hodeida, Yemen	Prevalence and Correlates of Anemia among Adolescents Living in Hodeida, Yemen	Cross- sectional study	The prevalence of anemia was 37.8%. Female gender, khat chewing, excessive menstruation, and experiencing headaches, fatigue, or dizziness were independent

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				predictors of anemia.
Hunersen et al. (2020)	Yemen	Child Marriage in Yemen: A Mixed Methods Study in Ongoing Conflict and Displacement	Mixed methods study	Displaced girls experience child marriage more than boys or host girls
Ghouthet al. (2017)	Hadramout, Yemen	Profile of Teenage Pregnancy in Hadramout, Yemen	cross-sectional study	Teenage pregnancy was associated with maternal anemia and high perinatal mortality rate **(134 per 1000 live births)**
Sama et al.(2017)	Sub-Saharan Africa	Prevalence, predictors and adverse outcomes of adolescent pregnancy in sub-Saharan Africa: a protocol of a systematic review	Systematic review	High rates of teenage pregnancy have been reported with a resultant significant morbidity and mortality. All these are happening within the backdrop of high rates sexually transmitted diseases (STDs
Yakubu &Salisu (2018)	Sub-Saharan Africa	Determinants of adolescent pregnancy in sub-Saharan Africa: a systematic review	Systematic review	High levels of adolescent pregnancies in Sub-Saharan Africa is attributable to multiple factors such as sociocultural, economic, individual, and health service related factors

III. METHODOLOGY

Moving average analysis is a statistical forecasting technique based on smoothing the original series using moving averages in order to generate forecasts. It involves taking a group of observations and calculating the average value as the forecast for the next period. In the double moving average (*DMA)* technique, the moving average occurs twice. This means that the double moving average method performs a moving average on a subset of data that represents a moving average of the original data set. This technique is suitable for the analysis of data with a trend whereas a *single moving average* (*SMA*) is ideal for modelling stationary data without trend and seasonality. In this study we applied the double moving average method: **MA** (3X3)

5steps for forecasting using the double moving average method are outlined as follows:

I. Calculate single moving average: $S'_t = \frac{Y_t + Y_{t-1} + Y_{t-2} + \cdots + Y_{t-N-1}}{N}$ where N=3

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II. Calculate the double moving average :$S''_t = \frac{S'_t + S'_{t-1} + S'_{t-2} + \cdots + s'_{t-N-1}}{N}$

III. Determine the value of the constant: $a_t = 2S'_t - S''_t$

IV. Determine the trend estimate (slope): $b_t = \frac{2}{N-1}(S'_t - S''_t)$

V. Determine the forecast value : $F_{t+m} = a_t + b_t m$

N is the number of time periods (data points) in the moving average: In this study N=3 i.e.*3year moving average*

*m*is the period ahead forecast: In this study m=10*(Forecast period is 2021-2030)*

Y_t is the adolescent fertility rate at time period *t*

Data Issues

This study is based on annual adolescent fertility 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

Double moving average model summary

Table 1: double moving average model summary

Variable	Y
Model	MA (3X3)
Included observations	56
Performance measures	
Mean absolute error (MAE)	1.116804
Sum squared error (SSE)	212.860550
Mean square error (MSE)	3.801081
Mean percentage error (MPE)	0.038439
Mean Absolute Percentage error (MAPE)	0.916741

Residual Analysis for the Applied Model

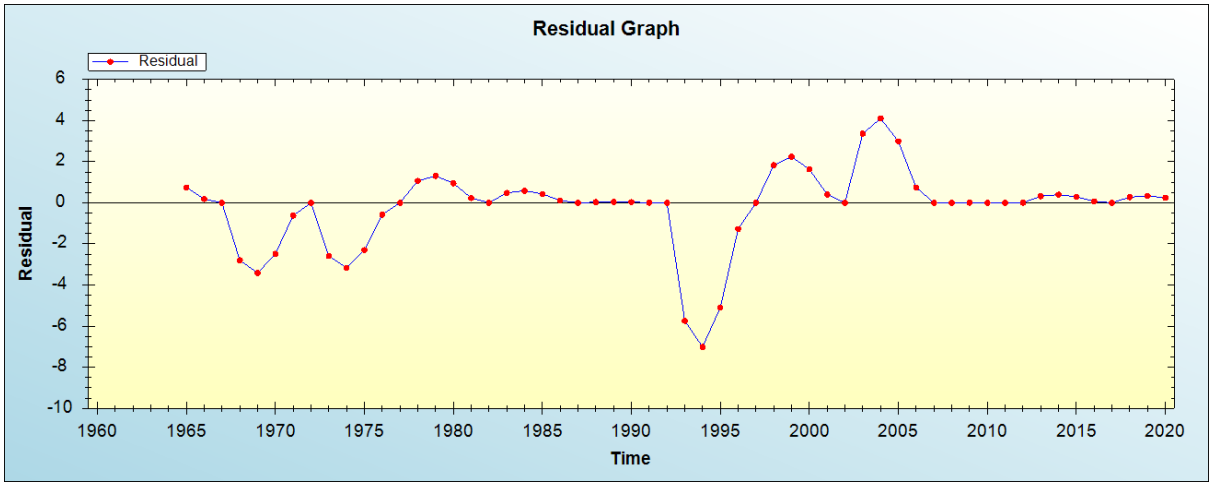

Figure 1: Residual analysis

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In-sample Forecast for Y

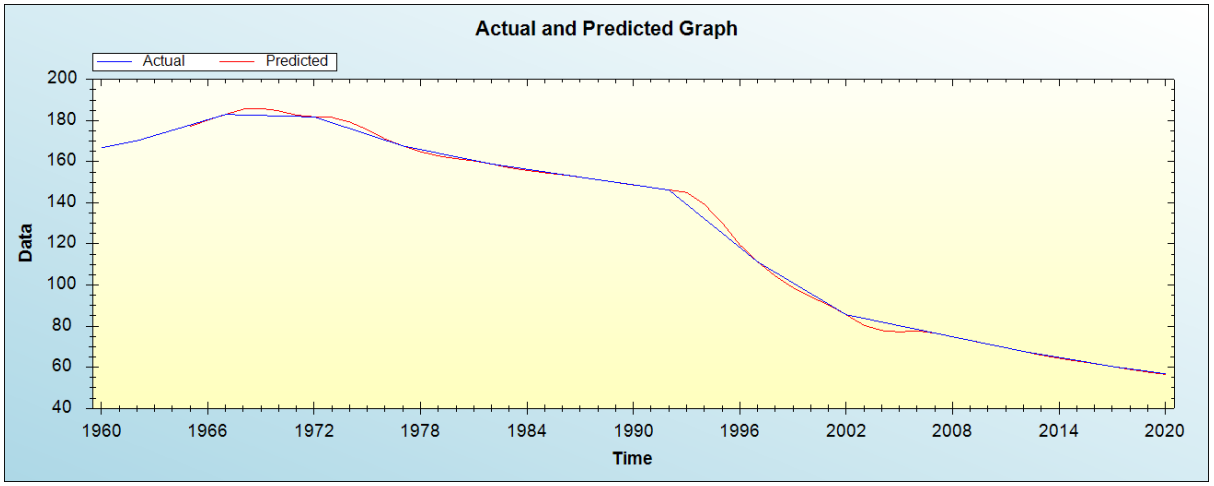

Figure 2: In-sample forecast for the Y series

Actual and smoothed graph for Y

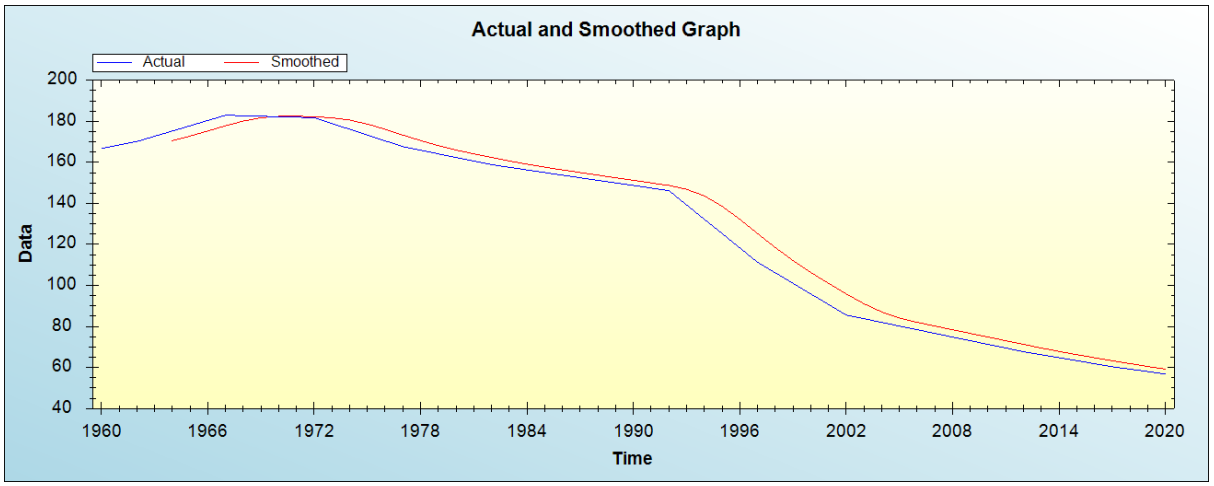

Figure 3: Actual and smoothed graph for Y

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

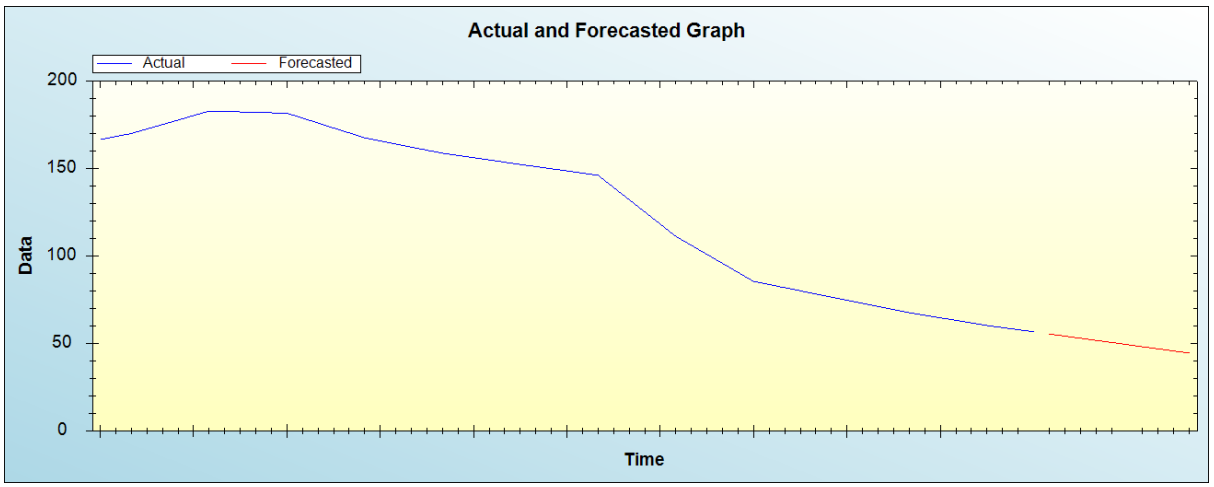

Figure 4: Out-of-sample forecast for Y: actual and forecasted graph

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Out-of-Sample Forecast for Y: Forecasts only

Table 2: Tabulated out-of-sample forecasts

2021	55.5326
2022	54.3125
2023	53.0924
2024	51.8724
2025	50.6523
2026	49.4322
2027	48.2121
2028	46.9920
2029	45.7719
2030	44.5518

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 continue to drop throughout the out of sample period.

V. POLICY IMPLICATION & CONCLUSION

Teenage conception remains a global health challenge due to the associated adverse pregnancy outcomes which threaten the lives of the mother and newborn. Addressing various problems that affect adolescent sexual and reproductive health will help to reduce teenage pregnancy and its complications. In this study we applied the double moving average method to forecast adolescent fertility for Yemen. The study findings revealed that adolescent fertility will continue to decline throughout the out of sample period. Therefore we encourage authorities in Yemen to scale up campaigns against sexual abuse of women and girls, enforce laws that safeguard sexual and reproductive health rights of women and girls and offer affordable and accessible adolescent health services.

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Citation of this Article:

Smartson. P. NYONI, Thabani NYONI, “Assessing the Feasibility of Ending Adolescent Births in Yemen Using the Double Moving Average Method” Published in *International Research Journal of Innovations in Engineering and Technology - IRJIET*, Volume 7, Issue 2, pp 486-491, February 2023. Article DOI https://doi.org/10.47001/IRJIET/2022.702081

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