

Prediction of HIV prevalence among individuals aged 15-49 years in Cameroon using Holt’s linear method

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Abstract

This study uses annual time series data of HIV prevalence among individuals aged 15-49 years for Cameroon from 1990 to 2020 to predict future trends of HIV prevalence over the period 2021 to 2030. The study utilizes Holt’s linear method. The optimal values of smoothing constants α and β are 0.9 and 0.2 respectively based on minimum MSE. The results of the study indicate that annual HIV prevalence among individuals aged 15-49 years will continue to decline over the out of sample period. Therefore, policy makers are encouraged to scale up HIV case detection, prevention and treatment particularly among key populations and vulnerable groups in the society.

Keyword: - Exponential smoothing, Forecasting, HIV prevalence

Background

HIV remains the leading cause of morbidity and mortality in Cameroon, accounting for 11.5 per cent of the disease burden and 14.2 per cent of deaths in 2013 (Global burden of diseases, 2020; MoPH, 2016). The overall adult HIV seroprevalence is on a downward trajectory, dropping from 5.4% in 2004 to 4.3% in 2011, 3.4% in 2017 and 2.7% in 2018 (2018 Cameroon DHS Summary Report; CAMPHIA 2017–2018; 2011 Cameroon Multiple indicator survey; 2004 Cameroon DHS). The downward trend in the prevalence of HIV witnessed amongst young men and women in Cameroon reflects tremendous progress made in controlling the HIV epidemic. It is important to highlight that antiretroviral therapy has transformed HIV infection to a manageable chronic medical condition with a different epidemiological pattern (Broder, 2010; Hariri & McKenna, 2007). The purpose of this research is to model and forecast HIV prevalence among individuals aged 15-49 years for Cameroon using Holt’s linear method. The results of this paper are expected to inform policy, planning and allocation of resources to targeted HIV prevention, treatment and care programs in the country.

Literature Review

Author(s)	Objective(s)	Methodology	Main finding(s)
Bekolo et al. (2023)	to review current evidence for declining HIV prevalence despite increasing survival owing to ‘universal test and treat’ and to explore the reason for the decrease, particularly the role of behavioral change.	conducted a secondary analysis using HIV prevalence, behavioral and social determinants data of the Demographic and Health Survey Program databases	The observed decline in HIV prevalence is statistically valid and reflects the observed decline in risky sexual behavior that need to be sustained by the National HIV programme
Djiyou et al. (2023)	To prospectively assess the rate of VS, and the factors associated with VF in	A cross-sectional study was carried out in 2021 among adolescents (aged 10–	Overall, 280 adolescents were enrolled, of whom 89.3% (250/280)

	a cohort of adolescents followed up according to the WHO guidelines in Cameroon	19 years) receiving ART in the national program in Cameroon	acquired HIV infection via mother-to-child transmission. -the VS rate was 88.2% (CI: 83.8-91.7%) overall; 89.0% (CI: 82.0-93.1%) and 88.7% (CI: 81.2-93.0%) in females and males, respectively
Akuoko et al. (2021)	The study focused on Cameroon, Ethiopia, Ghana, and Zambia to give a general overview of the HIV situation in the region.	2019 data by UNAIDS were assessed and compared with the 2018 data	The results revealed a disproportionate burden of the disease among women aged 15 years and above, as compared to men of the same ages and children below 15 years. Also, it was revealed that ARV services among pregnant women are effective in reducing the number of new infections among newborns.
Martial et al. (2021)	To examine the long-term trend of the overall HIV/AIDS incidence rates in four countries of the central region of Africa, using data from the Global Burden of Diseases (GBD) 2019 study.	The Age-Period-Cohort statistical model analysis was used to measure the trends of HIV/AIDS incidence rates in each of the four countries.	HIV/AIDS incidence rates are decreasing in each of the four countries.
Nsagha et al. (2012)	To assess the burden of orphans and vulnerable children due to HIV/AIDS in Cameroon.	Scoping review	Results showed that only 9% of all OVC in Cameroon are given any form of support. AIDS death continue to rise in Cameroon. In 1995, 7,900 people died from AIDS in the country; and the annual number rose to 25,000 in 2000. Out of 1,200,000 orphans and vulnerable

			children in Cameroon in 2010, 300,000(25%) were AIDS orphans. Orphans and the number of children orphaned by AIDS has increased dramatically from 13,000 in 1995 to 304,000 in 2010. By 2020, this number is projected to rise to 350,000
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Methodology

This study utilizes Holt’s double exponential smoothing technique to model and forecast future trends of HIV prevalence among individuals aged 15-49 years in Cameroon. 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

$$A_t = \mu_t + \rho_t t + \varepsilon_t \dots \dots \dots [1]$$

Smoothing equation

$$S_t = \alpha A_t + (1-\alpha) (S_{t-1} + b_{t-1}) \dots \dots \dots [2]$$

$$0 < \alpha < 1$$

Trend estimation equation

$$b_t = \beta (S_t - S_{t-1}) + (1-\beta) b_{t-1} \dots \dots \dots [3]$$

$$0 < \beta < 1$$

Forecasting equation

$$f_{t+h} = S_t + h b_t \dots \dots \dots [4]$$

A_t is the actual value of HIV prevalence at time t

ε_t is the time varying **error term**

μ_t is the time varying mean (**level**) term

ρ_t is the time varying **slope term**

t is the trend component of the time series

S_t is the exponentially smoothed value of HIV prevalence 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

b_t is the trend estimate (slope of the trend) at time t

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

Data Issues

This study is based on annual HIV prevalence among individuals aged 15-49 years in Cameroon for the period 1990 – 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.

Study findings

Exponential smoothing Model Summary

Table 1: ES model summary

Variable	A
Included Observations	31
Smoothing constants	
Alpha (α) for data	0.900
Beta (β) for trend	0.200
Forecast performance measures	
Mean Absolute Error (MAE)	0.259100
Sum Square Error (SSE)	6.127426
Mean Square Error (MSE)	0.197659
Mean Percentage Error (MPE)	-4.186224
Mean Absolute Percentage Error (MAPE)	15.754417

Residual Analysis for the Applied Model

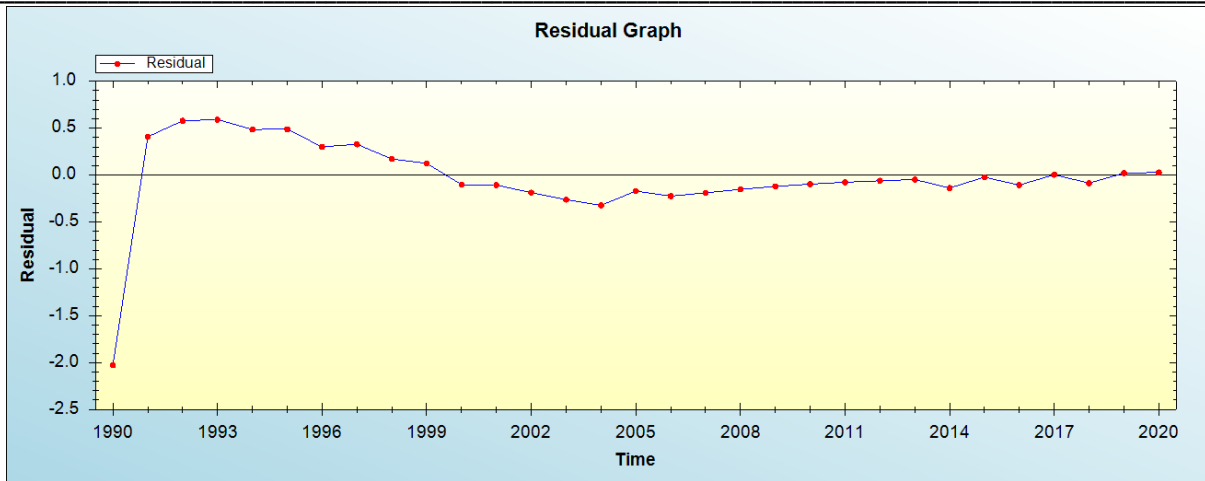


Figure 1: Residual analysis

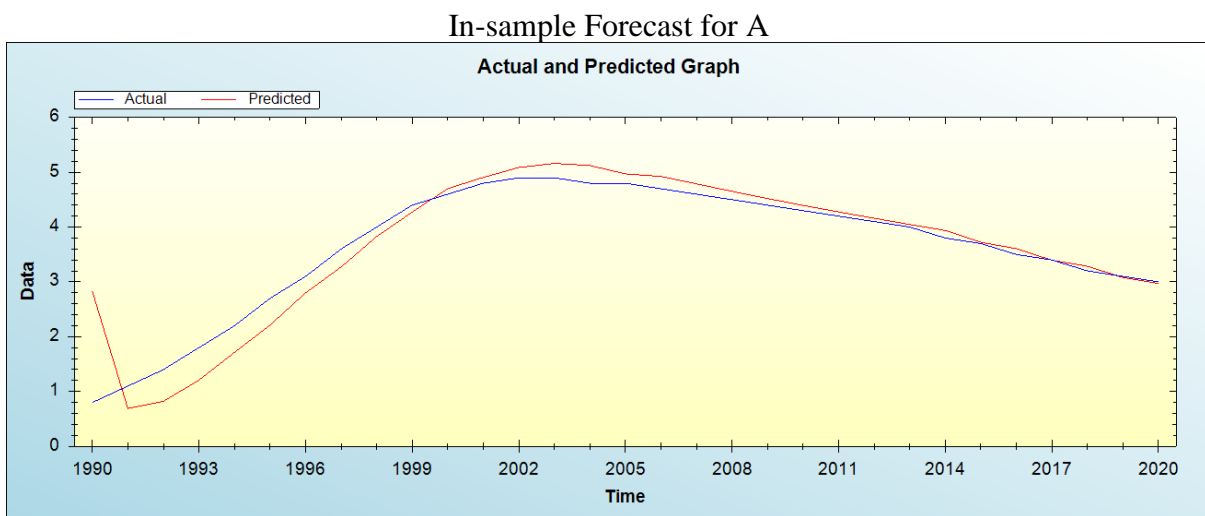


Figure 2: In-sample forecast for the A series

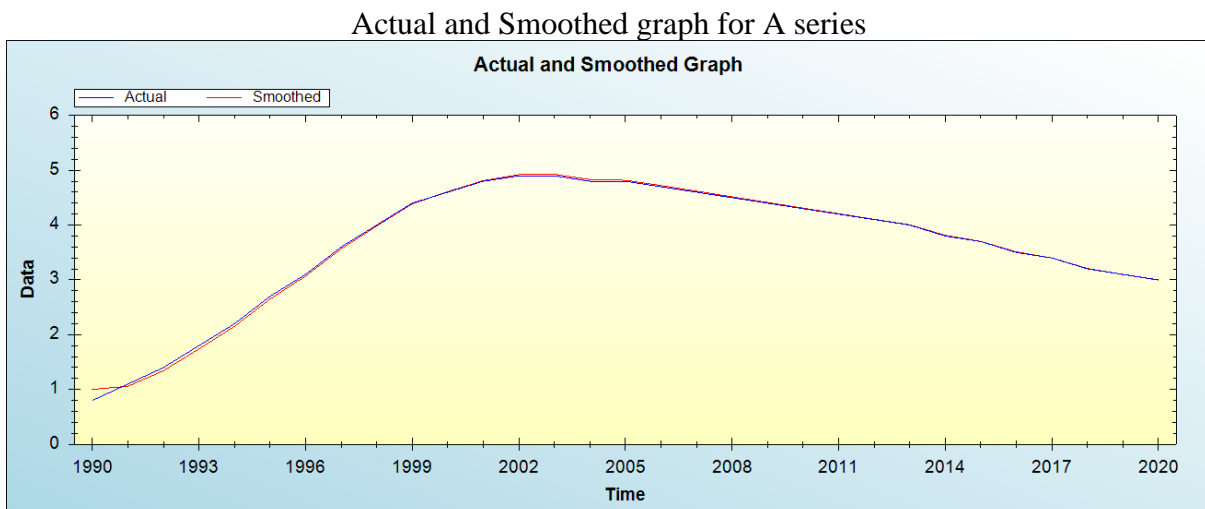


Figure 3: Actual and smoothed graph for A series

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

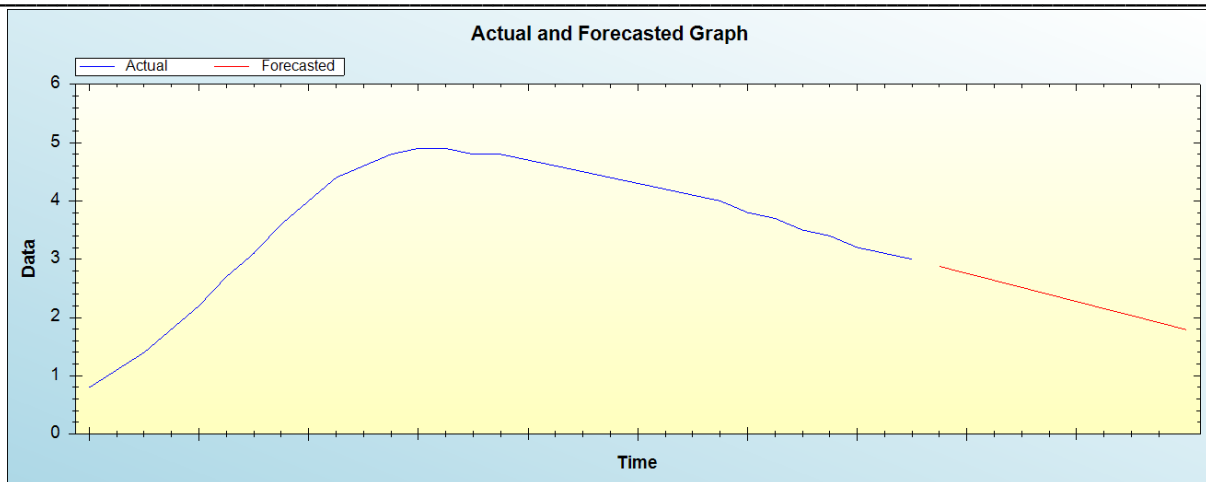


Figure 4: Out-of-sample forecast for A: actual and forecasted graph

Out-of-Sample Forecast for A: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Year	Forecasted HIV prevalence
2021	2.8766
2022	2.7559
2023	2.6352
2024	2.5146
2025	2.3939
2026	2.2732
2027	2.1526
2028	2.0319
2029	1.9112
2030	1.7906

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 HIV prevalence among individuals aged 15-49 years will continue to decline over the out of sample period.

Policy implications and conclusion

This study applied Holt’s double exponential smoothing technique to forecast annual HIV prevalence among individuals aged 15-49 years for Cameroon. Forecast results suggest a downward trajectory of HIV prevalence in the out of sample period. Therefore, policy makers are encouraged to scale up HIV case detection, prevention and treatment particularly among key populations and vulnerable groups in the society.

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