

Detecting future trends of HIV prevalence among individuals aged 15-49 years for Congo using Holt's double exponential smoothing technique

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Abstract

This study uses annual time series data of HIV prevalence among individuals aged 15-49 years for Congo from 1990 to 2020 to predict future trends of HIV prevalence over the period 2021 to 2030. The study utilizes Holt's double exponential smoothing model. The optimal values of smoothing constants α and β are 0.9 and 0.1 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, there is need to continuously support HIV prevention, testing, and treatment among this age group.

Keyword (s): - Exponential smoothing, Forecasting, HIV prevalence

Background

HIV remains a public health threat in the Republic of Congo and Sub-Saharan Africa as a whole. High levels of HIV infection among adolescents, particularly girls, have been a major concern in sub-Saharan Africa, where around 80% of the world's HIV-infected adolescents live (Slogrove *et al.* 2017; Idele *et al.* 2014). Adolescent girls and young women aged 15–24 years accounted for one in five new HIV infections, despite being just 10% of the population of sub-Saharan Africa (UNAIDS, 2019). UNAIDS reported that between 2010 and 2017, there was a 25% drop in new HIV infections among girls aged 10–19 years in Eastern and Southern Africa, but no decline in West and Central Africa. A recent analysis of pooled data from longitudinal community studies in Eastern and Southern Africa revealed that adolescent girls had 5.9 and 3.2 times higher HIV incidence than adolescent boys during 2005–2015, respectively, with only limited evidence of a decline over time (Birdthistle *et al.* 2019). In the case of Congo the HIV epidemic is concentrated among key populations that include sex workers, prisoners and men who have sex with other men. The national HIV program are currently prioritizing these key populations in order to curb new HIV infections.

The purpose of this paper is to model and forecast HIV prevalence among individuals aged 15-49 years for Congo using Holt's double exponential smoothing technique. Research findings are expected to inform national policy, planning and allocation of resources towards targeted HIV programs in the Republic of Congo so as to control the HIV epidemic.

Literature Review

Author(s)	Objective (s)	Methodology	Main finding(s)
Bongonya et al. (2023)	To determine the reasons behind the loss of patients on Antiretroviral Treatment (ART)	descriptive survey	Nearly half of the patients no longer return to the treatment centers where they started

	after 6 months of follow-up.		
Mukadi-Bamuleka et al. (2022)	To determine the prevalence of HIV and to describe the sexual practices and behaviors among MSM recruited in Kinshasa, DRC.	prospective cross-sectional study	The study reported a high prevalence of HIV among MSM which is associated with the high-risk sexual practices and behaviors such as the bisexuality, the multiple sexual partners, and the diversity of anal intercourses
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.
Dane et al. (2020)	To describe the programme and report testing yields before and after the intervention.	utilized χ^2 tests to compare the testing yield at the start of the intervention to that 10 months after the start of programme implementation	HIV testing yield increased over the course of implementation
Pour et al.(2020)	To evaluate the prevalence of HIV in patients in the urban Kinshasa area.	HIV prevalence was determined from data obtained between March-July of 2018 from 8320 individuals over the age of 18 years receiving care at one of 47 clinics in Kinshasa.	The prevalence of HIV in our study was 11.0% (95% CI 10.3-11.6%) overall and 8.14% in the subset of N = 1240 participants who were healthy mothers seeking prenatal care.

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 Congo. 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

$$V_t = \mu_t + \rho_t \mathbf{t} + \varepsilon_t \dots \dots \dots [1]$$

Smoothing equation

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

$$0 < \alpha < 1$$

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

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

V_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**

\mathbf{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 Congo 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	V
Included Observations	31
Smoothing constants	
Alpha (α) for data	0.900
Beta (β) for trend	0.100
Forecast performance measures	
Mean Absolute Error (MAE)	0.133963
Sum Square Error (SSE)	1.663612
Mean Square Error (MSE)	0.053665
Mean Percentage Error (MPE)	0.288069
Mean Absolute Percentage Error (MAPE)	3.199402

Residual Analysis for the Applied Model

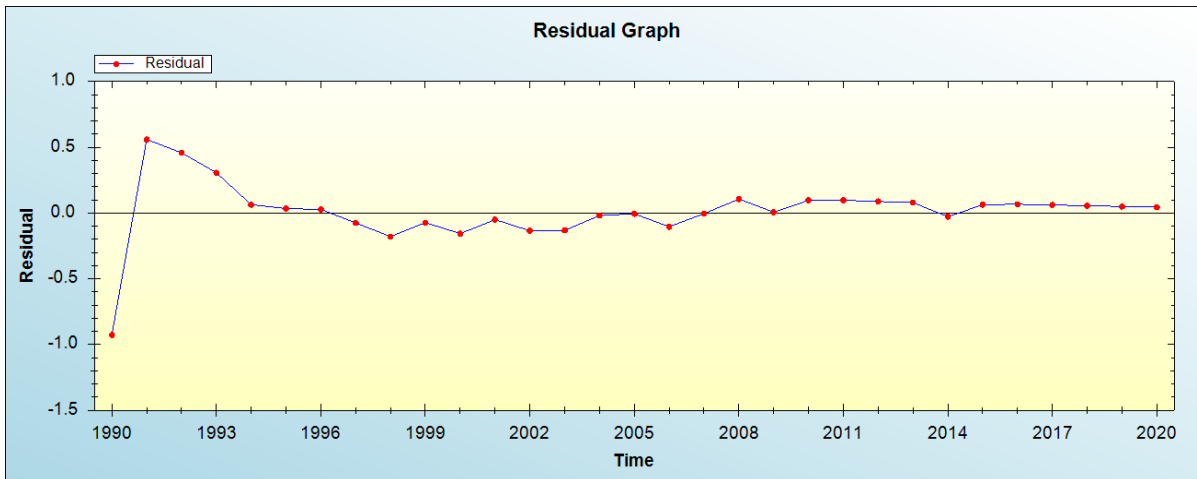


Figure 1: Residual analysis

In-sample Forecast for V

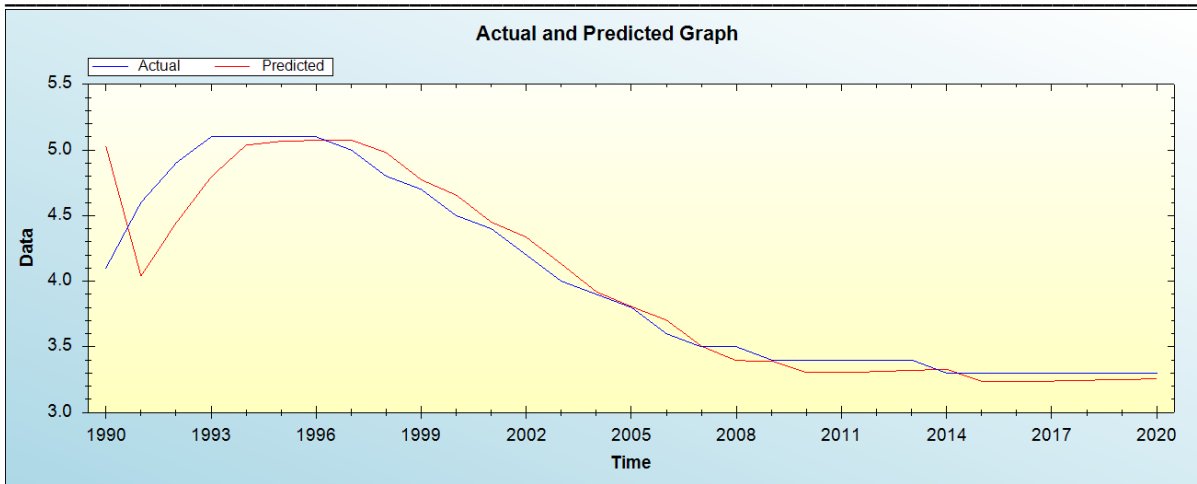


Figure 2: In-sample forecast for the V series

Actual and Smoothed graph for V series

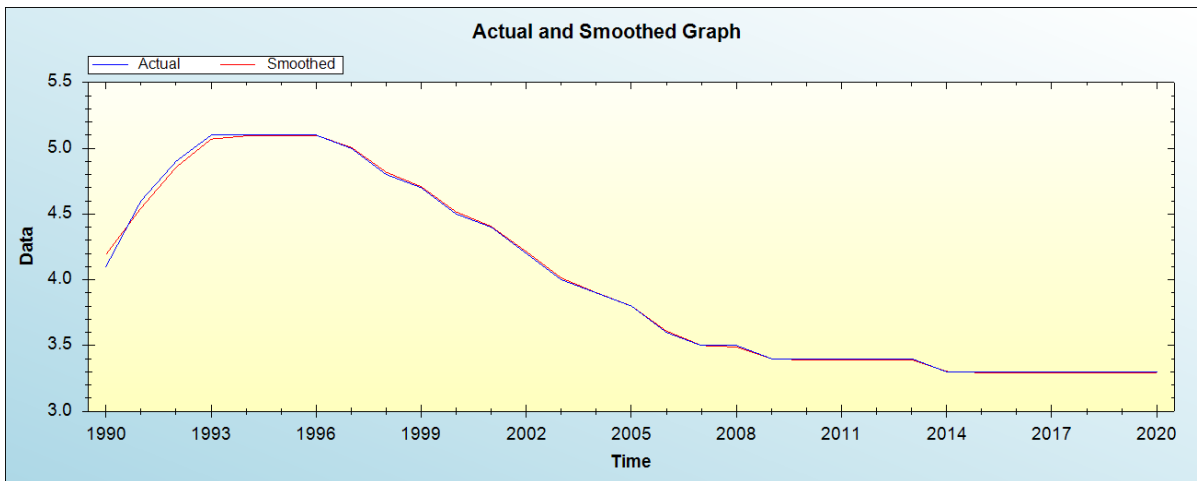


Figure 3: Actual and smoothed graph for V series

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

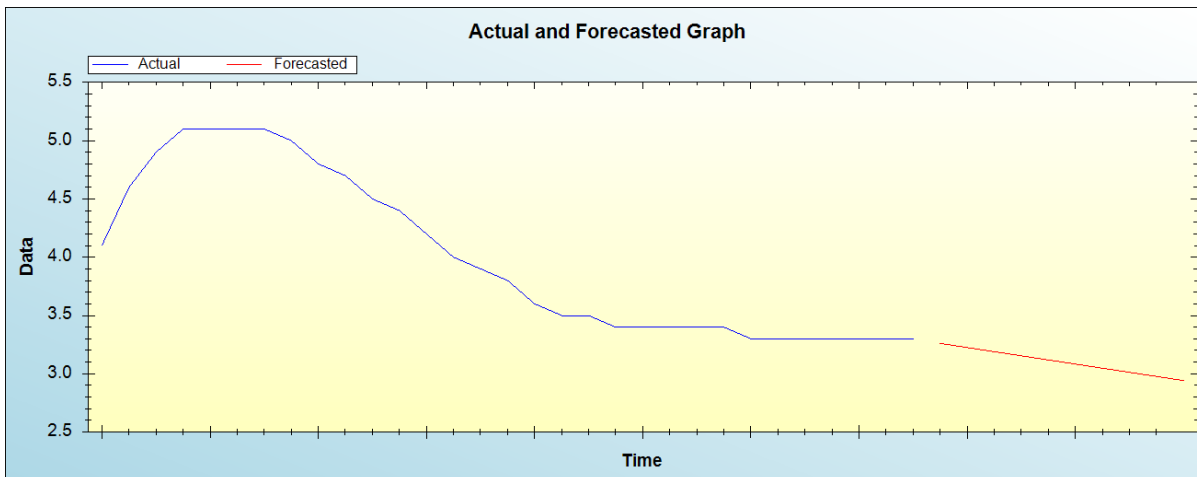


Figure 4: Out-of-sample forecast for V: actual and forecasted graph

Out-of-Sample Forecast for V: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Year	Forecasted HIV prevalence
2021	3.2601
2022	3.2247
2023	3.1893
2024	3.1539
2025	3.1184
2026	3.0830
2027	3.0476
2028	3.0122
2029	2.9767
2030	2.9413

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 implication and conclusion

Our study results indicate that annual HIV prevalence among individuals aged 15-49 years will continue to decline over the out of sample period. Hence, there is need to continuously support HIV prevention, testing, and treatment among this age group.

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