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APPLICATION OF HOLT'S LINEAR METHOD TO PROJECT HIV PREVALENCE AMONG INDIVIDUALS AGED 15-49 YEARS IN TOGO

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Abstract:

This study uses annual time series data of HIV prevalence among individuals aged 15-49 years for Togo from 1990 to 2020 to predict future trends of HIV prevalence over the period 2021 to 2030. The study utilizes Holt's linear 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 testing, treatment and HIV prevention programs especially among high-risk groups or key populations.

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

Introduction

According to UNAIDS data-2020 approximately 1.8 million adolescents aged 10–19 years were living with HIV in 2017 in the entire world. Sub-Saharan Africa is the most affected region, accounting for 84% of the adolescents living with HIV (ALHIV) (Slogrove *et al.* 2018; UNAIDS, 2018; UNICEF, 2017). UNICEF 2018 data revealed that adolescent girls accounted for three-quarters of all new HIV infections among adolescents in 2018. HIV/AIDS was the number one cause of mortality among adolescents in this region in 2016 (Lim *et al.* 2016). UNAIDS revealed that among the 23 African priority countries approximately 24,000 AIDS related deaths were reported in adolescents aged 10–14 years and 25,000 in those aged 15– 19 years in 2017. Addition, it was estimated that among the 120,000 PLWH in Togo in 2019, 20,000 (16.7%) were aged 50 years (UNAIDS, 2020). The purpose of this study is to model and forecast HIV prevalence among individuals aged 15-49 years for Togo using Holt's double exponential smoothing technique. The findings of this research are expected to inform policy, planning and allocation of resources towards targeted HIV prevention programs particularly for Key populations and other vulnerable groups in Togo.

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Literature Review

Author (s)	Objective (s)	Methodology	Key finding (s)
Gbeasor-Komlanvi et al. (2021)	To describe HIV testing uptake, as well as HIV prevalence and its associated factors among older adults aged 50 years in health facilities in Togo.	A cross-sectional study was carried out from February 2018 to June 2019 among hospitalized older adults aged 50 years in tertiary and secondary hospitals in Togo.	The majority of older adults in this study accepted testing for HIV and almost three in five HIV positive older adults were newly diagnosed with HIV as a result of this testing
Revegue et al. (2021)	To assess their 24-month outcomes in relation to the disclosure of their own HIV serostatus	-measured the HIV serostatus disclosure at baseline and after 24 months and analyzed its association with a favorable combined 24-month outcome using logistic regression.	The frequency of HIV-disclosure improved over time and differed across countries but remained low among West African APHIV. Overall, the 24-month outcomes were poor.
Okey (2020)	To determine the factors of regular ARV demand. The study concerns 2269 patients who initiated treatment between January 1 and December 31, 2017 in Togo.	From the study of the behavior of the care consumer the analysis of the non-monetary Determinants of health care demand is based on the Logit model.	Determinants were found to be Sex, occupational status, World Health Organization (WHO) stage of illness, marital status and administrative region of life influence patient compliance.
Amenyah-Ehlan et al. (2017)	To document the trend of HIV-2 prevalence over a decade of activities of the National Reference Center for HIV tests and screening (CNR-VIH)	A cross sectional study was carried out from the screening data archived from January 2005 to December 2014 at the CNR-VIH, a laboratory located in the Sylvanus Olympio University Hospital (CHU SO) Lome	Data from the National Reference Center for HIV Tests in Togo over the last ten years confirm the existence of a weak epidemic of HIV- 2 infection with a tendency towards stability
Teclessou et al. (2017)	To assess sexual behavior and measure HIV prevalence among MSM in 2015, in Togo. Methods: We conducted a cross-sectional study from February to March 2015 in nine major cities of Togo.	Behavioral data were collected by interviewer-administered questionnaires	The study confirmed that HIV prevalence among MSM is five times higher than in the general population (13% vs 2.5%)

Methodology

This study utilizes an exponential smoothing technique to model and forecast future trends of HIV prevalence among individuals aged 15-49 years in Togo. 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.

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Holt's linear method is specified as follows:

Model equation

$A_t=\mu_t + \rho_t \mathbf{t} + \varepsilon_t$

Smoothing equation

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

$0<\propto<1$

Trend estimation equation

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

$0<\beta<1$

Forecasting equation

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

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 Togo 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.

Findings of the study

Exponential smoothing Model Summary

Table 1: ES model summary

Variable	A
Included Observations	
Smoothing constants	
Alpha (α) for data	0.900
Beta (β) for trend	0.100
Forecast performance measures	
Mean Absolute Error (MAE)	0.154166
Sum Square Error (SSE)	2.105794
Mean Square Error (MSE)	0.067929
Mean Percentage Error (MPE)	-1.160075
Mean Absolute Percentage Error (MAPE)	6.169507

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Residual Analysis for the Applied Model

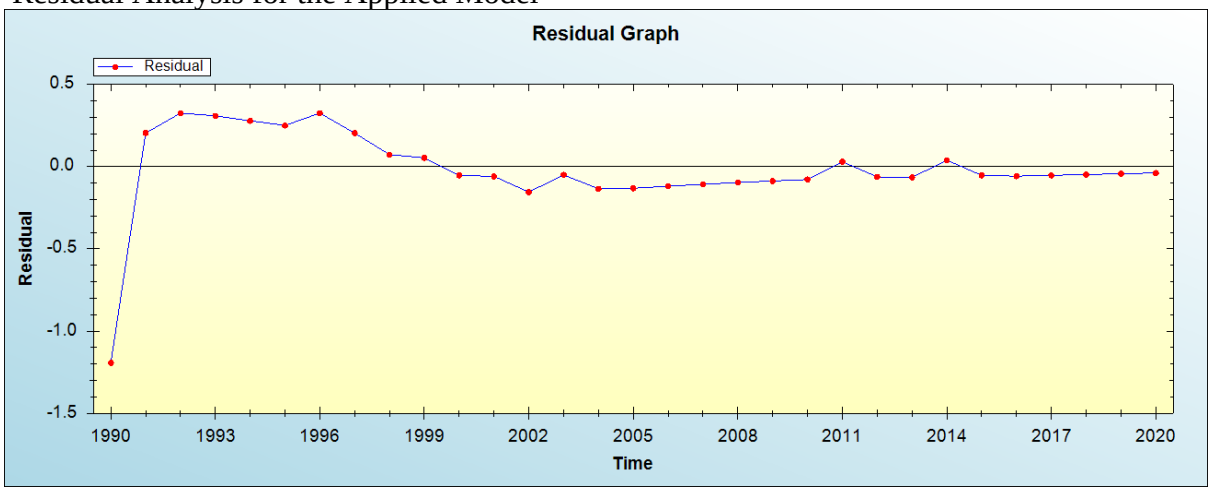

Figure 1: Residual analysis

In-sample Forecast for A

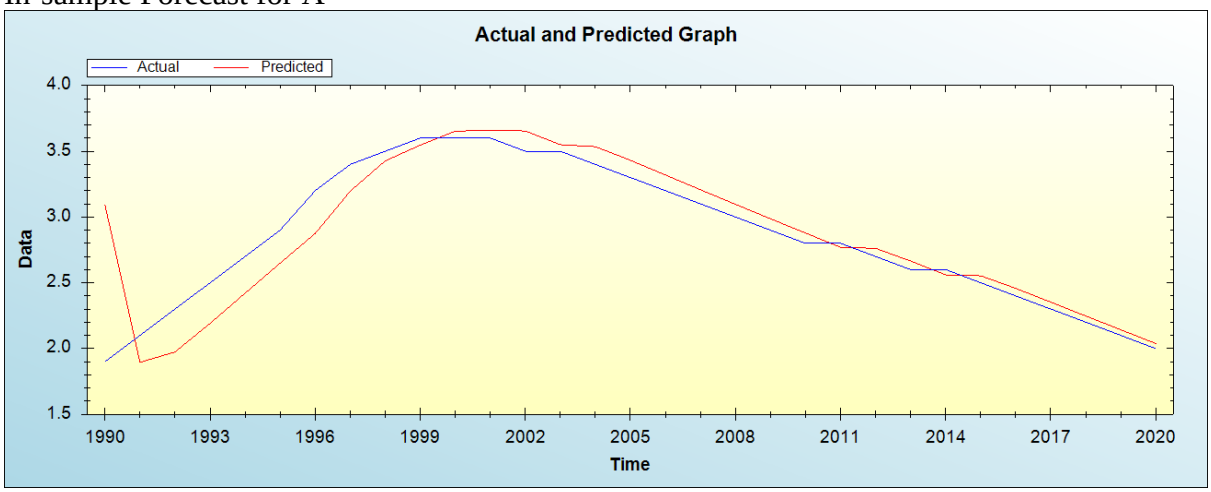

Figure 2: In-sample forecast for the A series

Actual and Smoothed graph for A series

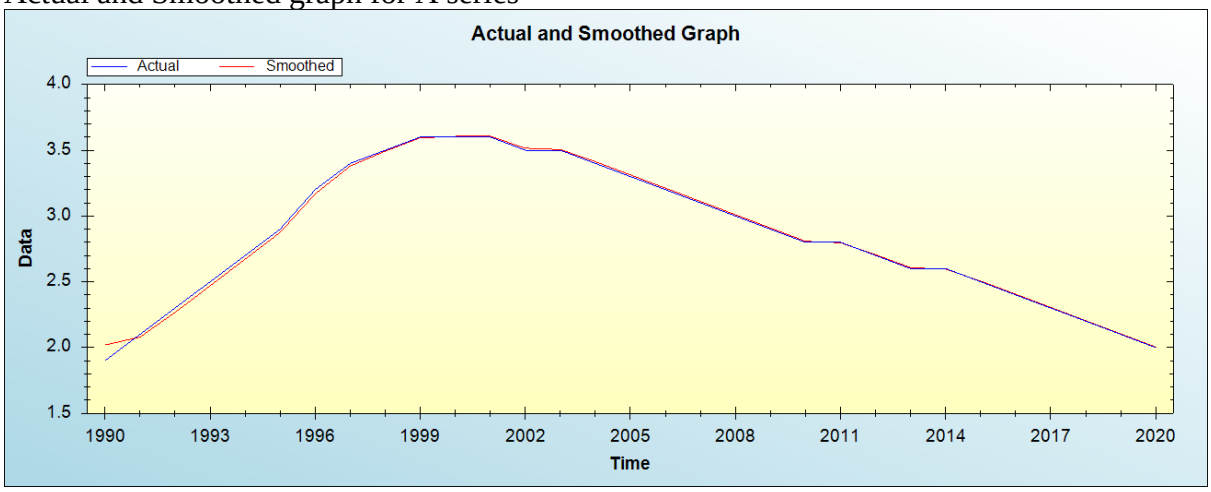

Figure 3: Actual and smoothed graph for A series

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

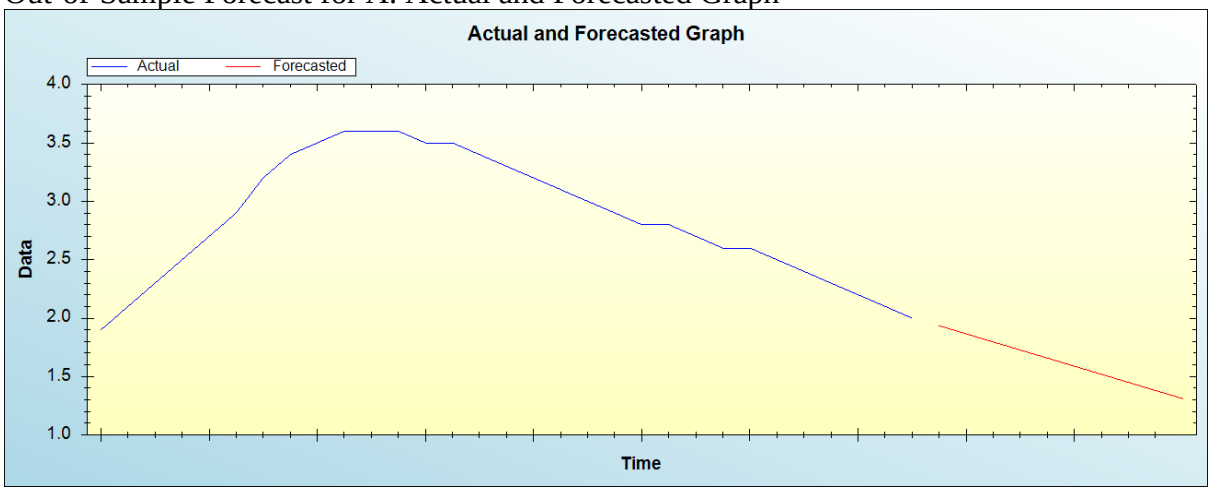

Figure 4: Out-of-sample forecast for A: actual and forecasted graph

Out-of-Sample Forecast for A: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Year	Forecasted HIV prevalence
2021	1.9346
2022	1.8653
2023	1.7960
2024	1.7267
2025	1.6574
2026	1.5882
2027	1.5189
2028	1.4496
2029	1.3803
2030	1.3110

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 model projections 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 testing, treatment and HIV prevention programs especially among high-risk groups or key populations.

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