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TRACKING FUTURE TRENDS OF HIV PREVALENCE AMONG INDIVIDUALS AGED 15-49 YEARS IN GUINEA BISSAU 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 Guinea Bissau 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 0.5 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, it is critical to direct more effort on improving ART retention and adherence especially among adolescents to minimize treatment failure.

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

Introduction

The joint United Nations programme on HIV/AIDS (UNAIDS) revealed that HIV prevalence among adults (15–49 years) in Guinea-Bissau was 3.4% in 2017 but variations exist within the country. Approximately 1–2 million people are living with HIV in West Africa (Arien *et al.* 2013) and the predominant subtype is HIV-2 (Clavel *et al.* 1986). According to the Bandim Health Project (BHP), the prevalence of HIV-1 increased from zero to 4.6% between 1987 and 2006 whereas HIV-2 has been steadily decreasing in prevalence from 8.9% in 1987 to 2.8% in 2016 (Olesen *et al.* 2018; da Silva *et al.* 2008; Larsen *et al.* 1998; Poulsen *et al*. 1989). The government of Guinea Bissau has made significant progress in terms of rolling out and scaling up ART services across the country. However, the national ART program has met several challenges such as loss to follow up, non-adherence to ART, treatment failure and HIV morbidity and mortality (Jespersen *et al.* 2020). The objective of this paper is to model and forecast future trends of HIV prevalence among adults aged 15-49 years using Holt's linear method. We anticipate that study results will highlight likely future trends of HIV sero-prevalence among adults aged 15-49 years and thus guide allocation of resources towards HIV, treatment and care programs for the sexually active age group.

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Literature review

Author (s)	Objective (s)	Methodology	Main finding (s)
Nshimirimana et al. (2022)	To assess HIV testing uptake and its determinants among adolescents and young adults	Cross- sectional design involving analysis of 2016 Demographic and Health Survey data.	Despite the interventions implemented to reach the 90- 90- 90 UNAIDS goals, HIV testing among youth in Burundi was low
Gelibo et al. (2021)	To identify geographic locations and drivers of HIV transmission in Ethiopia	Used data from adults aged 15–64 years who participated in the Ethiopian Population-based HIV Impact Assessment survey (October 2017–April 2018). Location-related information for the survey clusters was obtained from the 2007 Ethiopia population census. Spatial autocorrelation of HIV prevalence data were analyzed via a Global Moran's I test.	Uncircumcised men in certain hotspot towns and divorced or widowed individuals in hotspot woredas/towns might have contributed to the average increase in HIV prevalence in the hotspot areas.
Galjour et al. (2021)	To give a detailed information on HIV/AIDS epidemic in Guinea-Bissau during the Millennium Development Goals (MDGs) period (2000–2015	Systematic review	The results suggested the importance of considering a broader political epidemiology that accounts for socio-political aspects such as governance, human rights, and community responses into which any national HIV/AIDS response is integrated.
Njejimana et al. (2021)	To determine and characterize this problem in Burundi.	qualitative analysis based on an extensive series of 114 interviews	The problem of HIV/AIDS stigma is widespread in Burundian society, as all participants in the research reported having experienced some kind of HIV stigma. The seven dimensions of stigma identified in people living with HIV/AIDS (PLWHA) in Burundi are physical violence, verbal violence, marginalization, discrimination, self-stigma, fear and insecurity, and healthcare provider stigma
Rasmussen et al. (2020)	To assess changes in HIV prevalence, risk factors for HIV, provision of PMTCT antiretroviral treatment (ART), and the association between HIV infection, birth outcomes and maternal characteristics at the Simão Mendes National Hospital, Guinea-Bissau's largest maternity ward.	cross-sectional data collected from June 2008 to May 2013	Twenty-two percent of infants did not receive treatment, and 67% of HIV-2-infected mothers and 77% of their infants received ineffective non-nucleoside reverse transcriptase inhibitors for PMTCT. Maternal HIV was associated with low birth weight but not stillbirth. Inadequate continuity of care and ART coverage present challenges to optimal PMTCT in Guinea-Bissau.

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Jespersen et al. (2020)	to give an overview of HIV treatment outcomes in the West African country, Guinea-Bissau, and to assess how newer treatment strategies such as long-acting injectable drugs or an HIV cure may limit or stop the HIV epidemic in this politically unstable and low-resource setting.	Descriptive study	Poor adherence, lack of HIV viral load measurements, inadequate laboratory facilities, high rates of loss to follow-up, mortality, treatment failure and resistance development, are just some of the challenges faced putting the goal of "90–90–90″ for Guinea-Bissau well out of reach by 2020.

Methodology

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

$G_t=\mu_t + \rho_t \mathbf{t} + \varepsilon_t$……..…[1]

Smoothing equation

$S_t= \alpha G_t + (1-\alpha)\ (S_{t-1} + b_{t-1})$……..…[2]

$0<\propto<1$

Trend estimation equation

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

$0<\beta<1$

Forecasting equation

$f_{t+h}= S_t + hb_t$……[4]

G_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

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Data Issues

This study is based on annual HIV prevalence among individuals aged 15-49 years in Guinea Bissau 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	G
Included Observations	31
Smoothing constants	
Alpha (α) for data	0.900
Beta (β) for trend	0.500
Forecast performance measures	
Mean Absolute Error (MAE)	0.155071
Sum Square Error (SSE)	2.366590
Mean Square Error (MSE)	0.076342
Mean Percentage Error (MPE)	-10.111258
Mean Absolute Percentage Error (MAPE)	32.244615

Residual Analysis for the Applied Model

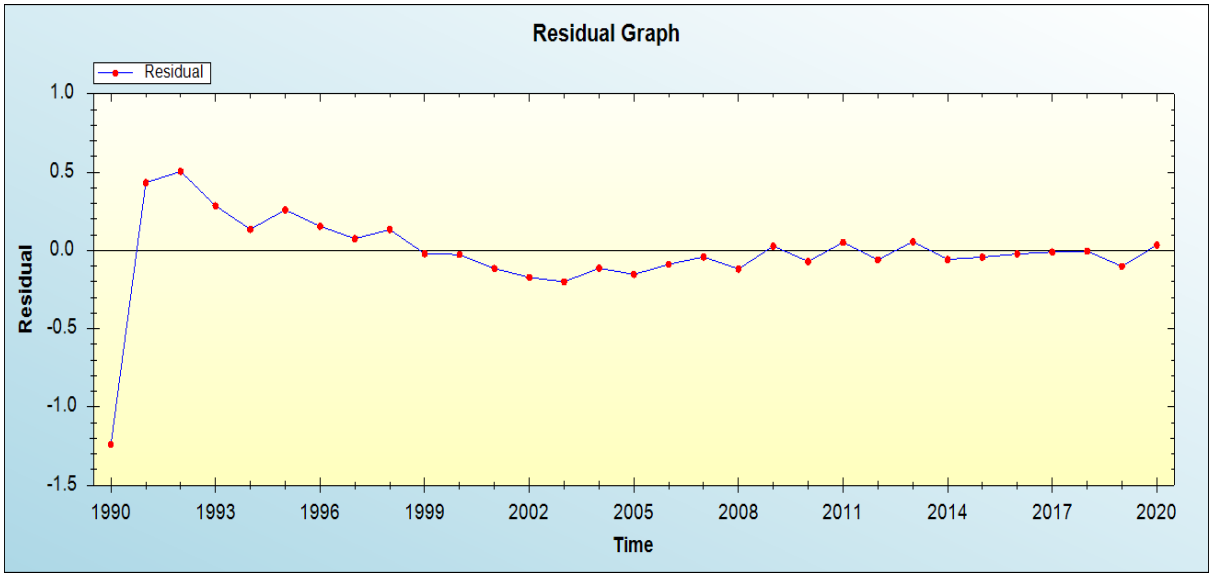

Figure 1: Residual analysis

In-sample Forecast for G

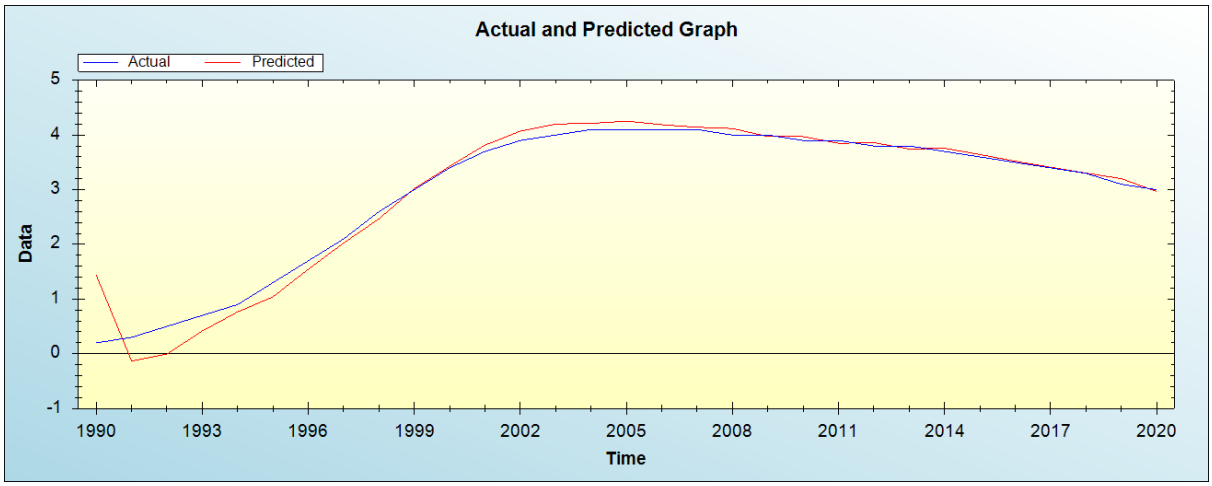

Figure 2: In-sample forecast for the G series

Actual and Smoothed graph for G series

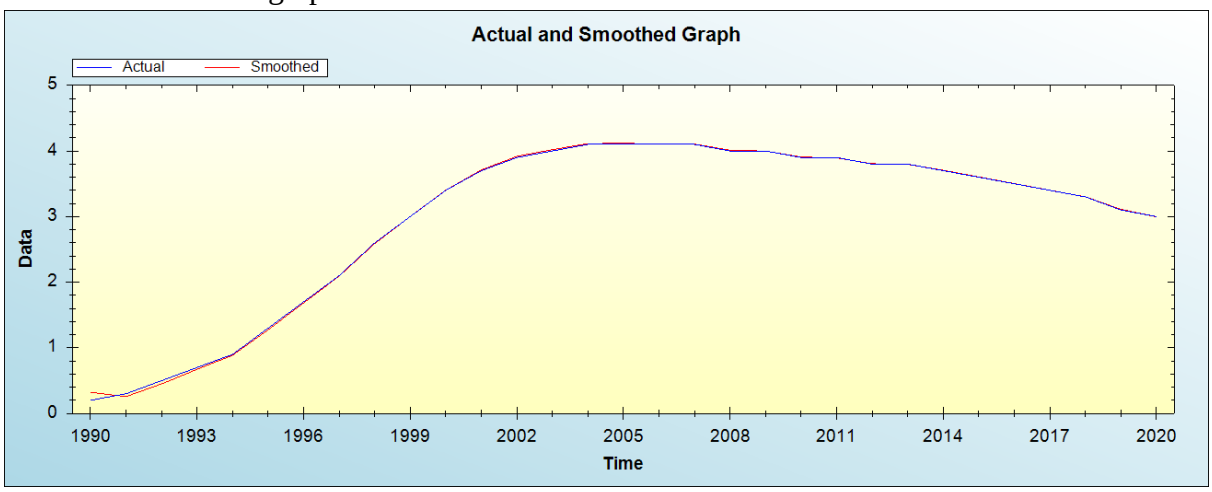

Figure 3: Actual and smoothed graph for G series

ut-of-Sample Forecast for G: Actual and Forecasted Graph

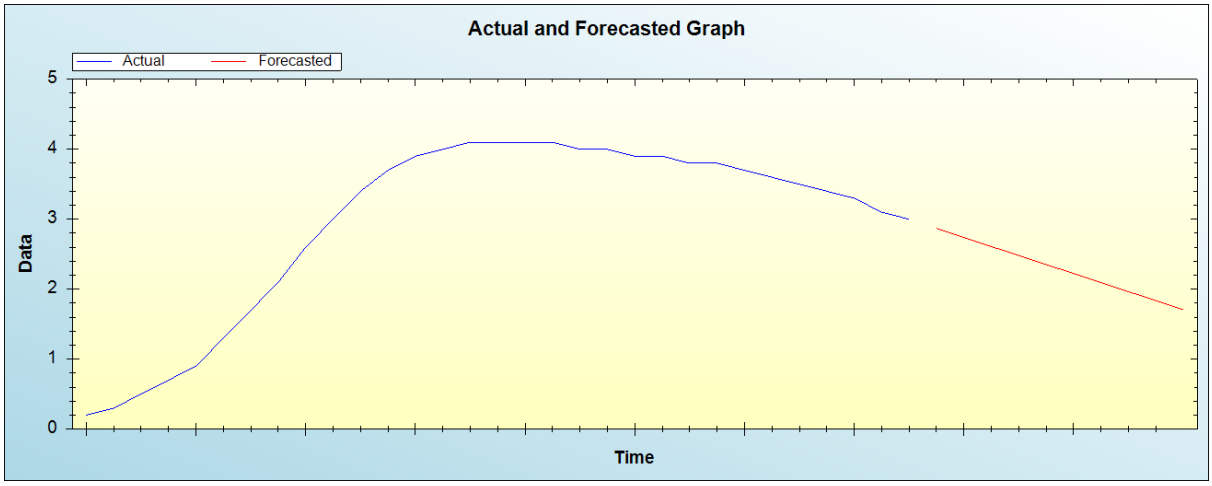

Figure 4: Out-of-sample forecast for G: actual and forecasted graph

Out-of-Sample Forecast for G: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Year	Forecasted HIV prevalence
2021	2.8676
2022	2.7385
2023	2.6095
2024	2.4805
2025	2.3515
2026	2.2225
2027	2.0934
2028	1.9644
2029	1.8354
2030	1.7064

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 results indicate that annual HIV prevalence among individuals aged 15-49 years is anticipated to continue going down in the out of sample period. Therefore, authorities should direct their efforts on improving ART retention and adherence especially among adolescents to minimize treatment failure.

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