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TRACKING THE FUTURE PATH OF HIV PREVALENCE AMONG INDIVIDUALS AGED 15-49 YEARS IN EQUATORIAL GUINEA USING HOLT'S LINEAR EXPONENTIAL SMOOTHING MODEL

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Abstract:

This study uses annual time series data of HIV prevalence among individuals aged 15-49 years for Equatorial Guinea 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 0.6 and 0.9 respectively based on minimum MSE. The results of the study indicate that annual HIV prevalence among individuals aged 15-49 years will continue to increase over the out of sample period. Therefore, we encourage authorities to address top drivers of HIV spread among this age group especially among adolescents and key populations.

Keywords: *Exponential smoothing, Forecasting, HIV prevalence*

BACKGROUND

According to UNAIDS, approximately 38.4 million people were living with HIV (PLHIV) in 2021, with around 1.5 million new HIV infections and 650,000 AIDS-related deaths. Equatorial Guinea is located in West Central Africa between Cameroon and Gabon. HIV/AIDS remains among the top causes of morbidity and mortality worldwide. In Equatorial Guinea, HIV seroprevalence in the general population is 7.8% and has been noted to be the highest within its Word Health Organization (WHO) region (Rodríguez-Galet *et al.* 2023). Women account for 53% of adults living with HIV, with higher HIV prevalence than men (9.4% vs. 5.2%) (UNAIDS, 2022). The HIV prevalence among key populations such as sex workers, men who have sex with men, transgender people, injecting drug users or prisoners in the country, is still unknown. The most common HIV transmission routes are heterosexual, followed by vertical transmission from HIV-infected mother to child and blood transfusions ((MINSAB, 2011; MINASIG, 2019). Approximately 66,000 are living with HIV in Equatorial Guinea, of which 8.6% are children and adolescents (UNAIDS, 2022). The national HIV response focuses on HIV testing services in healthcare facilities and , treatment and care programs in the country.

LITERATURE REVIEW

Author(s)	Objective (s)	Methodology	Key finding(s)
Jensena et al. (2023)	To evaluate whether Guinea-Bissau fulfills the	2601 participated in the survey and were used to estimate the proportion of PLHIV who knew	19.1% of PLHIV indicated to be aware of their HIV status. Of

communities, antiretroviral treatment at static and outreach facilities and the combined HIV prevention strategy. The government has made significant progress in the HIV response which has seen the rapid scale of services in the past decade. Equatorial Guinea has been affected by the dual epidemic of HIV/ AIDS and tuberculosis. According to the World Health Organization (WHO), Equatorial Guinea is one of the countries most affected by tuberculosis. Between 2006 and 2014, the number of diagnosed cases of tuberculosis (of all forms) increased from 420 to 1,220. From 2014–2015, the number of registered cases of tuberculosis increased from 153 to 172, of which 10% were new cases in 2015 and 62% were recurrences. The government has strengthened HIV/TB collaboration which emphasizes HIV testing and TB screening at every entry point in health facilities and then linking patients to HIV/TB care and treatment.

The objective of this study is to model and forecast HIV prevalence among the 15-49 years age group using Holt's linear method. The results of the study will provide scientific evidence that will be utilized in planning and allocation of resources to HIV/TB prevention

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	2020 treatment goals for both for HIV-1 and HIV-2.	their HIV status and the proportion of PLHIV on ART. Answers given in the survey were verified with treatment records from HIV clinics. measured viral load from biobank materials from HIV patients and estimated the proportion of virally suppressed PLHIV	these, 48.5% received ART, and 76.4% of these were virally suppressed. For HIV-1 and HIV-1/2 the results were 21.2%, 40.9% and 75.1%. For HIV-2 the results were 15.9%, 63.6% and 80.7%. 26.9% of all HIV-1 infected in the survey were virologically suppressed, indicating that a much higher number of HIV-1 infected were aware of their status and on treatment.
Rodríguez-Galet et al. (2023)	To update HIVDR data and HIV-1 variants in Equatorial Guinea	From 2019–2020, 269 dried blood samples (DBS) were collected in Bata Regional Hospital(EG) from 187 adults(73ARTnaïve/114ART-treated) and 82 children/adolescents (25HIV-exposed-ART-naïve/57ART-treated).	The observed high rate of ART-failure and transmitted/acquired HIVDR could compromise the 95-95-95 UNAIDS targets in Equatorial Guinea (EG).
Galjour et al. (2021)	To conduct a systematic review on the 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.
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,	-cross-sectional data was collected from June 2008 to May 2013	A total of 85% of HIV-infected women received ART as part of PMTCT, yet overall treatment coverage during labour and delivery declined significantly for both mothers and infants. Twenty-two percent of infants did not receive treatment, and 67% of HIV-2-infected mothers and 77% of

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	Guinea-Bissau's largest maternity ward.		their infants received ineffective non-nucleoside reverse transcriptase inhibitors for PMTCT
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 in the National HIV program

METHODOLOGY

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

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

Smoothing equation

$S_t = \alpha E_t + (1-\alpha)(S_{t-1} + b_{t-1})$.....[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

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

E_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 Equatorial Guinea 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	E
Included Observations	31

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Smoothing constants	
Alpha (α) for data	0.600
Beta (β) for trend	0.900
Forecast performance measures	
Mean Absolute Error (MAE)	0.048824
Sum Square Error (SSE)	0.109621
Mean Square Error (MSE)	0.003536
Mean Percentage Error (MPE)	-0.258294
Mean Absolute Percentage Error (MAPE)	1.479381

Residual Analysis for the Applied Model

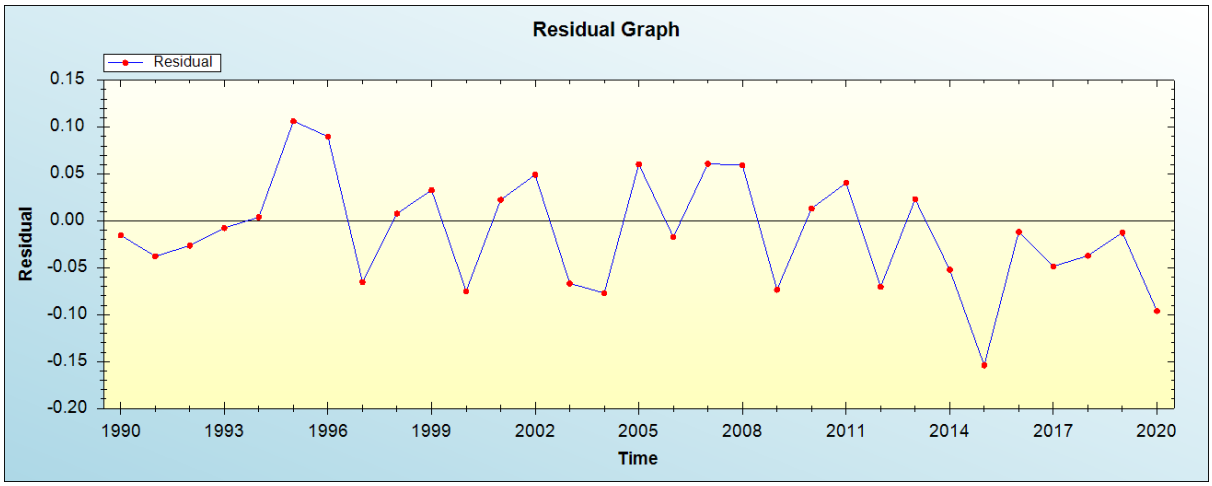

Figure 1: Residual analysis

In-sample Forecast for E

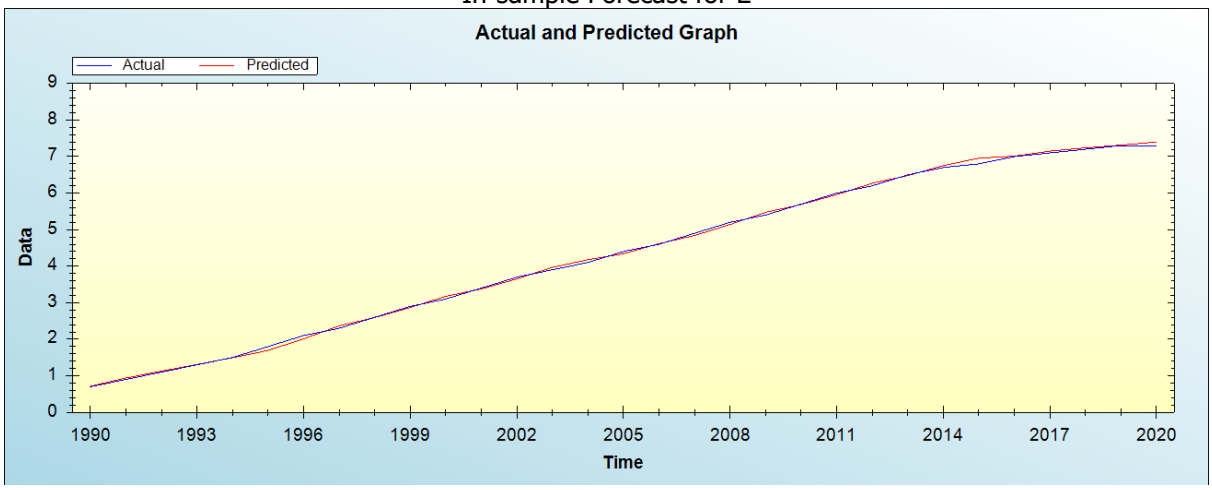

Figure 2: In-sample forecast for the E series

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Actual and Smoothed graph for E series

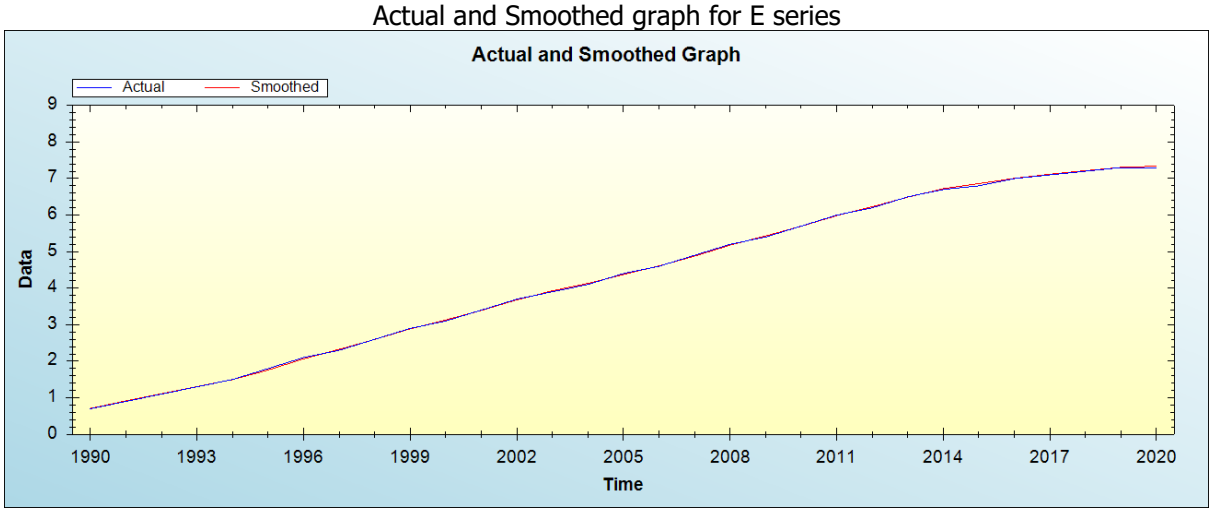

Figure 3: Actual and smoothed graph for E series

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

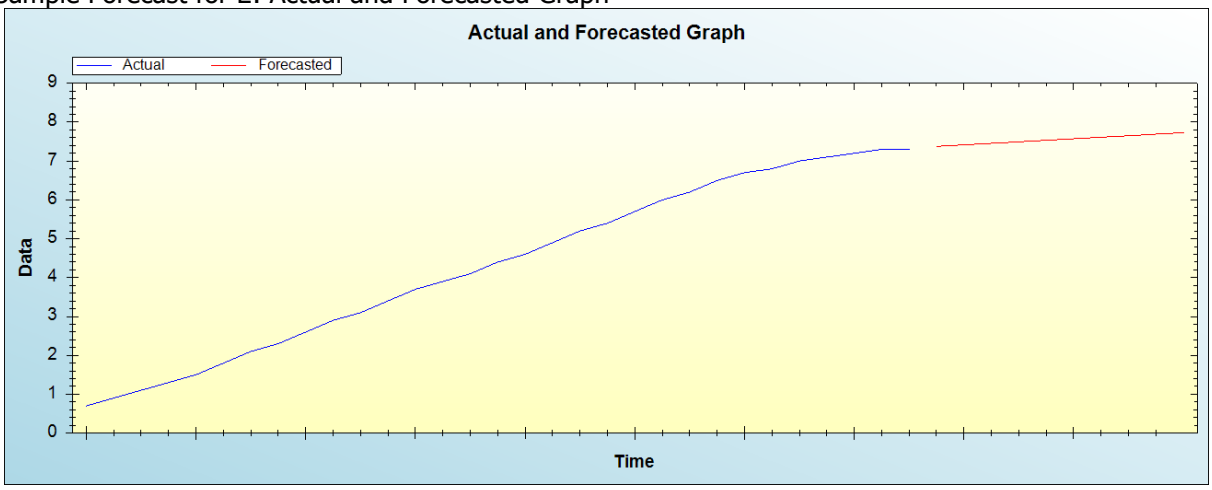

Figure 4: Out-of-sample forecast for E: actual and forecasted graph

Out-of-Sample Forecast for E: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Year	Forecasted HIV prevalence
2021	7.3775
2022	7.4166
2023	7.4558
2024	7.4949
2025	7.5340
2026	7.5732
2027	7.6123
2028	7.6515
2029	7.6906
2030	7.7297

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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 increase over the out of sample period.

Policy implication and conclusion

Our model predictions revealed that the annual HIV prevalence among individuals aged 15-49 years will continue to rise during the out of sample period. Hence, policy makers are encouraged to address top drivers of HIV spread among this age group especially among adolescents and key populations.

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