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EMPLOYING HOLT'S LINEAR METHOD TO PREDICT HIV PREVALENCE AMONG INDIVIDUALS AGED 15-49 YEARS IN THE GAMBIA

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Abstract:

This study uses annual time series data of HIV prevalence among individuals aged 15-49 years for the Gambia 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 0.4 respectively based on minimum MSE. The results of the study indicate that annual HIV prevalence among individuals aged 15-49 years will hover round 1.7% throughout the out of sample period. Therefore, we encourage authorities to strengthen HIV prevention, HIV diagnosis and treatment especially among key populations.

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

Introduction

Worldwide, approximately 38.0 million people lived with the human immunodeficiency virus (HIV) in 2019 (UNAIDS, 2019) and 3.4 million young people aged 15~24 years were living with HIV (UNAIDS, 2021). UNAIDS and UNICEF revealed that among young people living with HIV in West and Central Africa about 810,000 were aged 15~24 years. The Gambia Bureau of Statistics indicated that approximately 1761 (0.4%) adolescents aged 15~19 years and 1686 (0.1%) youth aged 20~24 years are living with HIV. Among people living with HIV, the majority (65%) of young people aged 15~24 years did not know their HIV status (Giguère *et al.* 2021). If the current trajectory persists, hundreds of thousands more will become HIV positive in the coming years, and without knowing their status, adolescents will miss out on life-saving treatment (UNICEF, 2019). The HIV response in the Gambia includes HIV testing services, rapid scale up of ART services, and implementation of the combined HIV prevention strategy (Sonko *et al.* 2022). The combined HIV prevention strategy is made up of initiatives such as behavioral change strategies, correct and consistent use of condoms, voluntary medical male circumcision, pre- and post-exposure prophylaxis. The purpose of this study is to model and forecast HIV prevalence among the 15-49 year age group. The results of the study are expected to inform policy, planning and allocation of resources to HIV programs targeting young adults.

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Literature Review

Author (s)	Objective (s)	Methodology	Key finding (s)
Soe et al. (2023)	To determine awareness of HIVST among Gambian men, and whether prior awareness of HIVST is associated with recent HIV testing uptake.	Used men's cross-sectional data from the 2019–2020 Gambian Demographic and Health Survey and then employed design-adjusted multivariable logistic regression to examine the association between HIVST awareness and recent HIV testing. Propensity-score weighting was conducted as sensitivity analyses	- 11% (372) were aware of HIVST and 16% (450) received HIV testing in the last 12 months -men who were aware of HIVST had 1.76 times (95% confidence interval: 1.26–2.45) the odds of having an HIV test in the last 12 months, compared to those who were not aware of HIVST
Sonko et al. (2022)	To assess predictors that influence the uptake of HIV testing among youth aged 15~24 years in The Gambia	-The 2013 Gambia Demographic and Health Survey data for youth aged 15~24 years was used. -A cross-sectional study design was used on 6194 subjects, among which 4730 were female. The analysis employed Chi-squared tests and hierarchical logistic regression	Those with adequate HIV knowledge and those who were sexually active and had aged at first sex15 years (aOR: 3.99) and those<15 years (aOR: 3.96) were more likely to have been tested for HIV compared to those who never had sex.
Tsegaw et al. (2022)	To assess factors associated with comprehensive knowledge on HIV among reproductive-age women in Gambia	Descriptive statistics and logistic regression models were used to summarize descriptive data and identify factors associated with HIV comprehensive knowledge respectively	Socio-demographic factors, contraceptive use, media exposure, tested for HIV, internet use and visiting health facility was significantly and positively associated with comprehensive HIV knowledge except being married and residing in Basse region in which they associated negatively and significantly.
Okomo et al. (2012)	To explore the correlates of loss to follow up and death prior to ART initiation among children	-Applied Cox-Proportional hazards model	Predictors of loss to follow up were being less than 2 years of age and WHO stage 3 and 4.

Methodology

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

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

Smoothing equation

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

$0<\propto<1$

Trend estimation equation

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

$0<\beta<1$

Forecasting equation

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

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

Data Issues

This study is based on annual HIV prevalence in the Gambia 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	G
Included Observations	31
Smoothing constants	
Alpha (α) for data	0.900
Beta (β) for trend	0.400
Forecast performance measures	
Mean Absolute Error (MAE)	0.068324
Sum Square Error (SSE)	0.432043
Mean Square Error (MSE)	0.013937
Mean Percentage Error (MPE)	-10.185392
Mean Absolute Percentage Error (MAPE)	25.359611

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Residual Analysis for the Applied Model

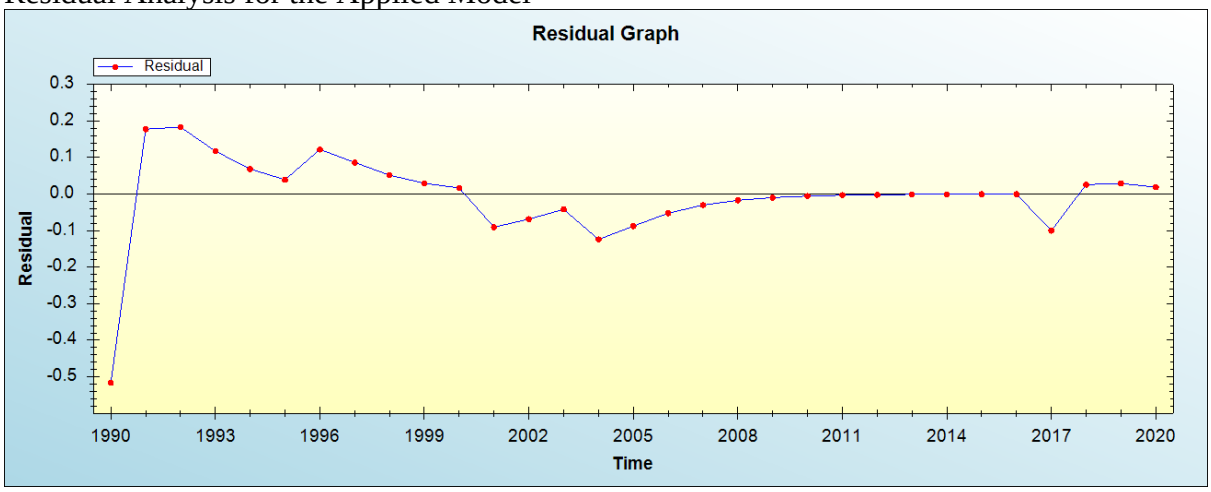

Figure 1: Residual analysis

In-sample Forecast for G

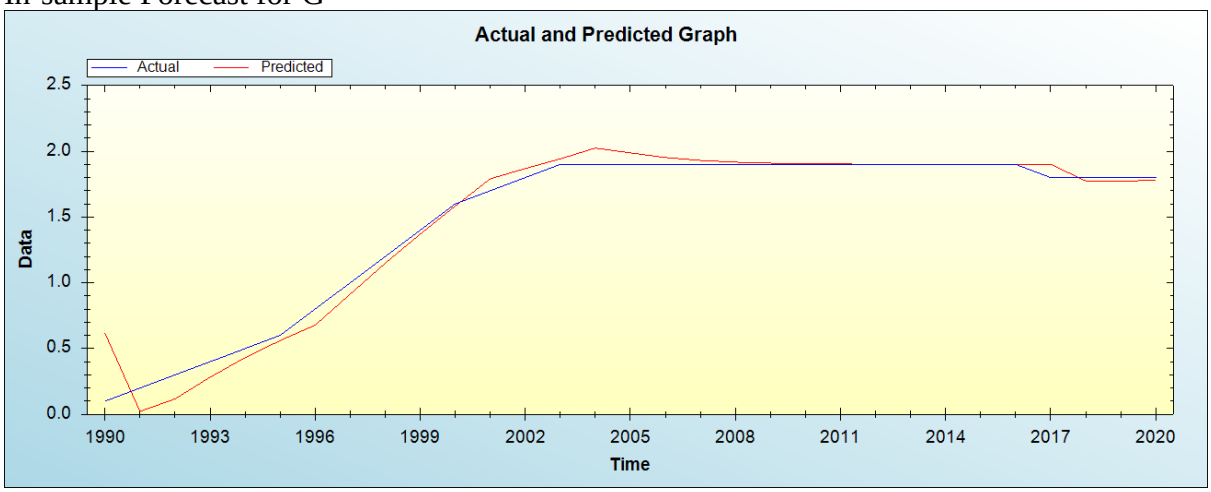

Figure 2: In-sample forecast for the G series

Actual and Smoothed graph for G series

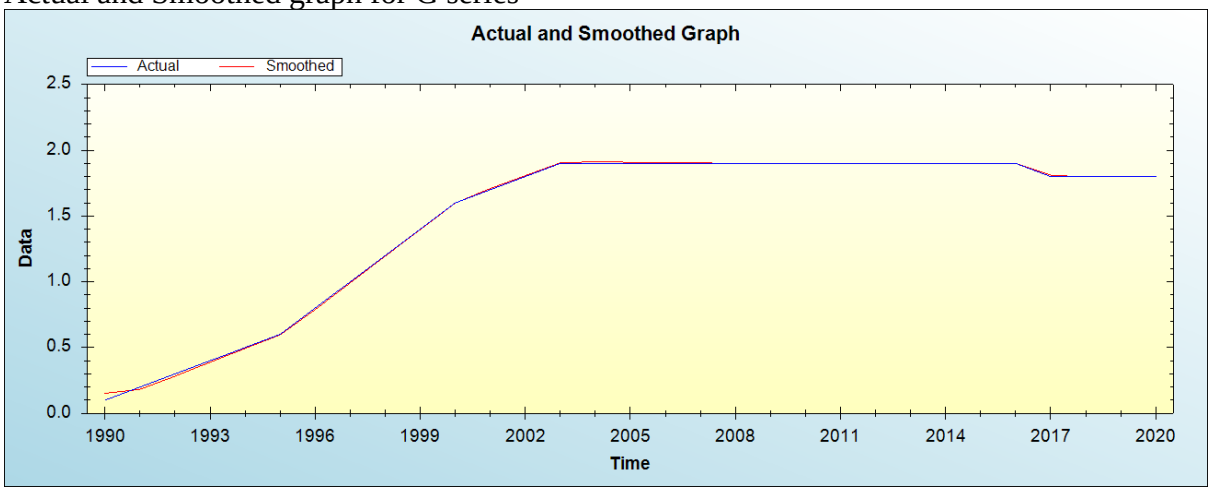

Figure 3: Actual and smoothed graph for G series

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

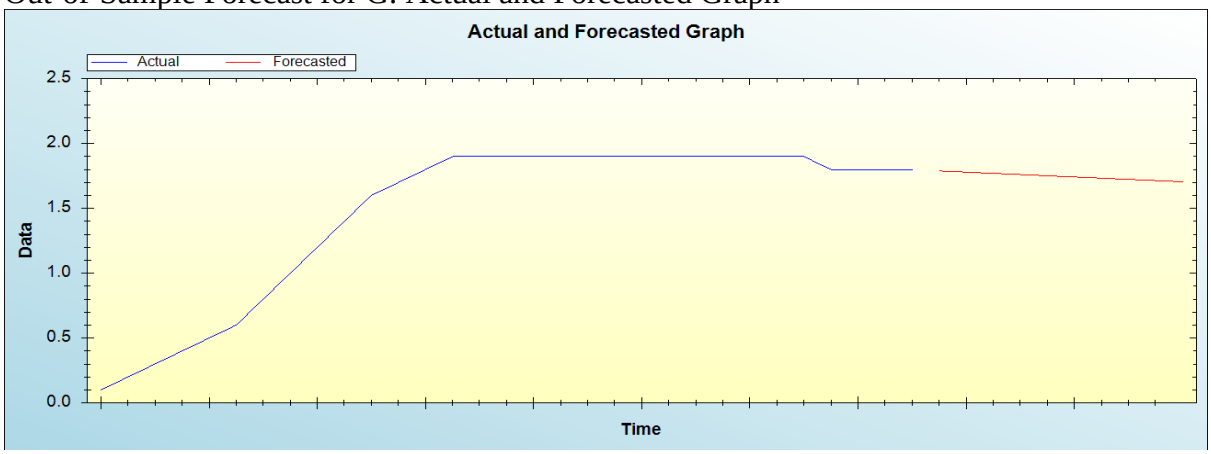

Figure 4: Out-of-sample forecast for G: actual and forecasted graph

Out-of-Sample Forecast for G: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Year	Forecasted HIV prevalence
2021	1.7888
2022	1.7796
2023	1.7703
2024	1.7611
2025	1.7518
2026	1.7426
2027	1.7333
2028	1.7241
2029	1.7148
2030	1.7056

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 hover around 1.7% throughout the out of sample period.

Policy implication and conclusion

This study revealed that annual HIV prevalence among individuals aged 15-49 years will hover around 1.7% throughout the out of sample period. Efforts should be continuously directed towards HIV prevention, HIV diagnosis and treatment especially among key populations.

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