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FORECASTING HIV PREVALENCE AMONG INDIVIDUALS AGED 15-49 YEARS IN GUYANA 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 Guyana 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 decline over the out of sample period. Therefore, there is need to strengthen HIV case detection and HIV prevention among key populations and vulnerable groups.

Keywords: - Exponential smoothing, Forecasting, HIV prevalence.

Introduction

HIV remains an important health problem worldwide. Guyana has a mixed HIV epidemic that disproportionately affects key populations (KPs) and vulnerable groups. According to UNAIDS data, HIV serorevalence has remained constant at around 1.4%. As revealed by the 2021-Integrated Behavioral and Biological Survey (IBBS), HIV prevalence is 2.2% among FSWs, 1.8% among MSM, and 11.8% among transgender individuals in Guyana. According to EPIC Guyana, Region 4, Demerara-Mahaica, is the most densely populated of the 10 administrative regions and the area most affected by HIV, accounting for 75.4% of all new HIV infections. Experiences of gender-based violence (GBV) among KP community members remains a problem in Guyana. A 2014 survey revealed that one-quarter to one-third of sex workers had experienced rape (25.2% male, 25.1% female, and 31.1% transgender individuals) (Guyana, 2014). Although acceptance of KP members has improved, much still needs to be done on stigma and discrimination. GTU has led the way in raising awareness and sensitizing various communities and organizations on gender related issues by collaborating with NAPS to conduct training sessions on GBV and sexual orientation, gender identity, and equality. The purpose of this research is to model and forecast HIV prevalence among individuals aged 15-49 years for Guyana using Holt's linear method. The results of this study are expected to facilitate planning and allocation of resources towards targeted HIV prevention, treatment, care and support programs in the country in order to effectively control the HIV epidemic especially among key populations and vulnerable groups.

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Literature Review

Author(s)	Objective (s)	Methodology	Key finding(s)
Joseph et al. (2024)	To examine the factors associated with HIV testing among women in Haiti and trends in HIV testing in 2006, 2012, and 2016/17	Data from the last three Haitian Demographic and Health Surveys (2006, 2012, and 2016/17) were used -multilevel regression model to describe the trends and identify factors associated with HIV testing in Haiti. P-value less than 0.05 was taken as a significant association.	HIV testing prevalence increased more than twofold from 2006 (8.8%) to 2017 (21.3%); however, it decreased by 11.6% between 2012 and 2016/17
Huff et al. (2022)	To explore the interplay between substance use (SU) and HIV in Latin America (LA).	scoping review	Factors associated with HIV among PWUS included being female, IDU and homelessness, and PWUS were likely to engage in risky sexual behaviors, start antiretroviral treatment late, have poor adherence, have treatment failure, be lost to follow-up, have comorbidities, ,as has been reported in PLWH with SU in other regions.
Dorcélus et al. (2021)	To assess these factors as potential barriers to adherence among patients receiving care in central Haiti.	-cross-sectional study was conducted among PLH receiving antiretroviral therapy (ART) at the TB/HIV clinic at St. Therese Hospital in Hinche, Ha	Nearly 78% had received ART for less than 10 years, 3.41% reported having poor adherence and 28% less than excellent adherence. Factors related to poor adherence in bivariate analysis were age less than 40 years (OR: 6.32, 95% CI 2.04–10.58, $p < 0.01$) and inability to meet basic needs (OR: 2.70, 95% CI 1.04–7.0, $p = 0.03$).
Local Burden of Disease HIV Collaborators (2021)	To address this gap and provide novel estimates of the HIV mortality rate and the number of HIV deaths by age group, sex, and municipality in Brazil, Colombia, Costa Rica, Ecuador, Guatemala, and Mexico	-Ecological study using VR data ranging from 2000 to 2017, dependent on individual country data availability. -modeled HIV mortality using a Bayesian spatially explicit mixed-effects regression model that incorporates prior information on VR completeness.	There was a significant spatial variation and diverging local trends in HIV mortality over time and by age.
Palmer et al. (2002)	To estimate HIV Prevalence in a Gold Mining Camp in the Amazon Region, Guyana	Cross-sectional study	The prevalence of HIV infection among men in a gold mining camp in the Amazon region of Guyana was 6.5%

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Methodology

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

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

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 Guyana 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	31
Smoothing constants	
Alpha (α) for data	0.900
Beta (β) for trend	0.500

Forecast performance measures	
Mean Absolute Error (MAE)	0.035576
Sum Square Error (SSE)	0.082230
Mean Square Error (MSE)	0.002653
Mean Percentage Error (MPE)	-2.230410
Mean Absolute Percentage Error (MAPE)	12.722550

Residual Analysis for the Applied Model

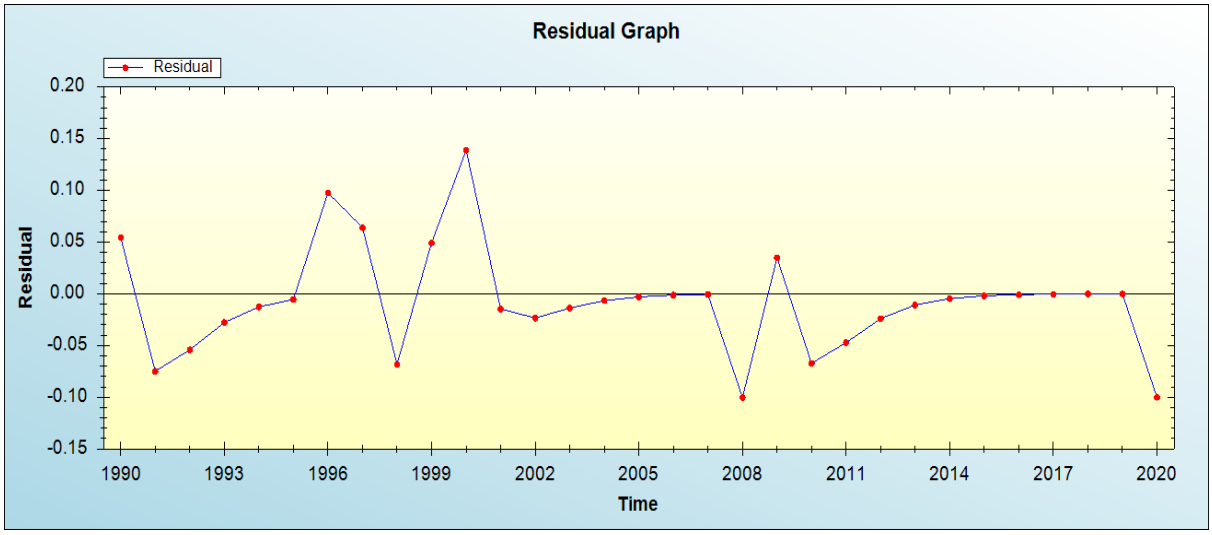

Figure 1: Residual analysis

In-sample Forecast for A

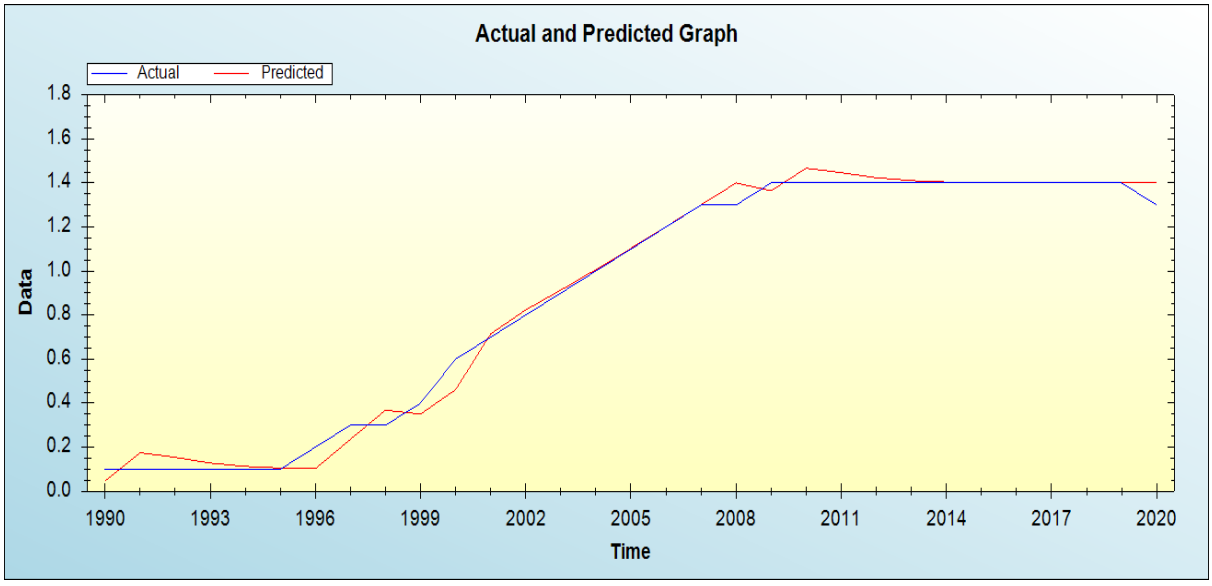

Figure 2: In-sample forecast for the A series

Actual and Smoothed graph for A series

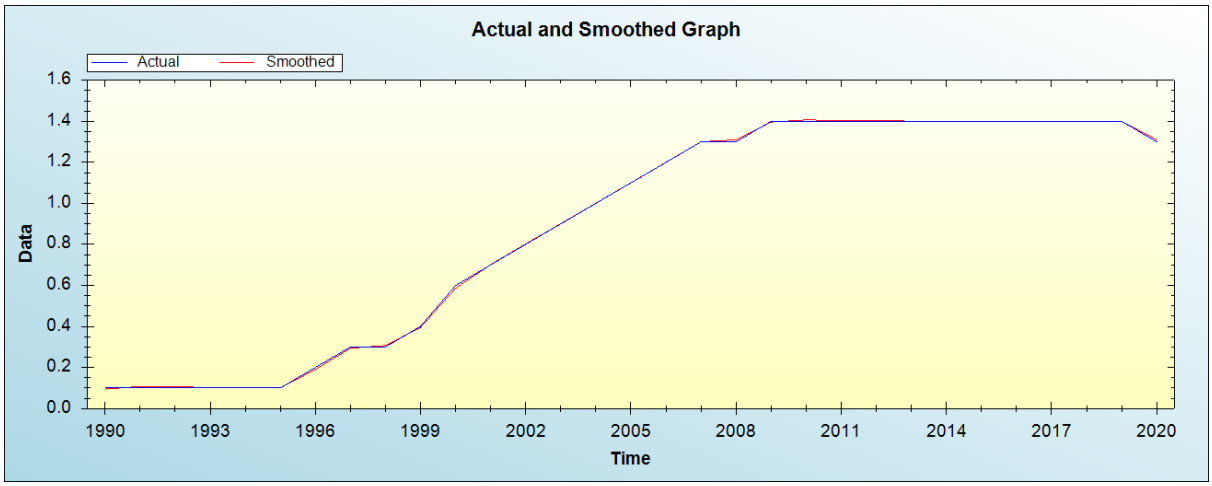

Figure 3: Actual and smoothed graph for A series

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

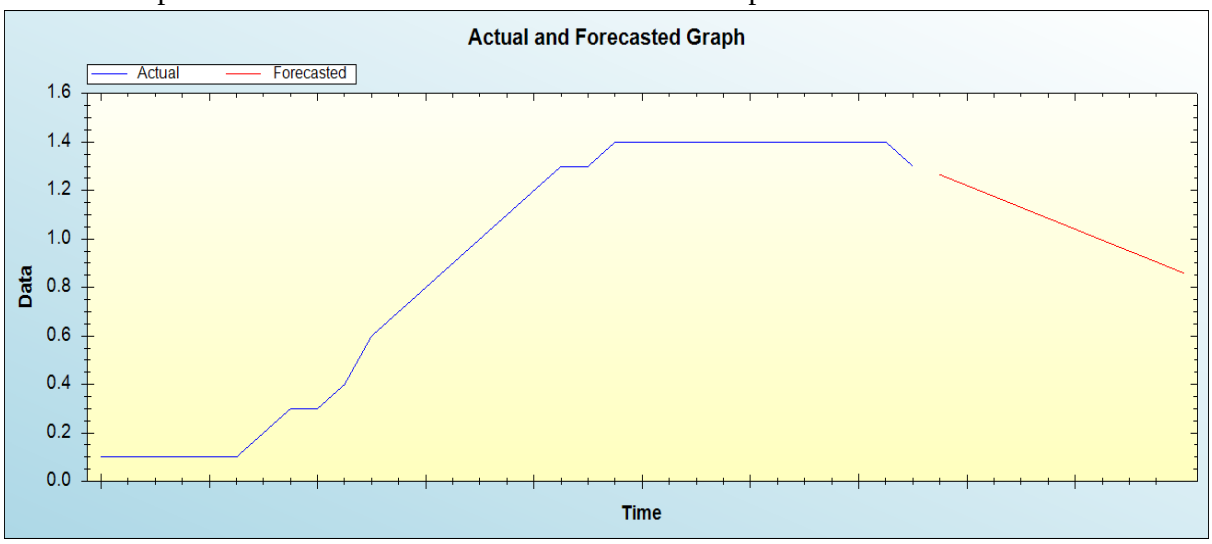

Figure 4: Out-of-sample forecast for A: actual and forecasted graph

Out-of-Sample Forecast for A: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Year	Forecasted HIV prevalence
2021	1.2650
2022	1.2200
2023	1.1750
2024	1.1300
2025	1.0850
2026	1.0400
2027	0.9950
2028	0.9501
2029	0.9051
2030	0.8601

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 decline over the out of sample period.

Policy implication and conclusion

Our research findings indicate that that annual HIV prevalence among individuals aged 15-49 years will decline over the out of sample period. Therefore, authorities should strengthen HIV case detection and HIV prevention among high risk groups.

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