

FORECASTING HIV PREVALENCE AMONG INDIVIDUALS AGED 15-49 YEARS IN TRINIDAD AND TOBAGO 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 Trinidad and Tobago 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 0.7 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 continue to decline over the out of sample period. Therefore, it is essential to channel resources towards HIV case detection especially among high-risk groups and also to improve ART treatment adherence for those living with HIV.

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

Background

Trinidad and Tobago refers to Twin Islands located off the Caribbean coast in South America. It is a high income country with a population size of 1.218 million people. There are two main ethnic groups that together account for roughly 60% of the population, which are East Indians, and Africans ("The World Fact book" 2017). The first cases of AIDS were detected in 1983 among gay/bisexual men (Bartholomew *et al.* 1983). In 1985, HIV transmission became predominantly heterosexual (Cleghorn *et al.* 1995). According to UNAIDS 2019 data, there are approximately 11,000 PLHIV in Trinidad & Tobago with an estimated 27% PLHIV unengaged in care/lost to follow up/not actively on ART treatment. The estimated HIV Prevalence for Ages 15-49 was 1.0% in 2021, less than 500 AIDS related deaths among HIV positive people 15 years and older in 2021, 2800 orphans due to AIDS in 2020 and 7174 people living with HIV(PLHV) (Age ≥ 15) were receiving antiretroviral therapy in 2021 (CDC, 2021). The aim of this paper is to model and forecast HIV prevalence among individuals aged 15-49 years for Trinidad and Tobago using Holt's double exponential smoothing technique. The research findings are expected to guide policy, planning and allocation of resources towards targeted HIV programs especially programs for key populations and other vulnerable groups.



Literature Review

Author (s)	Objective (s)	Methodology	Main finding (s)
Lyons et al. (2023)	To examine correlates of HIV testing in Venezuelan migrants residing in Trinidad.	Applied multivariable logistic regression	Persons who migrated with family or friends had greater odds of getting an HIV test relative to persons who arrived alone, and migrants who knew where to get an HIV test also greater odds of getting a test relative to person who did not know where to get a test. Migrants with known physical health problems had greater odds of getting an HIV test relative to migrants without these health problems
Edwards et al. (2021)	To assess the outcomes of retention in care and viral suppression by expansion of an intervention using two patient tracers to track patients lost to follow up at a large HIV clinic in Trinidad	Two Social Workers were trained as patient tracers and hired for 15 months (April 2017–June 2018) to call patients who were lost to follow up for 30 days or more during the period July 2016–May 2018 at the HIV clinic Medical Research Foundation of Trinidad and Tobago. -Applied logistic regression	Persons were more likely to be virally suppressed if they were employed (OR, 1.39; 95% CI 1.07–1.80), if they had baseline CD4 counts < 200 cells/mm ³ (OR, 1.71; 95% CI 1.26–2.32) and if they were retained in care at 12 months (OR, 2.48; 95% CI 1.90–3.24). Persons initiated on ART for 4–6 years (OR, 3.09; 95% CI 1.13–8.48), 7–9 years (OR, 3.97; 95% CI 1.39–11.31), > 10 years (OR, 5.99; 95% CI 1.74–20.64) were more likely to be retained in care
Reid et al. (2010)	To examine utilization of the National AIDS Hotline of Trinidad and Tobago (AIDSLINE), evaluate its validity as a reliable data source for monitoring national HIV related needs, and identify changes in caller requests between two different time periods	A total of 7 046 anonymous hotline calls in 1998–2002 (T1) and 2 338 calls in 2007 (T2) were analyzed for associations between caller characteristics and call content. A subsample of the data was also analyzed qualitatively.	Call content from T2 indicated an increase versus T1 in 1) general awareness of HIV and other sexually transmitted diseases; 2) HIV testing; and 3) knowledge of HIV symptoms and transmission. HIV-related mental health needs, and the relationship between HIV and both child sexual abuse (CSA) and intimate partner violence (IPV), were identified as emerging issues.
Baptiste et al. (2006)	To describe the HIV crises in these countries; outlines a community participatory research framework to adapt and deliver family-	Descriptive study	Both settings reported promising results including high recruitment and retention and favorable pre to post



	<p>based prevention; and presents preliminary data from intervention pilots in each setting.</p>		<p>changes in parent/youth frequency and comfort in talking about sensitive subjects, HIV transmission knowledge and attitudes about persons with HIV/AIDS.</p>
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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 Trinidad and Tobago. 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

$$Y_t = \mu_t + \rho_t t + \varepsilon_t$$

Smoothing equation

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

$$0 < \alpha < 1$$

Trend estimation equation

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

$$0 < \beta < 1$$

Forecasting equation

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

Y_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 Trinidad and Tobago 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	Y
Included Observations	31
Smoothing constants	
Alpha (α) for data	0.700
Beta (β) for trend	0.400
Forecast performance measures	
Mean Absolute Error (MAE)	0.060587
Sum Square Error (SSE)	0.228971
Mean Square Error (MSE)	0.007386
Mean Percentage Error (MPE)	-2.834024
Mean Absolute Percentage Error (MAPE)	13.146926

Residual Analysis for the Applied Model

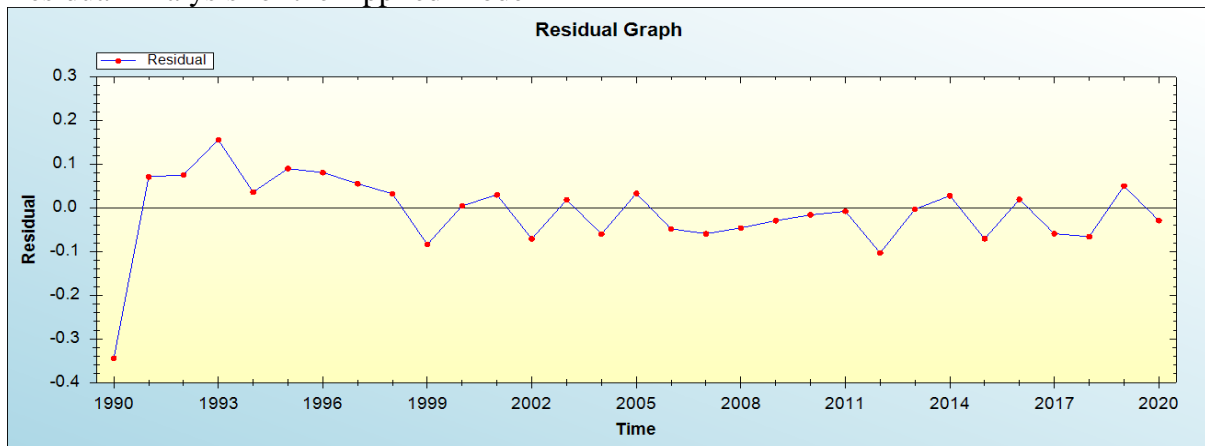


Figure 1: Residual analysis

In-sample Forecast for Y

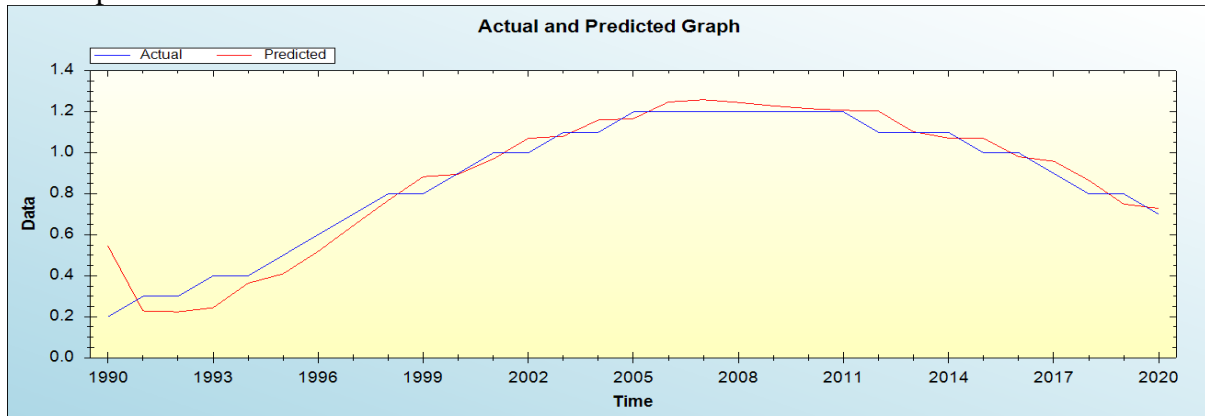


Figure 2: In-sample forecast for the Y series



Actual and Smoothed graph for Y series

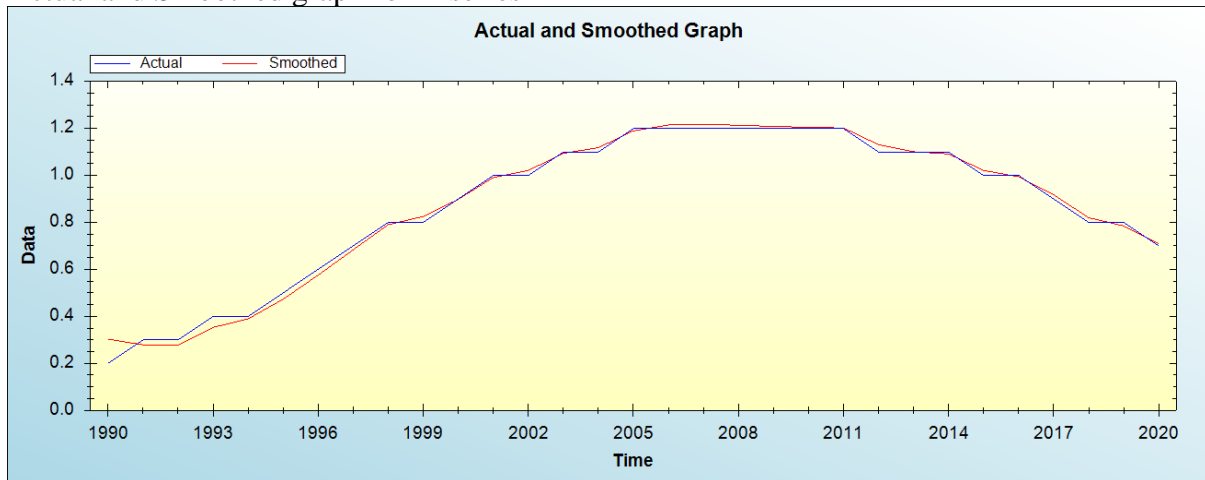


Figure 3: Actual and smoothed graph for Y series

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

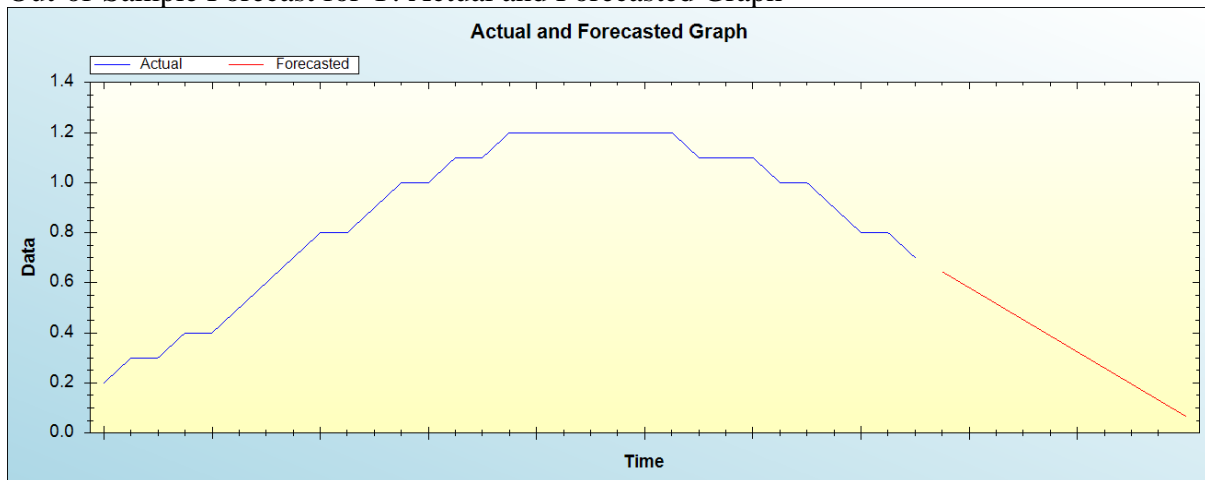


Figure 4: Out-of-sample forecast for Y: actual and forecasted graph

Out-of-Sample Forecast for Y: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Year	Forecasted HIV prevalence
2021	0.6445
2022	0.5803
2023	0.5162
2024	0.4521
2025	0.3879
2026	0.3238
2027	0.2596
2028	0.1955
2029	0.1313
2030	0.0672



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

This study established that annual HIV prevalence among individuals aged 15-49 years will continue to decline over the out of sample period. Therefore, it is essential to channel resources towards HIV case detection especially among high risk groups and also to improve ART treatment adherence for those living with HIV.

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