World Bulletin of Public Health (WBPH)
Available Online at: https://www.scholarexpress.net
Volume-35, June 2024
ISSN: 2749-3644

PROJECTION OF HIV PREVALENCE AMONG INDIVIDUALS AGED 15-49 YEARS IN SAO TOME AND PRINCIPE USING HOLT'S LINEAR METHOD

Dr. Smartson. P. NYONI[1], Thabani NYONI[2]
[1]ZICHIRe Project, University of Zimbabwe, Harare, Zimbabwe
[2]Independent Researcher & Health Economist, Harare, Zimbabwe

Article history:

Received: April 26th 2024
Accepted: May 20th 2024

Abstract:

This study uses annual time series data of HIV prevalence among individuals aged 15-49 years for Sao Tome and Principe 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 0.1 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, we encourage authorities to continuously support HIV diagnosis, treatment and prevention among this age group.

Keywords: *Exponential smoothing, Forecasting, HIV prevalence*

BACKGROUND

According to the World Health Organization (WHO) HIV continues to be a public health problem and has caused 40.1 million deaths to date and approximately 38.4 million people were living with HIV at the end of 2021. Sub-Saharan Africa (SSA) is the epicenter of HIV-related morbidity and mortality. Approximately 25 million people in the region are living with HIV, accounting for two-thirds of the global total. Furthermore, the region also accounts for over 70% of all AIDS-related deaths (WHO, 2021; Dwyer-Lindgren *et al.* 2019). High HIV infection rates among adolescents, particularly girls, have been a major issue in SSA, where around 80% of the world's HIV-infected adolescents live (Slogrove *et al.* 2017; Idele *et al.* 2014). According to UNAIDS 2019 data, adolescent girls and young women aged 15–24 years accounted for one in five new HIV infections, despite being just 10% of the population of sub-Saharan Africa. UNAIDS estimated that, between 2010 and 2017, there was a 25% drop in new HIV infections among girls aged 10–19 years in Eastern and Southern Africa, but no decline in West and Central Africa. A recent analysis of pooled data from longitudinal community studies in Eastern and Southern Africa revealed that adolescent girls had 5.9 and 3.2 times higher HIV incidence than adolescent boys during 2005–2015, respectively, with only limited evidence of a decrease over time (Birdthistle *et al.* 2019). The HIV epidemic in SSA varies by country and sub-regions (UNAIDS, 2019). Within countries, it varies by socioeconomic and geographic characteristics (Hajizadeh *et al.* 2014). National surveys usually show higher HIV prevalence among adolescents and adults with more education, living in wealthier households or in urban areas compared to less educated, poorer and rural residents (Hargreaves *et al.* 2013; Mishra *et al.* 2009; Mishra *et al.* 2007; García-Calleja *et al.* 2006).

The objective of this paper is to model and forecast HIV prevalence among individuals aged 15-49 years for Sao Tome and Principe using Holt's linear method. The study findings are expected to inform policy, planning, allocation of resources towards targeted HIV programs in Sao Tome and Principe in order to control the HIV epidemic in this country.

LITERATURE REVIEW

Author (s)	Objective (s)	Methodology	Main finding (s)
Dadzie et al. (2024)	To assess the socioeconomic inequalities in HIV testing during antenatal care (ANC) in sub-Saharan Africa.	-Benin, Burundi, Cameroon, Ethiopia, Gambia, Guinea, Liberia, Malawi, Mali, Mauritania, Mozambique, Rwanda, Sierra Leone, Uganda,	There is substantial wealth index-related inequalities in HIV testing, with women of the poorest wealth index disadvantaged in

World Bulletin of Public Health (WBPH)
Available Online at: https://www.scholarexpress.net
Volume-35, June 2024
ISSN: 2749-3644

		Zambia, and Zimbabwe were the countries included in the study. -This study used current Demographic and Health Surveys data spanning from 2015 to 2022. A total of 70,028 women who tested for HIV as part of antenatal contacts formed the sample for analysis.	relation to the HIV testing
Ijaiya et al. (2023)	To describe HIV research output in Africa by country from 1986 until 2020.	Applied Poisson regression models to explore the trends in countries' HIV research output over the study period. The Pearson correlation analysis assessed the association between research output, population size, GDP, and the number of PLHIV.A total of 83,527 articles from African countries on HIV indexed in PubMed were included for analysis	-Africa's contribution to global HIV research output increased over the 35 years, but it remains relatively low compared to the continent's burden of HIV infections -There were major differences in research output across sub-regions in Africa, with the Republic of South Africa having the highest output -factors associated with HIV research output were economic strength, disease epidemiology, and population size
Astawesegn et al. (2022)	To establish the trend and effect of ART coverage during pregnancy on mother-to-child HIV transmission in sub-Saharan Africa from 2010 to 2019.	-Country-level longitudinal ecological study design was used - Forty-one sub-Saharan Africa countries were included using publicly available data from the United Nations Programme on HIV/AIDS, World Health Organization, and World Bank.	ART coverage for HIV positive pregnant women and HIV incidence-to-prevalence ratio were significantly associated with MTCT rate in sub-Saharan Africa
Worku et al. (2022)	To investigate the pooled prevalence and associated factors of HIV testing among young women in east Africa.	The most recent DHS surveys done among 11 east African countries were pooled and a weighted sample of 73,661 young women were included.	Pooled prevalence of HIV testing among young women was 55.3%: 95% CI (54.97%, 55.69%). In the multilevel multivariable analysis: respondent age, marital

World Bulletin of Public Health (WBPH)
Available Online at: https://www.scholarexpress.net
Volume-35, June 2024
ISSN: 2749-3644

		-performed bivariate and multivariable analysis	status, educational level, occupation, media exposure, having higher and comprehensive knowledge about HIV / AIDS, having some and higher risky sexual behavior, visiting health care facilities, being rural dweller, being from rich households, having multiple sexual partners, early sex initiation and community-level education were significantly associated with HIV testing
Maulide Cane et al. (2021)	To assess the trends in HIV prevalence by gender in adolescents, as well as urban–rural disparities in SSA	-HIV prevalence data at ages 15–19 years were obtained for 31 countries with a national survey since 2010 and for 23 countries with one survey circa 2005 and a recent survey circa 2015 - Country medians and average annual rates of changes were used to summarize the trends for two sub-regions in sub-Saharan Africa, Eastern and Southern Africa and West and Central Africa,	HIV prevalence among adolescents declined in almost all countries during the last decade, in both urban and rural settings. The urban–rural gap persisted and HIV transmission to girls, but not boys, is still a major challenge in Eastern and Southern African countries
Belachew et al. (2020)	To assess the prevalence of vertical HIV infection and its risk factors among HIV-exposed infants in East Africa.	Systematic review	The pooled prevalence of the mother to child transmission of HIV is way more than the desired target of the World Health Organization, which is less than 5% in breastfeeding populations
Faust and Yaya (2018)	To systematically review and meta-analyze the evidence for the effect of HIV-related knowledge interventions on 1) the	Literature Review	Peer-education-based interventions appear to be particularly effective in facilitating the uptake of HIV-related knowledge, particularly

World Bulletin of Public Health (WBPH)
Available Online at: https://www.scholarexpress.net
Volume-35, June 2024
ISSN: 2749-3644

	improvement of HIV-related knowledge, 2) subsequent risk reduction behavior (condom use), 3) lower incidence of HIV infection		pertaining to transmission routes.

METHODOLOGY

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

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

Smoothing equation

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

$0<\propto<1$

Trend estimation equation

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

$0<\beta<1$

Forecasting equation

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

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 Sao Tome and Principe 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	0.900
Beta (β) for trend	0.100
Forecast performance measures	
Mean Absolute Error (MAE)	0.094795

World Bulletin of Public Health (WBPH)
Available Online at: https://www.scholarexpress.net
Volume-35, June 2024
ISSN: 2749-3644

Sum Square Error (SSE)	0.730746
Mean Square Error (MSE)	0.023572
Mean Percentage Error (MPE)	-0.457884
Mean Absolute Percentage Error (MAPE)	11.766417

Residual Analysis for the Applied Model

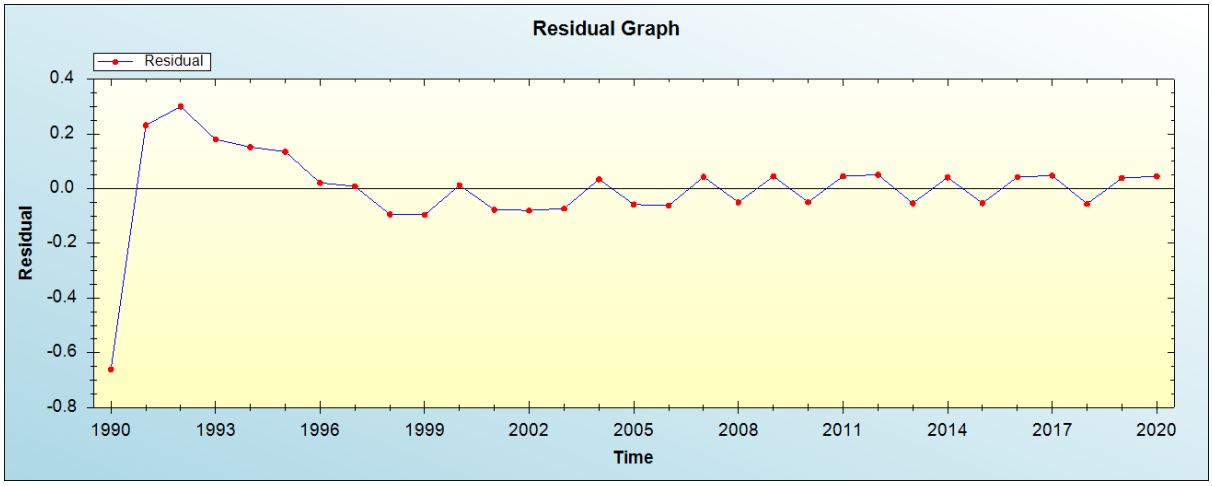

Figure 1: Residual analysis

In-sample Forecast for Y

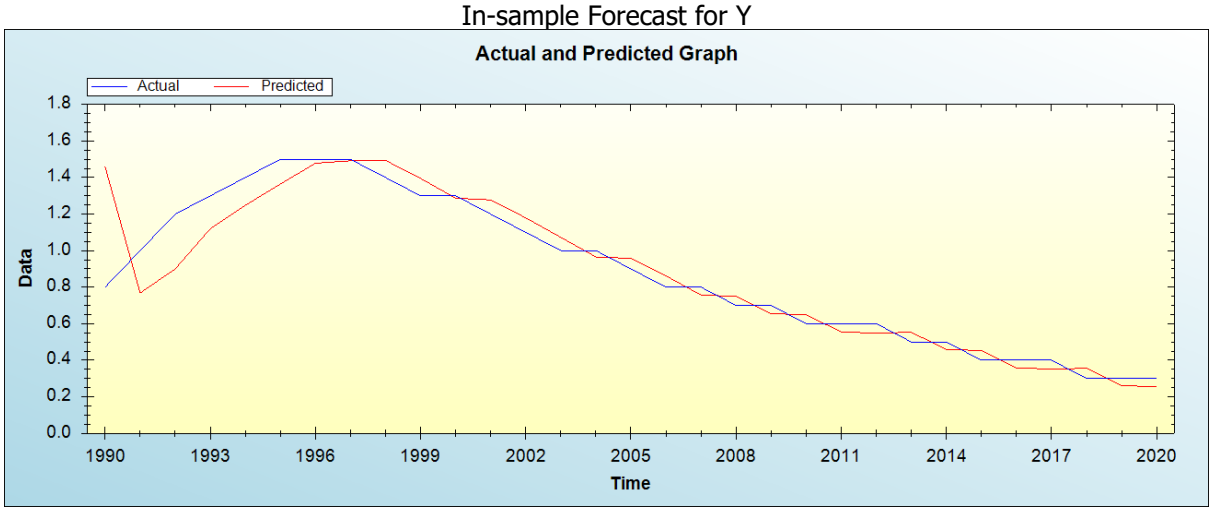

Figure 2: In-sample forecast for the Y series

Actual and Smoothed graph for Y series

World Bulletin of Public Health (WBPH)
Available Online at: https://www.scholarexpress.net
Volume-35, June 2024
ISSN: 2749-3644

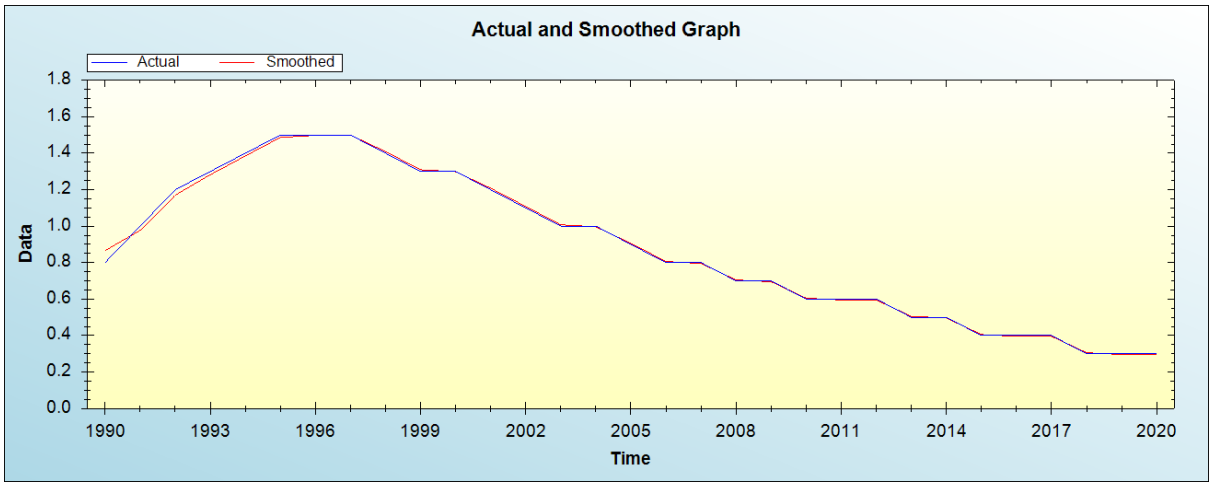

Figure 3: Actual and smoothed graph for Y series

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

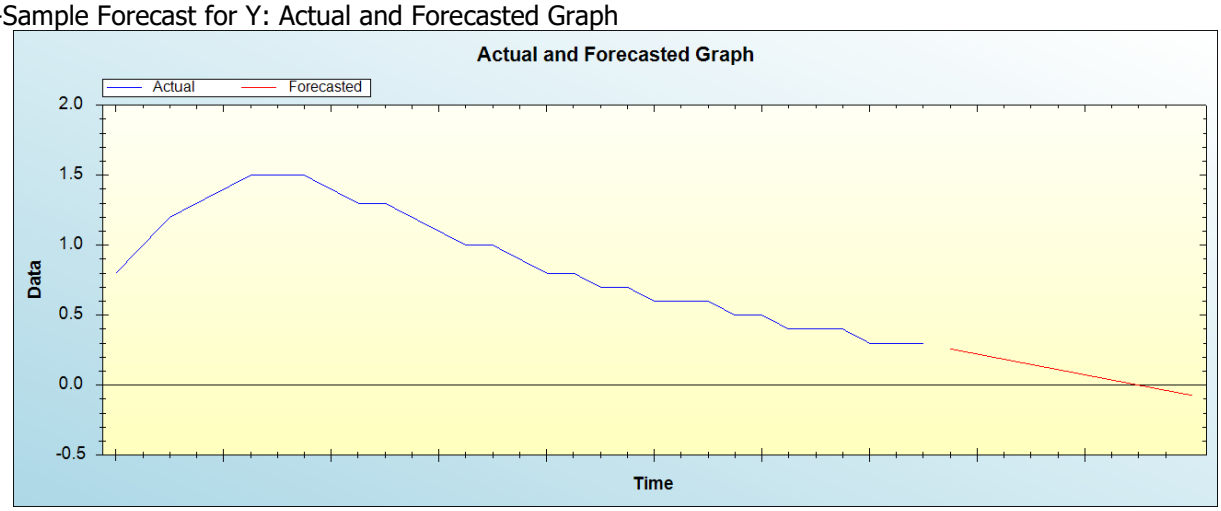

Figure 4: Out-of-sample forecast for Y: actual and forecasted graph

Out-of-Sample Forecast for Y: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Year	Forecasted HIV prevalence
2021	0.2585
2022	0.2215
2023	0.1845
2024	0.1476
2025	0.1106
2026	0.0736
2027	0.0366
2028	-0.0004
2029	-0.0374
2030	-0.0744

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

World Bulletin of Public Health (WBPH)
Available Online at: https://www.scholarexpress.net
Volume-35, June 2024
ISSN: 2749-3644

This research paper established that annual HIV prevalence among individuals aged 15-49 years will continue to decline over the out of sample period. Therefore, it is important to continuously support HIV diagnosis, treatment and prevention among this age group.

REFERENCES

[1] World Health Organization (2021). HIV. Available from: https://www.who.int/news-room/fact-sheets/detail/hiv-aids.
[2] Dwyer-Lindgren L, Cork MA, Sligar A, Steuben KM, Wilson KF & Provost NR (2019). Mapping HIV prevalence in sub-Saharan Africa between 2000 and 2017. Nature. 570(7760):189–93. https://doi.org/10.1038/s41586-019-1200-9
[3] Slogrove AL, Mahy M, Armstrong A & Davies MA (2017). Living and dying to be counted: what we know about the epidemiology of the global adolescent HIV epidemic. J Int AIDS Soc. 2017; 20(Suppl 3):21520.
[4] Idele P, Gillespie A, Porth T, Suzuki C, Mahy M, Kasedde S, & Luo C (2014). Epidemiology of HIV and AIDS among adolescents: current status, inequities, and data gaps. J Acquir Immune Defic Syndr. 2014; 66(Suppl 2):S144–53.
[5] UNAIDS (2019). Women and HIV. A spotlight on adolescent girls and young women. Geneva.
[6] Birdthistle I, Tanton C & Tomita A (2019). Recent levels and trends in HIV incidence rates among adolescent girls and young women in ten high prevalence African countries: a systematic review and meta-analysis. Lancet Glob Health. 2019; 7:e1521–40.
[7] UNAIDS. UNAIDS Data 2019. Available from: http:// rstesa. unaids. org/ publi catio ns/ global- publications/ item/ 208- unaids- data- 2019. Accessed 7 May 2020.
[8] Hajizadeh M, Sia D, Heymann SJ & Nandi A (2014). Socioeconomic inequalities in HIV/AIDS prevalence in sub-Saharan African countries: evidence from the Demographic Health Surveys. Int J Equity Health. 2014;13:18
[9] Hargreaves JR, Davey C, & White RG (2013). Does the "inverse equity hypothesis" explain how both poverty and wealth can be associated with HIV prevalence in sub-Saharan Africa? J Epidemiol Community Health. 67(6):526–9.
[10] Mishra V, Assche SB, Greener R (2007). HIV infection does not disproportionately affect the poorer in sub-Saharan Africa. AIDS. 21(Suppl 7):S17-28.
[11] Mishra V, Medley A, Hong R, Gu Y, & Robey B (2009). Levels and spread of HIV seroprevalence and associated factors: evidence from national household surveys. DHS Comparative Reports No. 22. Calverton, Maryland, USA: Macro International Inc.; 2009.
[12] García-Calleja JM, Gouws E, & Ghys PD (2006). National population-based HIV prevalence surveys in sub-Saharan Africa: results and implications for HIV and AIDS estimates. Sex Transm Infect. 82(Suppl 3):64–70. https:// doi. org/ 10. 1136/ sti. 2006. 019901.