PREDICTION OF HIV PREVALENCE AMONG INDIVIDUALS AGED 15-49 YEARS IN HAITI USING HOLT'S LINEAR METHOD

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

Abstract

This study uses annual time series data of HIV prevalence among individuals aged 15-49 years for Haiti 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 scale up HIV testing and strengthen prevention measures among high-risk groups.

Keywords: - Exponential smoothing, Forecasting, HIV prevalence.

Introduction

Basing on the 3rd sustainable development goal, HIV/AIDS remains a major global health problem which is among the top priority infectious diseases (UN, 2020; WHO, 2019; UNICEF, 2018; UN, 2016; UN, 2015). UNAIDS revealed that 38.4 million people were living with HIV (PLWH). Furthermore, it highlighted that more than two-thirds of PLWH were from Eastern and southern Africa (UNAIDS, 2023). The Caribbean is the second-most affected region in the world in terms of HIV. According to UNAIDS, the estimated HIV seroprevalence among adults was 1.2% in this region, with 14,000 people newly infected in 2021. Haiti alone accounts for close to 50% of new HIV infections and AIDS related mortality. World Bank data indicates that there are more than 150,000 people living with HIV in Haiti which translates to a prevalence of 1.8%. The country's HIV prevalence declined from 6.2% in 1993 to 2.2% in 2012, with recent data from the Joint United Nations Programme on HIV/AIDS (UNAIDS), indicating this may have dropped further to 1.7% in 2022 (UNAIDS, 2022; Delcher *et al.* 2020; PEPFAR, 2020). AIDS-related illnesses and comorbidities are among Haiti's 10 leading causes of death (Delcher *et al.* 2020). Moyo et al. 2023 revealed that among people living with HIV, around 33 % do not know their status and 58% are not receiving antiretroviral treatment. Haiti's national response to HIV is characterized by advocacy, HIV testing, offering antiretroviral therapy, HIV care and support services (Koenig *et al.* 2010; Nierengarten, 2003; Pape *et al.* 19993; Pape *et al.* 1983).

The objective of this paper is to model and forecast HIV prevalence among individuals aged 15-49 years for Haiti using Holt's linear method. The results of this paper are expected to facilitate allocation of resources towards targeted HIV programs in the country.

Literature Review

Author (s)	Objective (s)	Methodology	Main 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	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
Antabe & Sano (2024)	To evaluate effectiveness of HIV information dissemination has been in reducing HIV misconceptions.	Utilized the 2005-06, 2012, and 2016-17 Haiti Demographic and Health Surveys and applied logistic regression	Among males, after controlling for demographic, socioeconomic, and behavioral factors at the multivariate level, those in 2012 (OR ¼ 1.55, p<0.001) and 2016-17 (OR ¼ 1.24, p<0.01) were more likely to endorse HIV misconceptions compared to men in 2005-06
Dorcélus et al. (2021)	To assess these factors as potential barriers to adherence among patients receiving care in central Haiti.	A cross-sectional study was conducted among PLH receiving antiretroviral therapy (ART) at the TB/HIV clinic at St. Therese Hospital in Hinche, Haiti	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).
Dunbar et al. (2021)	To present the epidemiology, social and cultural factors driving the HIV epidemic among men who have sex with men (MSM) in the Caribbean region and to highlight the regional and national responses, and what remains to be addressed to close the gaps in order to ending AIDS by 2030	literature review	The prevalence of HIV among MSM is high and the rates also do vary among Caribbean countries.

Methodology

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

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

Smoothing equation

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

$0 < \alpha < 1$

Trend estimation equation

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

$0 < \beta < 1$

Forecasting equation

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

H_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 Haiti 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

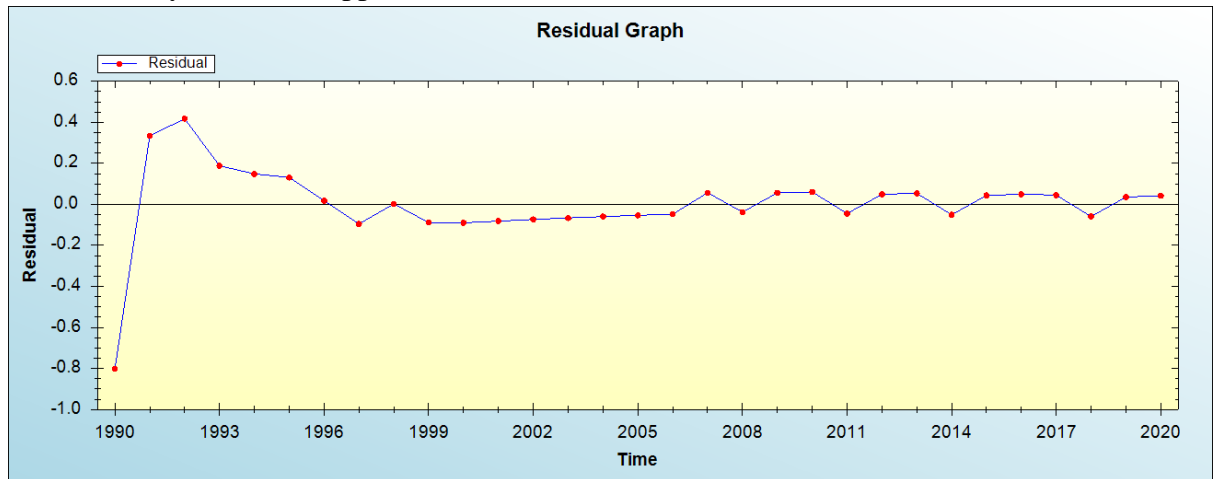| Variable	H
Included Observations	31
Smoothing constants	
Alpha (α) for data	0.900
Beta (β) for trend	0.100
Forecast performance measures	
Mean Absolute Error (MAE)	0.109046
Sum Square Error (SSE)	1.088151
Mean Square Error (MSE)	0.035102
Mean Percentage Error (MPE)	-0.051819
Mean Absolute Percentage Error (MAPE)	4.355163

Residual Analysis for the Applied Model

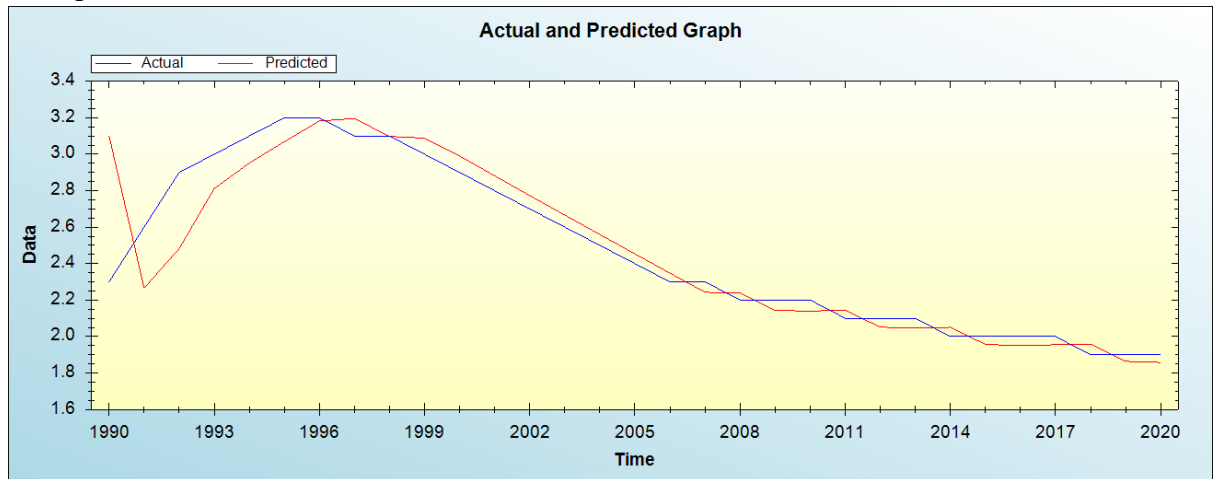Figure 1: Residual analysis

In-sample Forecast for H

Figure 2: In-sample forecast for the H series
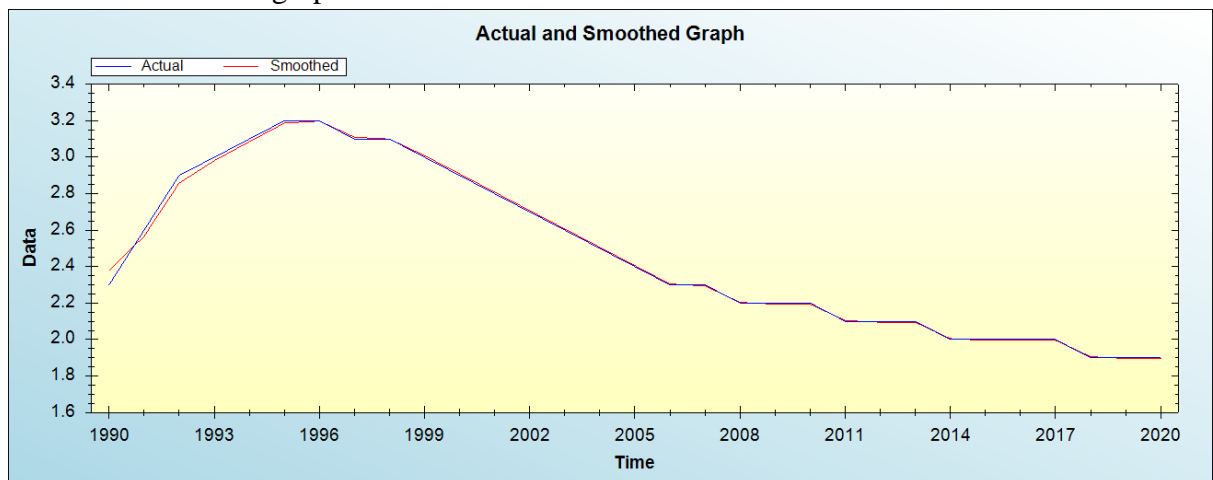
Actual and Smoothed graph for H series

Figure 3: Actual and smoothed graph for H series

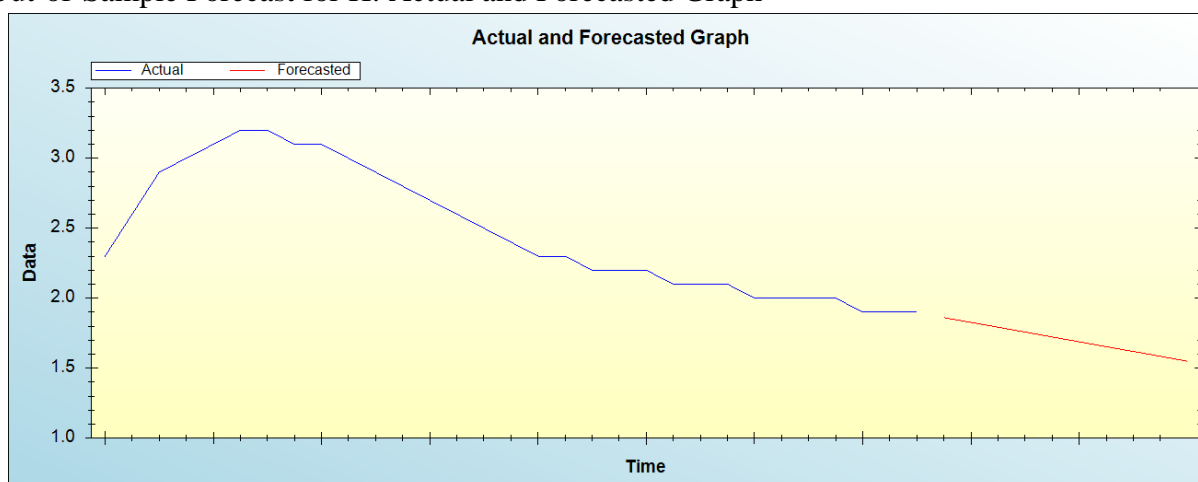Out-of-Sample Forecast for H: Actual and Forecasted Graph

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

Out-of-Sample Forecast for H: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Year	Forecasted HIV prevalence
2021	1.8612
2022	1.8265
2023	1.7919
2024	1.7573
2025	1.7226
2026	1.6880
2027	1.6534
2028	1.6187
2029	1.5841
2030	1.5495

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

Our research findings indicate that annual HIV prevalence among individuals aged 15-49 years will continue to decline in the out of sample period. Therefore, the government should scale up HIV testing and strengthen prevention measures among high risk groups.

References

1. United Nations (2023). Joint United Nations Programme on HIV/AIDS, UNAIDS, Haiti. 2023. Available at: https:// www. unaids. org/ en/ regions countries/ countries/ haiti

2. Moyo E, Moyo P, Murewanhema G, Mhango M, Chitungo I, and Dzinamarira T (2023). Key populations and Sub-Saharan Africa's HIV response. Front Public Health. 11:1079990.

3. UNAIDS (2018). Joint United Nations Programme on HIV/AIDS. https:// www. unaids. org/ sites/ default/ files/ media_ asset/ miles- to- go_ Caribbean_ en. Pdf

4. World Bank (2022). Prevalence of HIV, total (% of population ages 15–49) - Haiti.

5. UNAIDS. Country factsheets: Haiti 2022. UNAIDS. 2021. Available from: https://aidsinfo.unaids.org/%250D

6. PEPFAR (2020). Haiti PEPFAR country operational plan (COP). 2020 strategic direction summary. 2020. Available from: https://www.state.gov/wp-content/ uploads/2019/09/Namibia_COP19-Strategic-Directional- Summary_public.pdf

7. Delcher C, Robin EG, and Pierre DM (2020). Haiti HIV surveillance system: past, present, and future. Am J Trop Med Hyg. 103(4):1372–1375.

8. Koenig S, Ivers LC, and Pace S (2010). Successes and challenges of HIV treatment programs in Haiti: Aftermath of the earthquake. HIV Ther. 4(2):145–160

9. Nierengarten M-B (2003). Haiti's HIV equity initiative. Lancet Infect Dis. 3(5):266.

10. Pape JW, Liautaud B, and Thomas F (1983). Characteristics of the acquired immunodeficiency syndrome (aids) in Haiti. N Engl J Med. 309(16):945–950.

11. Pape J, and Johnson WD (1993). AIDS in Haiti: 1982–1992. Clin Infect Dis. 17 Suppl 2(Supplement_2):S341–S345

12. United Nations. (2015). transforming our world: The 2030 agenda for sustainable development, A/RES/70/1. New York: UN General Assembly.

13. UN (2020) sustainable development goals. https://www.un.org/sustainabl development/development-agenda

14. UNICEF (2018). Every Child alive. New York: UNICEF

15. World Health Organization (WHO) (2019). SDG 3: Ensure healthy lives and promote wellbeing for all at all ages.

16. United Nation (2016). Transforming our world: The 2030 agenda for sustainable development.