



PROJECTION OF HIV PREVALENCE AMONG INDIVIDUALS AGED 15-49 YEARS IN NIGERIA USING HOLT’S LINEAR METHOD

Dr. Smartson. P. NYONI¹, Thabani NYONI²

¹ZICHIRE Project, University of Zimbabwe, Harare, Zimbabwe

²Independent Researcher & Health Economist, Harare, Zimbabwe

Article history:	Abstract:
<p>Received: June 20th 2024 Accepted: July 14^h 2024</p>	<p><i>This study uses annual time series data of HIV prevalence among individuals aged 15-49 years for Nigeria 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 hover around 1.3% throughout the out of sample period. Therefore, we encourage authorities to strengthen HIV case finding, HIV prevention and treatment among this age group.</i></p>

Keywords: Exponential smoothing, Forecasting, HIV prevalence

BACKGROUND

Nigeria has an estimated population size of approximately 206,139,589 people (EROS, 2022; Worldometer, 2022). It is found within the eastern strip of West Africa with an area of 923,768 Km² (Ministry of Health, 2004). The first HIV/AIDS sentinel survey was carried out in 1991 and reported HIV prevalence of 1.8% which since then increased to 3.8% in 1993, 4.5% in 1996, and 5.4% in 1999, and peaked at 5.8% in 2001. After 2001, a downward trend was observed in 2003 (5.0%), 2005 (4.4%), 2008 (4.6%), 2010 (4.1%), 2013 (3.4%) (Awofala *et al.* 2018; Ministry of Health 2012). Nigeria ranks 4th in global HIV burden with approximately 1.8 million persons living with HIV as of 2019 (Ufornwa & Okoroiwu, 2021; UNAIDS, 2020; Coco-Basse *et al.* 2019). The National Agency for the control of AIDS revealed that the current national prevalence of HIV in Nigeria is 1.4% and stratification based on states

indicated the highest prevalence in Akwa Ibom (5.6%), Benue (4.9%), Rivers (3.8%), Taraba (2.7%) and Anambra (2.7%) and the least prevalence in Jigawa (0.3%) and Katsina (0.3%). The Test and Treat policy was introduced into the guidelines for managing HIV/AIDS by the Federal Ministry of Health in December 2016. This policy was implemented in response to the Treat All initiative of the World Health Organization (WHO) (WHO, 2016). The policy puts emphasis on the universal access to comprehensive HIV treatment and care and requires that all people with HIV are eligible for antiretroviral therapy (ART) immediately after diagnosis. The objective of this study is to model and forecast of HIV prevalence among individuals aged 15-49 years for Nigeria using Holt’s linear method. The study findings will trigger an appropriate national response to the HIV epidemic especially by facilitating allocation of resources towards targeted HIV programs in the country.

LITERATURE REVIEW

Author(s)	Objective (s)	Methodology	Key finding (s)
Iwelunmor et al. (2023)	To review lessons learned from research to date, to point out a path forward for sustaining evidence-based interventions in resource-limited settings	Applied PLAN	PLAN is designed to further the dialogue on ways research and practice teams can critically work to ensure the sustainability of their evidence-based interventions from the onset, particularly in settings and with



			populations limited with resources.
Ozim et al. (2023)	To estimate prevalence of HIV infection in Nigeria and examine variations by geopolitical zones and study characteristics to inform policy, practice and research.	-conducted a comprehensive search of bibliographic databases including PubMed, CINAHL, PsycINFO, Global Health, Academic Search Elite and Allied and Complementary Medicine Database (AMED) and grey sources for studies published between 1 January 2008 and 31 December 2019.	Pooled prevalence for most individual geopolitical zones showed substantial variations compared with overall prevalence. North- Central (6.84%, 95% CI 4.73 to 9.79) and South- West zones (6.27%, 95% CI 4.75 to 8.24) had lower prevalence whereas South- East zone (17.04%, 95% CI 9.01 to 29.86) had higher prevalence
Okoroiwu et al. (2022)	To analyze the trend of HIV/AIDS research in Nigeria.	used the PUBMED database to a conduct bibliometric analysis of HIV/AIDS-related research in Nigeria from 1986 to 2021 employing "HIV", "AIDS", "acquired immunodeficiency syndrome", "Human immunodeficiency virus", and "Nigeria" as search description	The growth of scientific literature in HIV/AIDS-related research in Nigeria was found to be high and increasing. However, the hotspot analysis still shows more unexplored grey areas in future
Odediran et al. (2022)	Explores the factors associated with retention in care among women with HIV in a large HIV clinic in Lagos, Nigeria, under the Test and Treat policy	Women living with HIV/AIDS (n24) enrolled in an HIV study at the AIDS Prevention Initiative in Nigeria (APIN) clinic in Lagos, Nigeria, were interviewed from April 1 to October 31, 2021, using a semi-structured interview guide.	Several deterring factors to retention in HIV care, such as nondisclosure of status, absence of social support, and clinic barriers, persist under the Test and Treat policy.
Kanki et al. (2020)	To characterize the HIV-1 molecular epidemiology by analyzing 1442 HIV-1 pol sequences collected 1999–2014 from four geopolitical zones in Nigeria	Applied state-of-the-art maximum-likelihood and Bayesian phylogenetic analyses.	Bayesian phylodynamic analysis suggested that five major Nigerian HIV-1 subepidemics were introduced in the 1960s and 1970s, close to the Nigerian Civil War
Onoja et al. (2020)	To assess knowledge and high risk practices to HIV infection among	cross sectional quantitative survey	The prison inmates had the highest prevalence of STIs, 37% of the



	the people of lake Chad Basin in Bono State, Nigeria		respondents didn't know that they were at risk of contracting HIV. The knowledge of HIV status was higher among the males (80.2%) than the females (19.3%). The use of male and female condom was higher among the rural (19.2%) than the urban (10.8%) respondents
Odimegwu et al. (2017)	to identify critical areas that research and programs must address in order to accelerate the progress towards zero (new infections, discrimination, and death) target by year 2030	Synthesized information on research studies, policies, and programs related to HIV-stigma in Nigeria.	Nigeria does not lack relevant policies; what needs to be strengthened are design, planning, implementation, monitoring, and evaluation of context-specific stigma reduction programs

METHODOLOGY

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

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

Smoothing equation

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

$$0 < \alpha < 1$$

Trend estimation equation

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

$$0 < \beta < 1$$

Forecasting equation

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

N_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 Nigeria 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	N
Included Observations	31
Smoothing constants	
Alpha (α) for data	0.900
Beta (β) for trend	0.100
Forecast performance measures	
Mean Absolute Error (MAE)	0.060871
Sum Square Error (SSE)	0.324901
Mean Square Error (MSE)	0.010481
Mean Percentage Error (MPE)	-1.178244
Mean Absolute Percentage Error (MAPE)	6.480688

Residual Analysis for the Applied Model

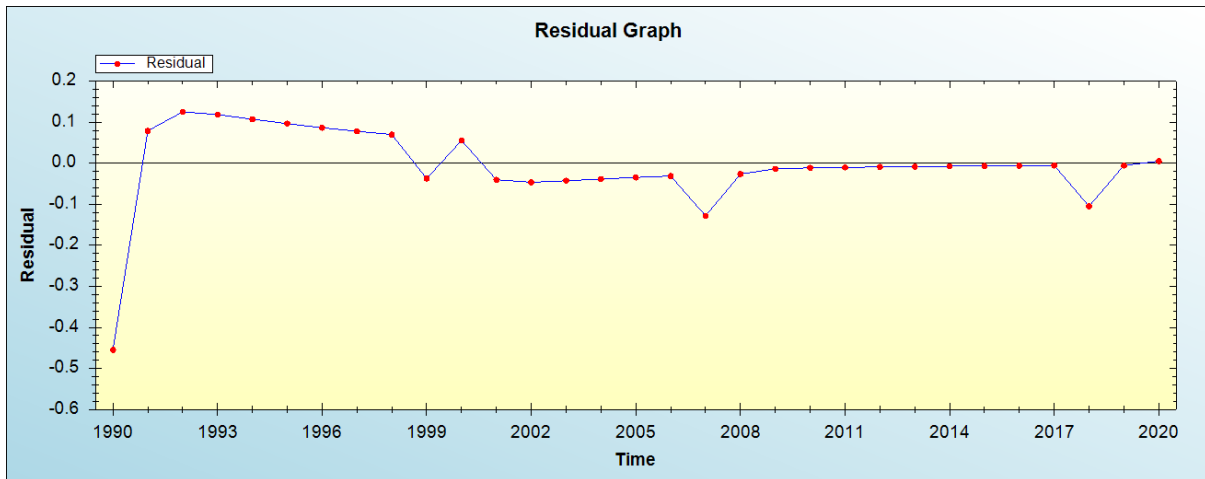


Figure 1: Residual analysis

In-sample Forecast for N

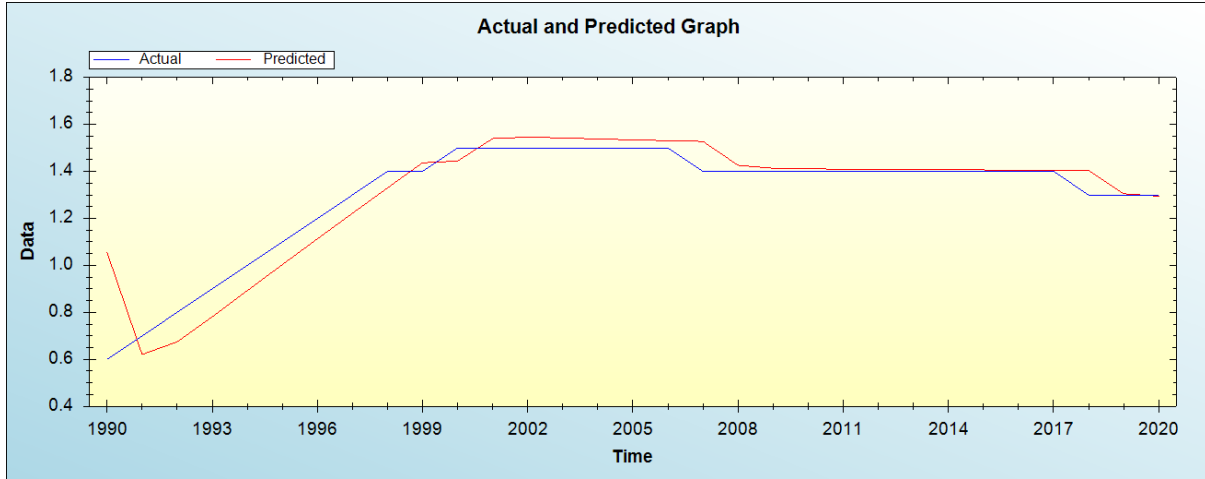


Figure 2: In-sample forecast for the N series

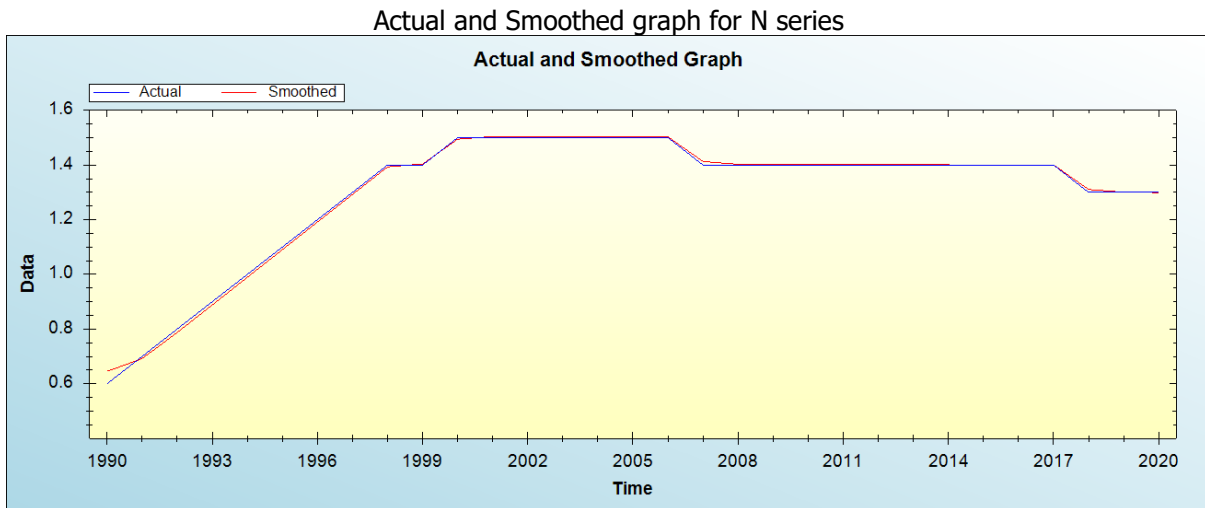


Figure 3: Actual and smoothed graph for N series

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

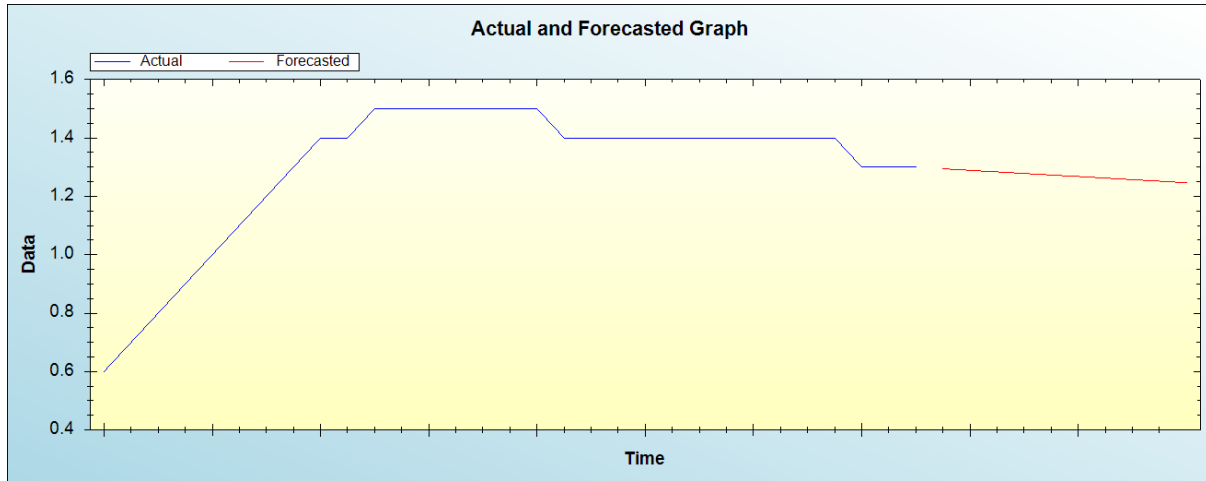


Figure 4: Out-of-sample forecast for N: actual and forecasted graph

Out-of-Sample Forecast for N: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Year	Forecasted HIV prevalence
2021	1.2942
2022	1.2889
2023	1.2836
2024	1.2783
2025	1.2730
2026	1.2677
2027	1.2624
2028	1.2571
2029	1.2518
2030	1.2465

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 1.3% throughout the out of sample period.

POLICY IMPLICATION AND CONCLUSION

Our research findings indicate that annual HIV prevalence among individuals aged 15-49 years will hover around 1.3% throughout the out of sample period. Therefore, this research calls for strengthening of HIV case finding, HIV prevention and treatment among this age group.

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