European Science Methodical Journal
ISSN (E): 2938-3641
Volume 2, Issue 9, September- 2024

PREDICTION OF HIV PREVALENCE AMONG INDIVIDUALS AGED 15-49 YEARS IN NIGER 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 Niger 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 0.1respectively 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 increase HIV diagnosis, treatment and prevention especially among high risk groups.

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

Introduction

Approximately 36.7 million people were living with HIV globally in 2015 with 70 % of infected people were living in sub-Saharan Africa (UNAIDS, 2016 & Hodgson & Rachanis, 2002). Developing countries account for 97% of global HIV cases and Sub-Saharan Africa is the world's worst affected region (Kautako-Kiambi *et al.* 2015). Around 3.9 million young people worldwide were infected with HIV in 2017 (Bekele & Fekadu, 2020). About 2.9 million of the 4.9 million young people living with HIV / AIDS live in eastern and southern Africa (Peltzer K & Matseke, 2013). Young women are more vulnerable to HIV due to extreme peer pressure and the emergence of their sexual and social identities (UNAIDS, 2008). Predictors of young people's HIV testing include demographic factors, HIV risk behavior, psychosocial variables associated with HIV awareness and stigma attitudes (Erena *et al.* 2019; Muyunda *et al.* 2018; Paulin *et al.* 2015; Nwachukwu & Odimegwu, 2011). The aim of this paper is to model and forecast HIV prevalence among individuals aged 15-49 years for Niger using Holt's linear method. The results of this paper are envisaged to inform policy, planning and allocation of resources towards targeted HIV prevention, treatment, support and care programs in Niger in order to curb new infections and reduce morbidity and mortality related to HIV/AIDS.

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Literature Review

Author (s)	Objective (s)	Methodology	Key finding (s)
Seifu et al. (2024)	To assess the level of comprehensive knowledge about HIV/AIDS and its associated factors among reproductive age women in Liberia	The prevalence and associated factors of comprehensive knowledge about HIV/AIDS among reproductive age women in Liberia were determined using secondary data analysis of 2019–2020 Liberia Demographic and Health Surveys (LDHS).	The prevalence of comprehensive HIV/AIDS knowledge among Liberian women aged 15–49 was 33.5%. Women's age and education, and distance to health facility were positively associated with comprehensive knowledge about HIV/AIDS among Liberian reproductive age women
Djiyou et al. (2023)	To prospectively assess the rate of VS, and the factors associated with VF in a cohort of adolescents followed up according to the WHO guidelines in Cameroon	A cross-sectional study was carried out in 2021 among adolescents (aged 10–19 years) receiving ART in the national program in Cameroon	Overall, 280 adolescents were enrolled, of whom 89.3% (250/280) acquired HIV infection via mother-to-child transmission. -the VS rate was 88.2% (CI: 83.8-91.7%)
Kudo (2022)	To examine the impact of human immunodeficiency virus (HIV)-specific laws criminalizing HIV non-disclosure, exposure, and transmission on women's voluntary testing, using a regression discontinuity design that exploits the enaction timing of such legislation in Mali	nationally representative household survey	the law discouraged test uptake among HIV-positive females by reinforcing HIV stigma and/or fear of legal punishment
Kra et al. (2021)	To investigate the impact on, the adaptation of and the disruption of field activities.	Focused only on outreach activities among key populations, analyzes quantitative, and qualitative program data collected during implementation to examine temporal trends in HIVST distribution and their evolution in the context of the COVID-19 health crisis.	The impact of the COVID-19 pandemic on HIVST distribution among key populations was visible in the monthly activity reports
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
Telly et al. (2020)	To study factors associated with not being HIV tested among MSM	A cross-sectional bio-behavioral survey among MSM in Bamako	HIV prevalence found in the study among MSM in Bamako was 13.7%. More than a quarter of the MSM population, 27% had not been tested for HIV. Factors associated with not being tested for HIV included older age, the type of occupation, the use of

			alcohol and a history of sexual assaults
Jary et al. (2019)	To assess prevalence and risks factors associated with HIV, HBV, HCV and syphilis infections.	cross-sectional study	-HIV-seroprevalence was 2.16% and significantly increased with age, being married and decreasing education level -Overall, HIV and HBV infection was higher in individuals with a lower level of education, HBV infection was higher in men, and HCV infection was higher in people living outside of Bamako
Sagaon-Teyssier et al. (2017)	To estimate HIV prevalence and the factors associated with HIV sero-positivity in the population living and working at the informal artisanal small-scale gold mining (IASGM) site of Kokoyo in Mali	a cross sectional survey	HIV prevalence for the total sample was 8% (95% CI 7.7% to 8.3%), which is much higher than the 2015 national prevalence of 1.3% -The probability of HIV seropositivity was 7.8% (p=0.037) higher for female non-sex workers than for any other category, and this probability increased significantly with age.
Hurley et al. (2017)	To define PPC dimensions relevant to ART programs in Bamako, Mali through recordings of clinical interactions, in-depth interviews and focus-group discussions with 69 patients and 17 providers.	Qualitative analysis revealed two PPC dimensions similar to those described in the literature on patient-centered communication (level of psychosocial regard, balance of power), and one unique dimension that emerged from the data (guiding patient behavior: easy/tough/sharp).	Highly educated participants chose biomedical and shared power styles more frequently, while less educated participants more frequently indicated "no preference"

Methodology

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

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

Smoothing equation

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

$0<\alpha<1$

Trend estimation equation

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

$0<\beta<1$

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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 Niger 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)	0.053204
Sum Square Error (SSE)	0.218121
Mean Square Error (MSE)	0.007036
Mean Percentage Error (MPE)	-3.319848
Mean Absolute Percentage Error (MAPE)	16.408029

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Residual Analysis for the Applied Model

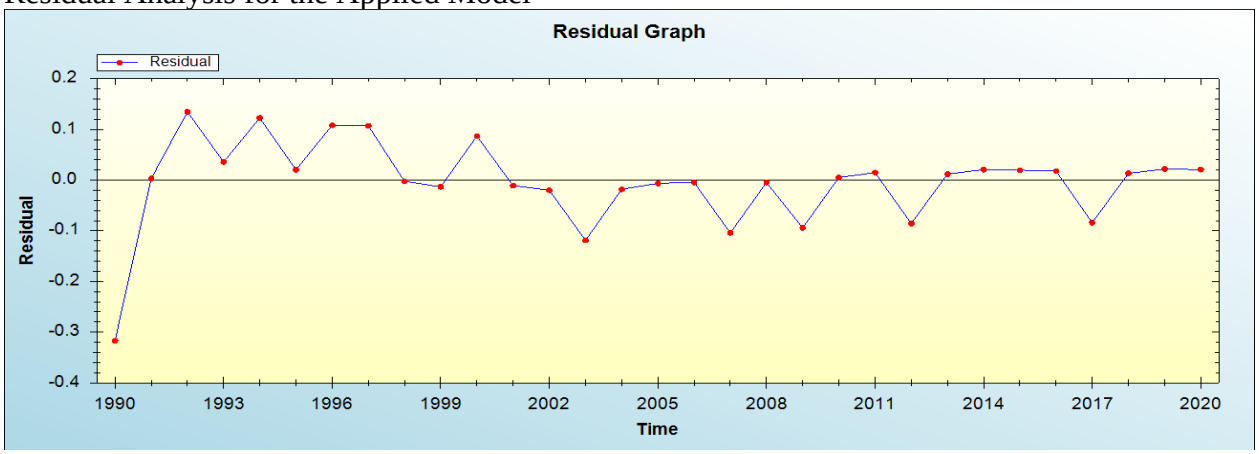

Figure 1: Residual analysis

In-sample Forecast for N

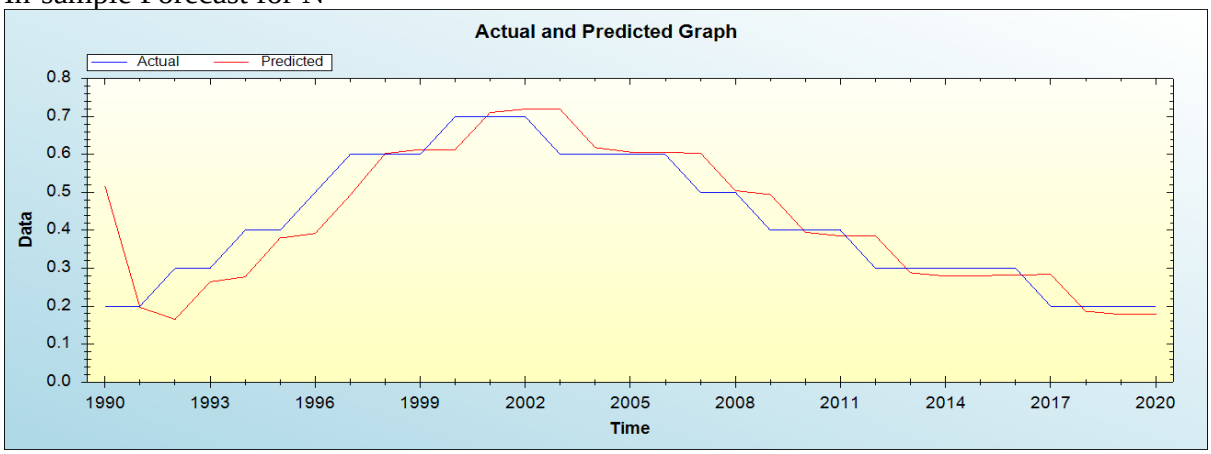

Figure 2: In-sample forecast for the N series

Actual and Smoothed graph for N series

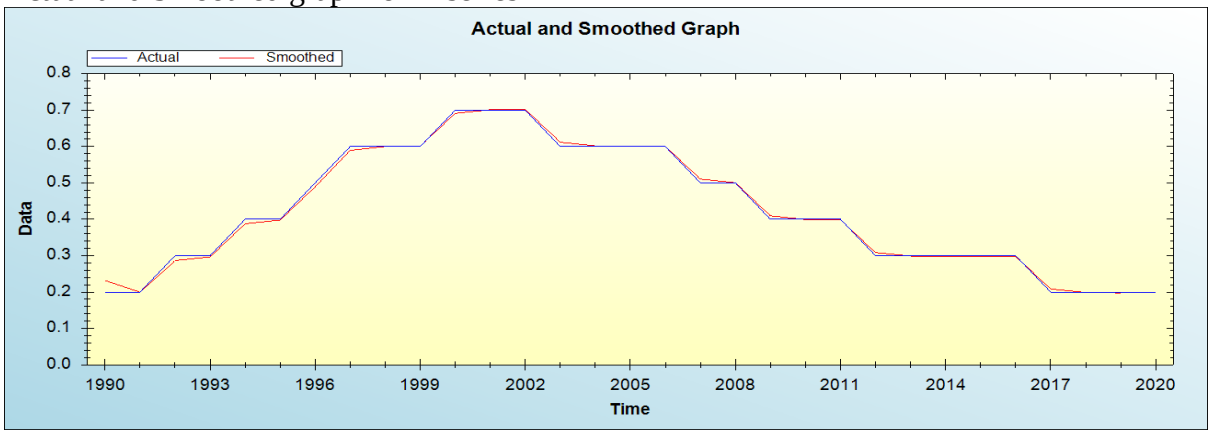

Figure 3: Actual and smoothed graph for N series

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

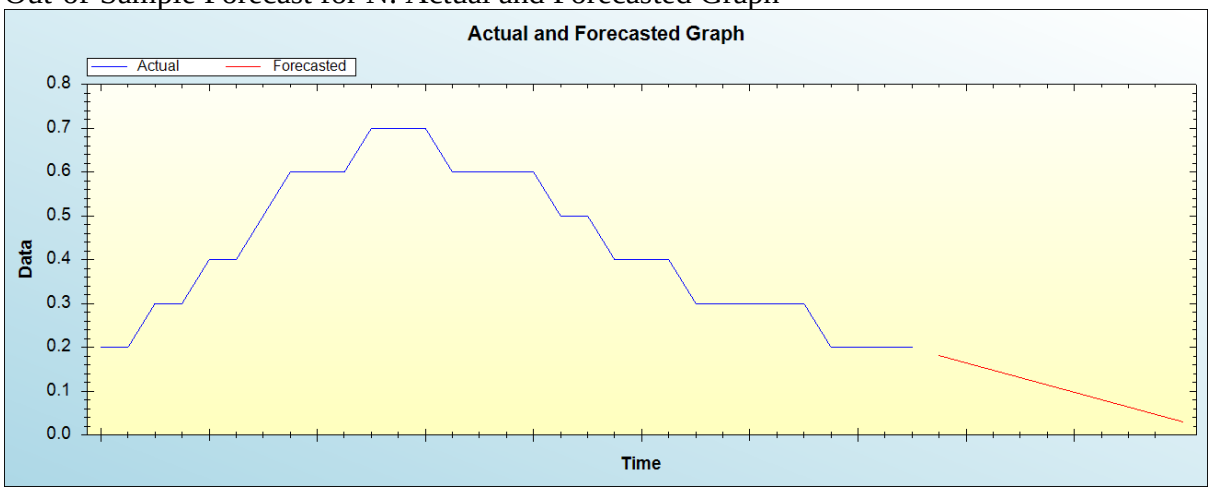

Figure 4: Out-of-sample forecast for N: actual and forecasted graph

Out-of-Sample Forecast for N: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Year	Forecasted HIV prevalence
2021	0.1811
2022	0.1644
2023	0.1476
2024	0.1308
2025	0.1140
2026	0.0973
2027	0.0805
2028	0.0637
2029	0.0469
2030	0.0302

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 implications and conclusion

Our model projections indicate that annual HIV prevalence among individuals aged 15-49 years will continue to decline over the out of sample period. This paper calls for improvement in HIV case detection, treatment and prevention especially among high risk groups.

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