ANALYZING HIV PREVALENCE AMONG INDIVIDUALS AGED 15-49 YEARS IN UGANDA 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 Uganda 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 0.8 and 0.9 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 improve HIV case detection, prevention and treatment especially among high-risk groups.

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

Introduction

HIV remains a serious public health challenge globally due to the associated high morbidity and mortality besides the obvious high health related costs. In 2018, approximately 38 million people were living with HIV/AIDS, with nearly 21 million living in eastern and southern Africa (UNAIDS, 2019). In that same year, about 1.7 million people became newly infected with HIV (UNAIDS, 2019). Nearly a third of these people newly living with HIV were young people aged 15–24 years. Over 3.5 million young people are living with HIV globally, of whom 63% reside in East and Southern Africa (UNAIDS data, 2019). According to UPHIA 2016–2017, the prevalence of HIV among adults aged 15 to 64 in Uganda is 6.2%: 7.6% among females and 4.7% among males. This corresponds to approximately 1.2 million people aged 15 to 64 living with HIV in Uganda. HIV prevalence is higher among women living in urban areas (9.8%) than those in rural areas (6.7%).The prevalence of VLS among all HIV-positive adults aged 15 to 64 in Uganda is 59.6%: 62.9% among females and 53.6% among males. The prevalence of VLS in children aged 0-14 is 39.3%. Among adults aged 15 to 64, the prevalence of HIV varies geographically across Uganda, ranging from 3.1% in West Nile to 8.0% in Central 1. Among HIV-positive adults aged 15 to 64, prevalence of VLS varies geographically across the country, ranging from 48.8% in the East-Central region to 70.0% in the North-East region. The purpose of this study is to model and forecast HIV prevalence among individuals aged 15-49 years for Uganda using Holt's double exponential smoothing technique. The research output is expected to inform policy, planning and allocation of resources towards

targeted HIV prevention and treatment programs in order to control the HIV epidemic in Uganda.

Literature Review

Author (s)	Objective (s)	Methodology	Key finding (s)
Bekolo et al. (2023)	to review current evidence for declining HIV prevalence despite increasing survival owing to 'universal test and treat' and to explore the reason for the decrease, particularly the role of behavioral change.	conducted a secondary analysis using HIV prevalence, behavioral and social determinants data of the Demographic and Health Survey Program databases	The observed decline in HIV prevalence is statistically valid and reflects the observed decline in risky sexual behavior that need to be sustained by the National HIV programme
Kalibbala et al. (2022)	To determine the prevalence and factors influencing HIV testing among young people in a peri-urban district with the highest proportion of young people	-conducted a nested explanatory sequential mixed-methods study from March to May 2019 in Wakiso district	The prevalence of testing for HIV was 80.2%. Young people related their decisions about HIV testing to self-evaluation of their risk and perceived ability to manage the consequences of a positive result. Participants reported high levels of support for HIV testing from peers, partners, and family members.
Wakida et al. (2022)	To evaluate the perceptions of undergraduates and mentors on the appropriateness, acceptability, and feasibility of a mentored seed-grant (micro-research) by Health Professions Education Partnership Initiative - Transforming Ugandan Institutions Training Against HIV/AIDS (HEPI-TUITAH) program on HIV training in Uganda	conducted a cross-sectional descriptive qualitative study with focus groups, on HIV micro-research training, with undergraduate health professions students and faculty mentors across three partner institutions in rural Uganda	The HEPI-TUITAH micro-research program was perceived as acceptable, appropriate, and feasible for health professions undergraduate students. It also promoted teamwork and academic collaboration
Akuoko et al. (2021	The study focused on Cameroon, Ethiopia, Ghana, and Zambia to give a general overview of the HIV situation in the region.	2019 data by UNAIDS were assessed and compared with the 2018 data	The results revealed a disproportionate burden of the disease among women aged 15 years and above, as compared to men of the same ages and children below 15 years. Also, it was revealed that ARV services among pregnant women are

			effective in reducing the number of new infections among newborns.
Martial et al. (2021)	To examine the long-term trend of the overall HIV/AIDS incidence rates in four countries of the central region of Africa, using data from the Global Burden of Diseases (GBD) 2019 study.	The Age–Period–Cohort statistical model analysis was used to measure the trends of HIV/AIDS incidence rates in each of the four countries.	HIV/AIDS incidence rates are decreasing in each of the four countries
Nabukenya and Matovu (2018)	To explore the correlates of HIV status awareness among older adults (45 years and above) in Uganda	Secondary analysis of existing data on people aged between 45 and 59 years from AIDS indicator survey conducted between February and September 2011	-Less than a quarter of Ugandans were aware of their HIV status -High levels of stigma and low comprehensive knowledge on HIV/AIDS remain critical barriers to HIV testing and awareness of HIV status

Methodology

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

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

Smoothing equation

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

$0 < \alpha < 1$

Trend estimation equation

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

$0 < \beta < 1$

Forecasting equation

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

U_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 Uganda 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	U
Included Observations	31
Smoothing constants	
Alpha (α) for data	0.800
Beta (β) for trend	0.900
Forecast performance measures	
Mean Absolute Error (MAE)	0.058699
Sum Square Error (SSE)	0.172770
Mean Square Error (MSE)	0.005573
Mean Percentage Error (MPE)	-0.026680
Mean Absolute Percentage Error (MAPE)	0.757609

Residual Analysis for the Applied Model
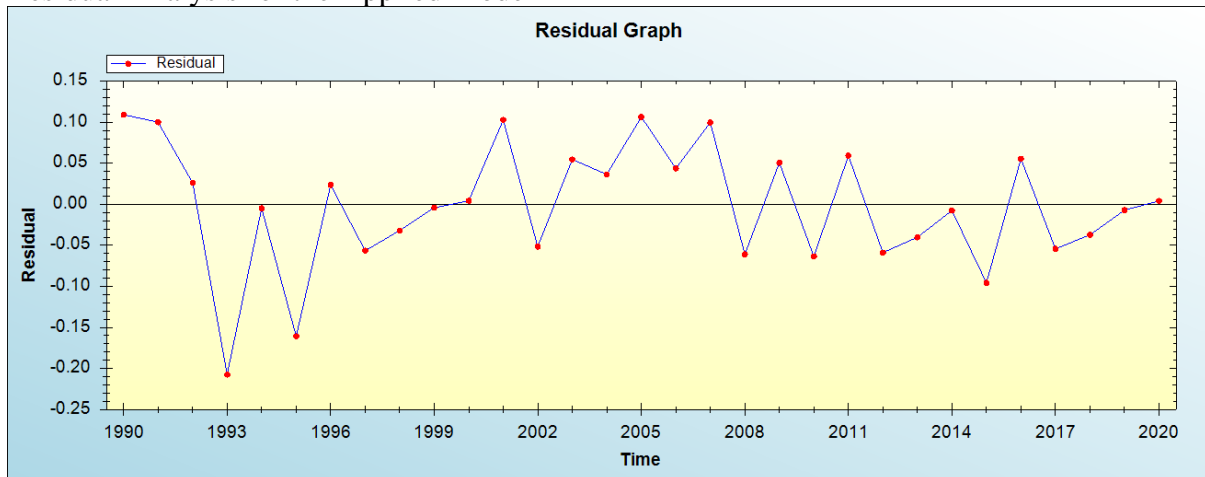

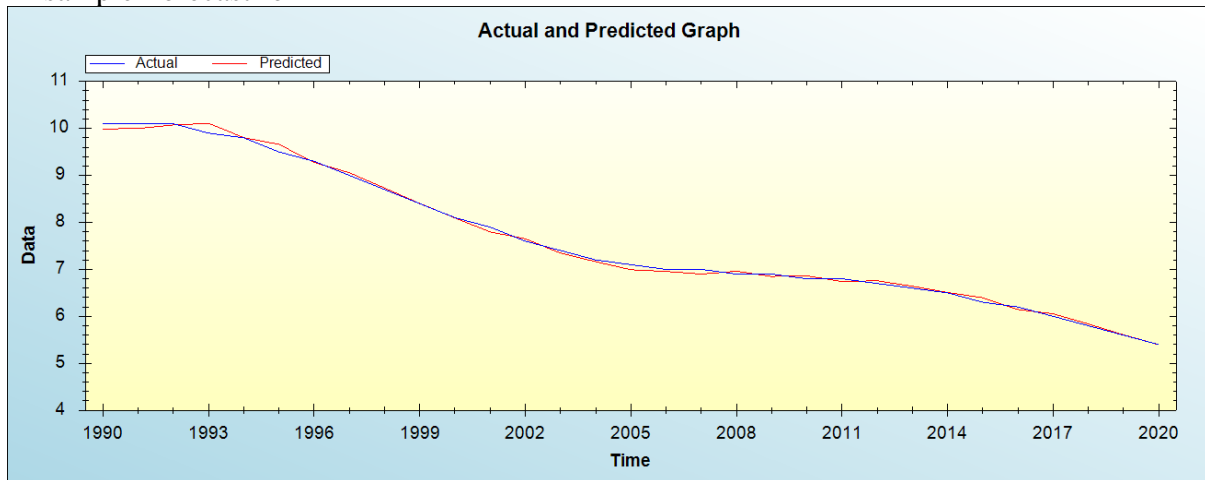Figure 1: Residual analysis

In-sample Forecast for A

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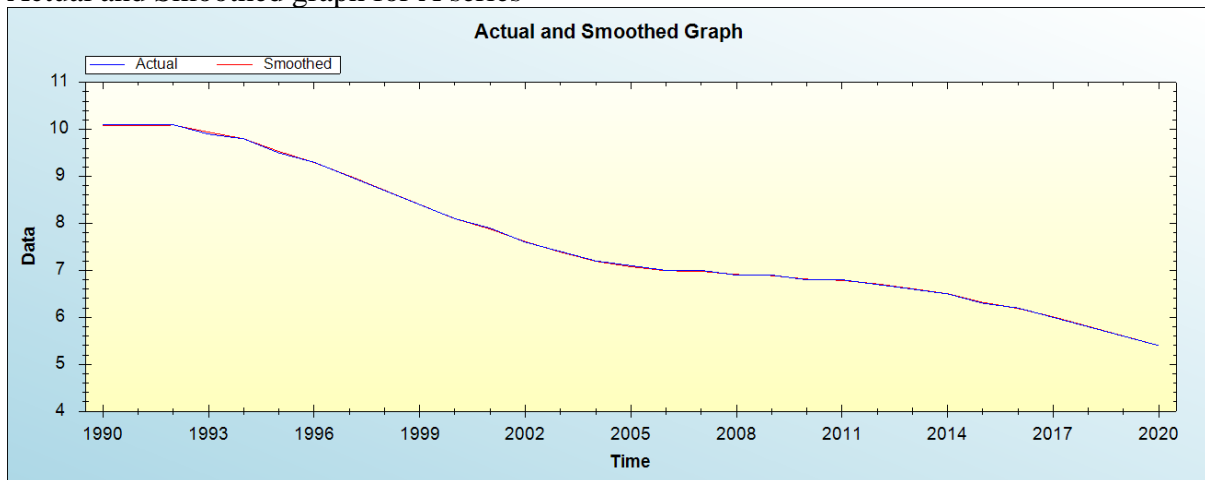
Actual and Smoothed graph for A series

Figure 3: Actual and smoothed graph for A series

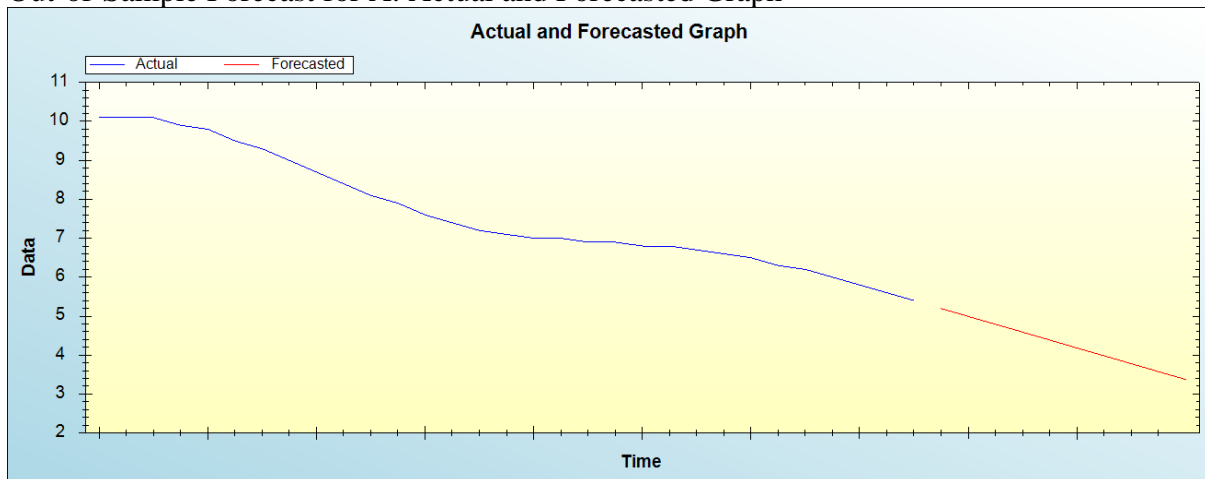Out-of-Sample Forecast for A: Actual and Forecasted Graph

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

Out-of-Sample Forecast for A: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Year	Forecasted HIV prevalence
2021	5.1966
2022	4.9941
2023	4.7916
2024	4.5890
2025	4.3865
2026	4.1840
2027	3.9814
2028	3.7789
2029	3.5763
2030	3.3738

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 applied double exponential smoothing technique to forecast annual HIV prevalence among individuals aged 15-49 years. Results indicate that annual HIV prevalence among individuals aged 15-49 years will continue to decline over the out of sample period. Therefore, there is need to improve HIV case detection, prevention and treatment especially among high risk groups.

References

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