ANALYZING HIV PREVALENCE AMONG INDIVIDUALS AGED 15-49 YEARS IN SENEGAL USING HOLT'S LINEAR METHOD

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Article history:		Abstract:
		This study uses annual time series data of HIV prevalence among individuals aged 15-49 years for Senegal 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 0.2 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, policymakers should continue allocating resources for HIV diagnosis, treatment and prevention especially among high risk groups.

BACKGROUND

According to UNAIDS, globally at the end of 2017, 36.9 million people were living with HIV and 940,000 died from HIV/AIDS related causes. The HIV epidemiology across the world varies according to world geographical zones, sub-Saharan Africa being the most affected region with more than 66% of new infections (UNAIDS, 2018). The 2017 Senegal Demographic and Health Survey reported an overall HIV prevalence of 0.5% in the general population. In the Sedhiou region HIV prevalence is 1.8% in the general population, 3.8% in MSM, 6.6% in PS, and 5.2% in the UID (CNLS, 2018). The Goudomp district had a seroprevalence of 1.1% in 2016 and 1.52% in 2017. In the commune of Niagha had sero prevalence of 6.5 % (Khadim *et al.* 2020). Senegal has made significant progress in the HIV/AIDS response as evidenced by a low and stable prevalence of 0.4% in adults age 15–49 (UNAIDS, 2018), a gradual decline in new HIV infections as well as in HIV-related deaths,

and a significant increase of 57% in antiretroviral therapy coverage in 2017 (CNLS, 2018). The National Statistic and Demographic Agency of Senegal & ICF revealed that HIV is a female epidemic, with a prevalence of 0.5% in women versus 0.4% in men. According to the Senegal National strategic Plan 2018-2022, the HIV epidemic in Senegal is concentrated among key populations. In addition of these populations, the mostly exposed populations to HIV related risks are composed of young people, prisoners, artisanal gold miners, people with disabilities, truckers, fishermen, soldiers and police. The objective of this paper is to model and forecast HIV prevalence among individuals aged 15-49 years for Senegal using Holt's linear method. The results of this research will inform policy, planning and allocation of resources towards targeted HIV programs in order to curb new HIV infections among key populations and other vulnerable groups.

LITERATURE REVIEW

Author (s)	Objective (s)	Methodology	Key finding (s)
Benzekri et al. (2021)	To determine the impact of food insecurity on HIV outcomes in Senegal, West Africa.	Logistic regression was used to determine the association between food insecurity and HIV outcomes.	Severe food insecurity was a strong predictor of loss to follow-up (OR 3.13 [1.08–9.06]) and persistent severe food insecurity was associated with virologic failure (OR 5.14 [1.01–26.29]) and poor adherence to ART 8.00 [1.11–57.57]. Poor nutritional status

			was associated with poor immunologic recovery (OR 4.24 [1.56–11.47]), virologic failure (OR 3.39 [1.13–10.21]), and death (OR 3.35 [1.40–8.03]).
Kra et al. (2021)	To investigate the impact on, the adaptation of and the disruption of field activities.	The study focused only on outreach activities among key populations, analyzed 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	In all three countries, the pre-COVID-19 period was marked by a gradual increase in HIVST distribution. The period corresponding to the initial emergency response (March-May 2020) witnessed an important disruption of activities: a total suspension in Senegal, a significant decline in Côte d'Ivoire, and a less pronounced decrease in Mali.
Ba et al. (2020)	To determine the prevalence of HIV infection among prisoners and describe associated factors	descriptive and analytical cross-sectional study conducted from December 2015 to October 2016	Prisoners are very vulnerable to HIV infection with a high prevalence compared to the national rate
Khadim et al. (2020)	To determine the factors related to HIV-positive status in people aged 15 to 49 years of age in the commune of Niagha in Goudomp	-Descriptive and analytically cross-cutting and had taken place in a release of 2018. -Bivariate analyses and logistical modelling have been used to investigate the factors associated with HIV status.	HIV infection was found in 19 people, 6.0% seroprevalence, with 16 cases of HIV 1 infection and three cases of HIV 2 infection. Several risk behaviors were found in this study. However, none of them had a statistically significant link to HIV seropositivity.
Lakhe et al. (2020)	To assess the factors associated with HIV testing among sexually active women and men in Senegal. Knowledge of HIV status is the gateway to antiretroviral treatment.	multivariable logistic regression analyses were performed to identify the socio-demographic, HIV knowledge, media exposure, and behavioral factors associated with HIV testing in Senegal	among men the factors independently associated with being tested for HIV were: age groups 20–24 to 40–44 and age group 50–54; a higher level of education; being in the richest household wealth quintile; being married; knowing about the efficacy of HAART during pregnancy; having 2 or more lifetime sex partners and owning a mobile phone. Among women factors independently

			associated with HIV testing were: being in any age groups versus 15–19; a higher level of education; being in the richest household wealth quintile; being married; knowing about the efficacy of HAART during pregnancy; having any STI in last 12 months; fearing stigma; owning a mobile phone; and having any number of ANC visits, versus none

METHODOLOGY

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

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

Smoothing equation

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

$0 < \alpha < 1$

Trend estimation equation

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

$0 < \beta < 1$

Forecasting equation

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

A_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 Senegal 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

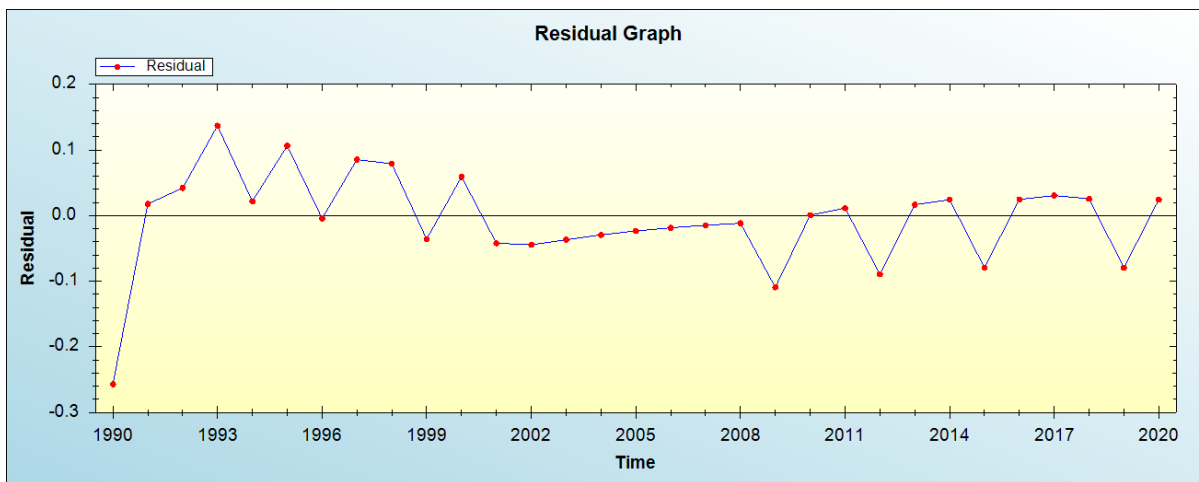| Variable	A
Included Observations	31
Smoothing constants	
Alpha (α) for data	0.900
Beta (β) for trend	0.200
Forecast performance measures	
Mean Absolute Error (MAE)	0.051032
Sum Square Error (SSE)	0.160544
Mean Square Error (MSE)	0.005179
Mean Percentage Error (MPE)	-2.043604
Mean Absolute Percentage Error (MAPE)	14.065895

Residual Analysis for the Applied Model
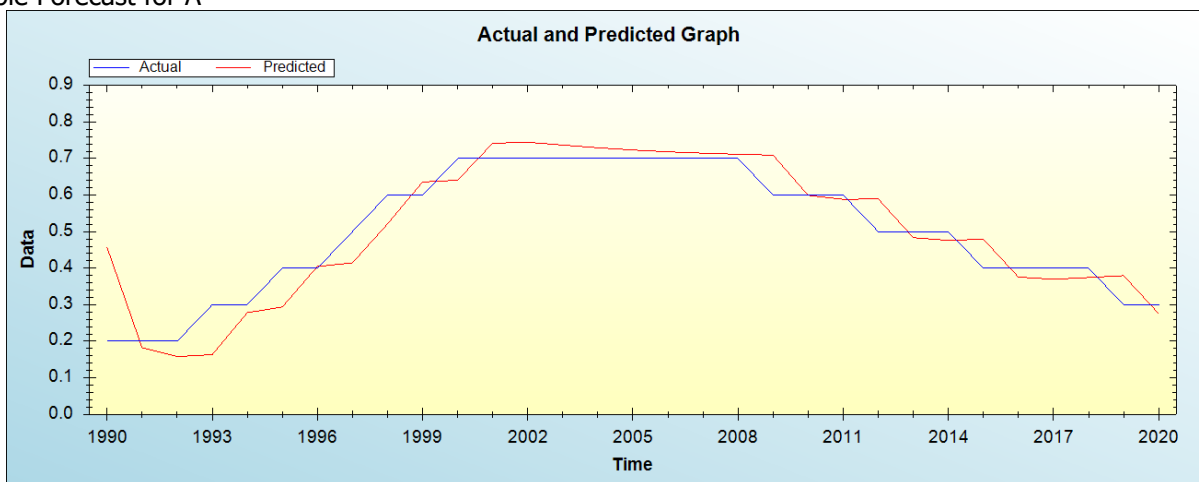
Figure 1: Residual analysis

In-sample Forecast for A

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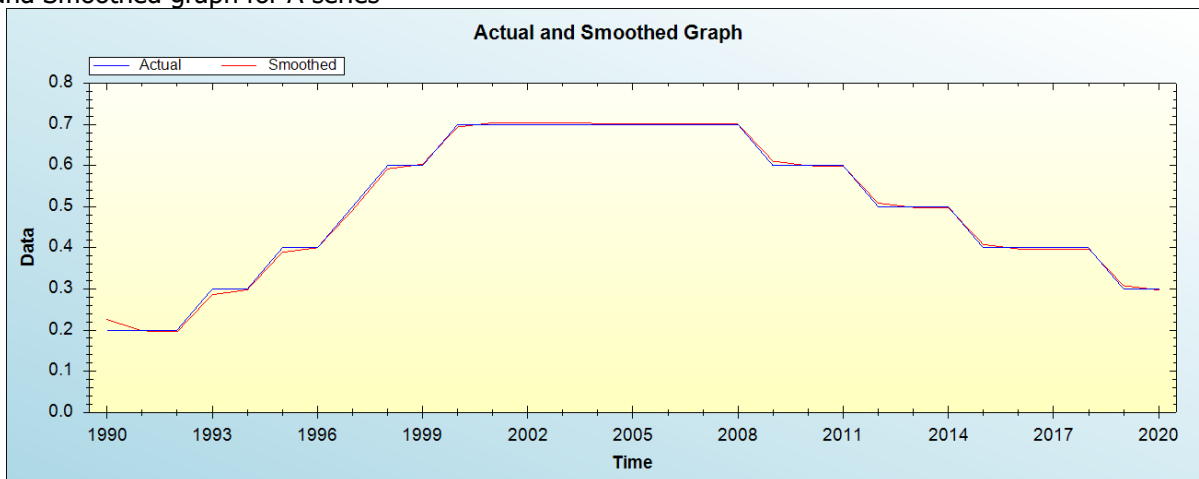
Actual and Smoothed graph for A series

Figure 3: Actual and smoothed graph for A series
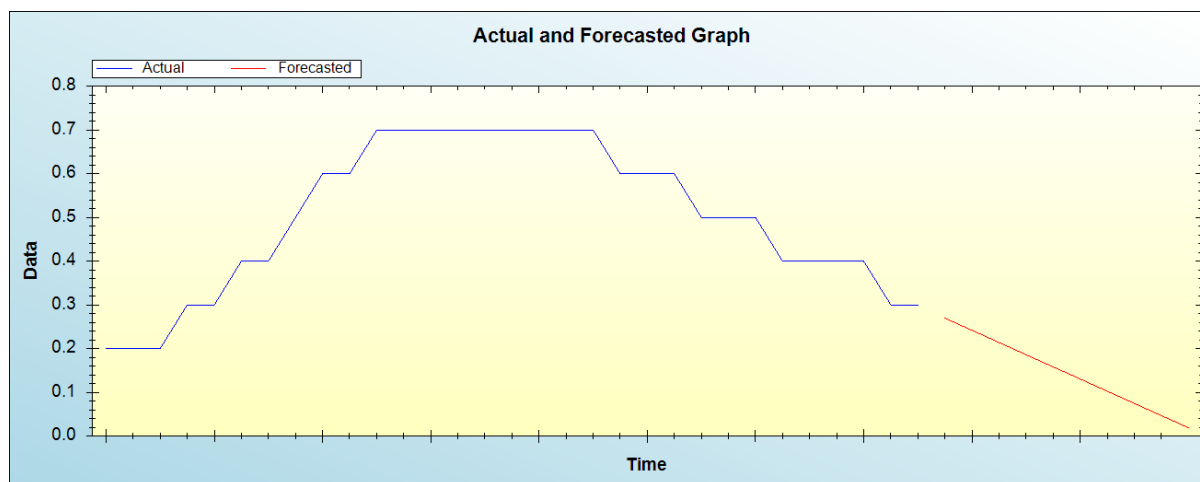
Out-of-Sample Forecast for A: Actual and Forecasted Graph

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	0.2697
2022	0.2418
2023	0.2139
2024	0.1861
2025	0.1582
2026	0.1303
2027	0.1024
2028	0.0745
2029	0.0467
2030	0.0188

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 paper establishes that annual HIV prevalence among individuals aged 15-49 years will continue to decline over the out of sample period. Therefore, policymakers should continue allocating resources for HIV diagnosis, treatment and prevention especially among high risk groups.

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