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DETECTING FUTURE TRENDS OF HIV PREVALENCE AMONG INDIVIDUALS AGED 15-49 YEARS FOR MOZAMBIQUE 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 Mozambique 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 0.5 respectively based on minimum MSE. The results of the study indicate that annual HIV prevalence among individuals aged 15-49 years will slightly decline over the out of sample period but still remain high. Therefore, there is need to scale up of HIV testing, ART coverage and prevention services among this age group. In addition, there is need to address top drivers of HIV spread among this age group.

Keywords: Exponential smoothing, Forecasting, HIV prevalence.

Introduction

The HIV epidemic remains a serious public health and economic challenge even for Mozambique (Korenromp *et al.* 2015). According to the World Health Organization (WHO) Mozambique is among the top ten countries in the world (WHO, 2018), with HIV prevalence of 13.2% in adults aged 15 to 49 years (Mozambique, 2015). Among key populations the HIV seroprevalence is as follows: female sex workers (FSW) 31.2% (Pond *et al.* 2014) and among MSM the prevalence was 8.2% (Nala *et al.* 2015). In 2018, approximately 2.2 million people were living with HIV, and there were 54,000 reported HIV-related deaths. In 2015, Gonza ´lez et al. indicated that there was a high HIV incidence in the Central and Southern Provinces of the country and among adult women aged 15–49 years. Furthermore, Audet et al. revealed that HIV prevalence varies by region, sex, and age in Mozambique. Key drivers of HIV transmission include cultural practices among Mozambicans which vary from region to region and are gender-dependent on the person subjected to the ritual, have been reported as key to the spread of HIV infections (Cruz et al. 2018). Literature shows that other risk factors for HIV spread include multiple sexual partners, extramarital sex, intimate partner violence, poverty or household wealth, and infrequent or lack of condom use (Sabri *et al.* 2019; Mitchell *et al.* 2016; Gumbe *et al.* 2015; Sathiyasusuman *et al.* 2015; Zembe *et al.* 2015; Hearst *et al.* 2013; Kaiser *et al.* 2011; Pettifor *et al.* 2011). HIV prevalence is higher among women (15.4%) than men (10.1%), a trend that remains among young women aged 15-24 (9.8%) and young men (6.9%) (McLemore *et al.* 2021; Burke *et al.* 2019). Factors that increase

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women and girls' vulnerability to HIV include high rates of poverty; early sexual relations, multiple partners, and low condom use. Existing gender norms and inequalities increase this vulnerability: limited ability to negotiate condoms, transactional sex, and fear and experiences of violence and abandonment (Burke *et al.* 2019). Going to School has been shown to reduce vulnerability to HIV and unfortunately the school dropout rate is high for girls in Mozambique (Burke *et al.* 2019).

The objective of this paper is to model and forecast HIV prevalence among the 15-49 year age group using Holt's linear method. The research findings are expected to guide planning and allocation of resources to fund HIV programs targeting young adults in the country.

Literature review

Author(s)	Objective (s)	Methodology	Main finding (s)
Orel et al. (2022)	To predict the HIV status of individuals living in Angola, Burundi, Ethiopia, Lesotho, Malawi, Mozambique, Namibia, Rwanda, Zambia and Zimbabwe with the highest precision and sensitivity for different policy targets and constraints based on a minimal set of socio-behavioral characteristics.	Analyzed the most recent Demographic and Health Survey from these 10 countries to predict individual's HIV status using four different algorithms (a penalized logistic regression, a generalized additive model, a support vector machine, and a gradient boosting trees).	The gradient boosting trees algorithm performed best in predicting HIV status with a mean F1 score of 76.8% [95% confidence interval (CI) 76.0%-77.6%] for males (vs [CI 67.8%-70.6%] for SVM) and 78.8% [CI 78.2%-79.4%] for females (vs [CI 73.4%-75.8%] for SVM).
Boothe et al. (2021)	To assess service uptake and progress through the HIV treatment cascade among MSM, FSW, and PWID	conducted a secondary data analysis of HIV-positive participants in the first Bio-behavioral Surveillance (BBS) surveys in Mozambique conducted 2011–2014	Among the three high risk populations in Mozambique, losses occurred throughout critical areas of service uptake with the most alarming breakpoint occurring at knowledge of HIV status
Banze et al. (2021)	To evaluate electronic national health information system (SIS-MA) performance to verify if the data flow procedures met its objectives and evaluated the prevention of mother-to-child transmission (PMTCT) surveillance system to access its attributes and usefulness.	Descriptive, cross-sectional evaluation of the PMTCT surveillance system in eight facilities in Gaza and Inhambane provinces using the centers for disease control and prevention guidelines (2001).	we verified that the registry books contain more than 30 variables. The system was 83% flexible in maintaining functionality with the introduction of new health facilities in the system. The completeness of the data was 50% and concordance of data from the register book and monthly reports was 89%
Ekholuenetale et al. (2020)	To examine the prevalence and individual-, household- and community-level factors associated with HIV infection among women of reproductive age in Mozambique.	-Applied multivariable multilevel logistic regression model	-The sero-prevalence of HIV among women in Mozambique was 10.3% (95% CI 9.2%, 11.6%). - women who had two, three and four or more total lifetime number of sex partners were 2.73, 5.61 and 3.95 times as likely to have HIV infection when compared with women with only one lifetime sex partners, respectively - Women of Islam religion had 60% reduction in HIV infection

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			when compared with Christian women (adjusted odds ratio, AOR = 0.40; 95% CI 0.16, 0.99).
Nutor et al. (2020)	To investigate the predictors of HIV prevalence in Mozambique	Complex samples logistic regression and spatial mapping approach using nationally representative data.	The study revealed associations between high-risk sexual behavior and HIV infection. Results from our spatial mapping approach can help health policy makers to better allocate resources for cost-effective HIV/AIDS interventions
Muleia et al. (2020)	To investigate the spatial distribution of HIV infection among adolescents and young people in Mozambique using the 2009 AIDS Indicator Survey (AIS).	-Generalized geo additive modeling, combining kriging and additive modeling, was used to study the geographical variability of HIV risk among young people. -The nonlinear spatial effect was assessed through radial basis splines	The results showed a greater burden of HIV/AIDS in the central and northern regions of the country. Several socio-demographic, biological, and behavioral factors were found to be significantly associated with HIV infection among young people
Ha et al. (2019)	To assess the gendered differences in the relationship between stigma and HIV testing.	A cross-sectional, household probability survey was implemented between November and December 2016 in the Sofala province of Mozambique.	Men have lower uptake of HIV testing in Mozambique when compared to women. Even amidst the beneficial effects of HIV messaging, individual stigma is negatively associated with recent HIV testing among men.
Macicame et al. (2018)	To determine HIV prevalence and risk behavior among males and females screened for a HIV vaccine preparedness study in Maputo, Mozambique	All participants were screened for HIV and a questionnaire was administered to each participant to assess HIV risk behavior	HIV prevalence was much higher among MSM compared to the overall prevalence. Behavioral factors were found to be more associated with HIV prevalence than demographic factors

Methodology

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

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

Smoothing equation

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

$0<\alpha<1$

Trend estimation equation

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

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$0<\beta<1$

Forecasting equation

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

X_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 Mozambique 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	X
Included Observations	31
Smoothing constants	
Alpha (α) for data	0.900
Beta (β) for trend	0.500
Forecast performance measures	
Mean Absolute Error (MAE)	0.254398
Sum Square Error (SSE)	7.065779
Mean Square Error (MSE)	0.227928
Mean Percentage Error (MPE)	-2.139121
Mean Absolute Percentage Error (MAPE)	10.918043

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Residual Analysis for the Applied Model

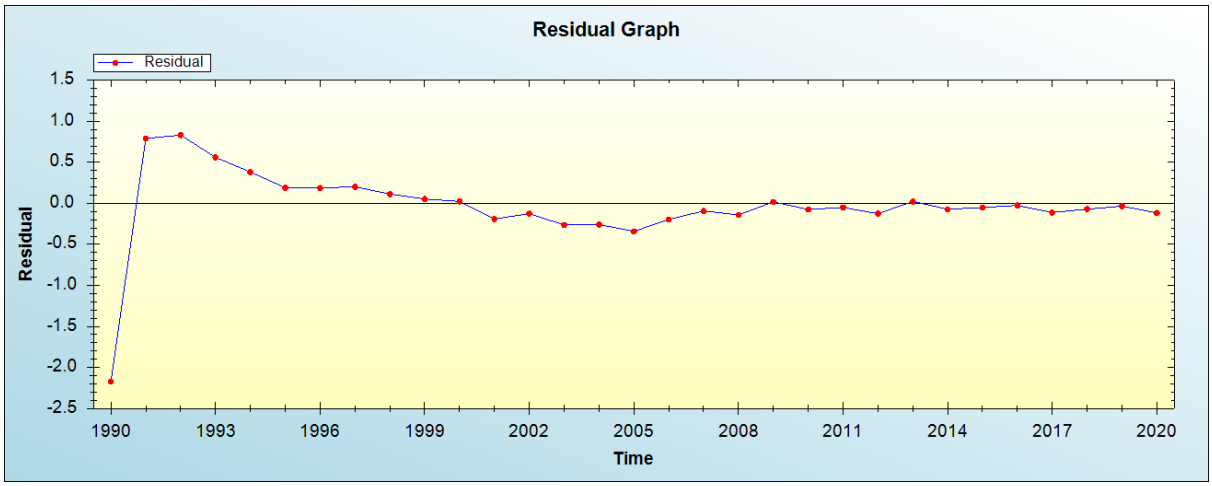

Figure 1: Residual analysis

In-sample Forecast for X

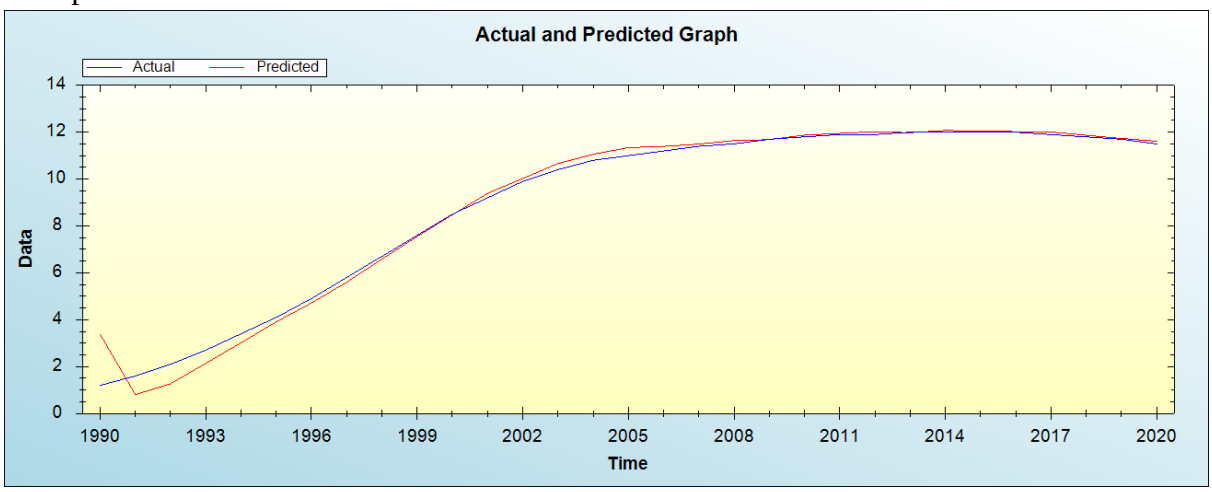

Figure 2: In-sample forecast for the X series

Actual and Smoothed graph for X series

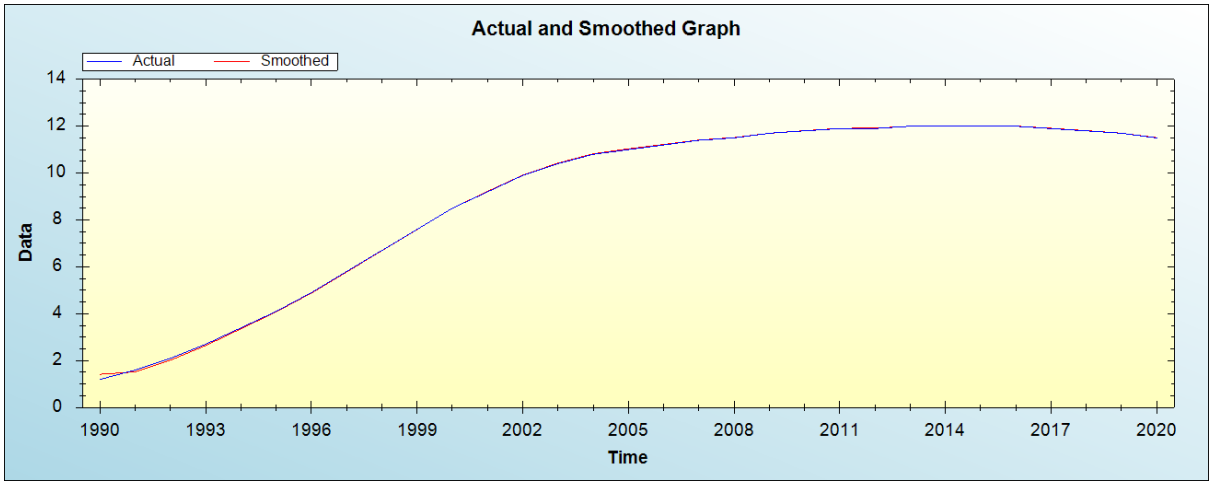

Figure 3: Actual and smoothed graph for X series

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

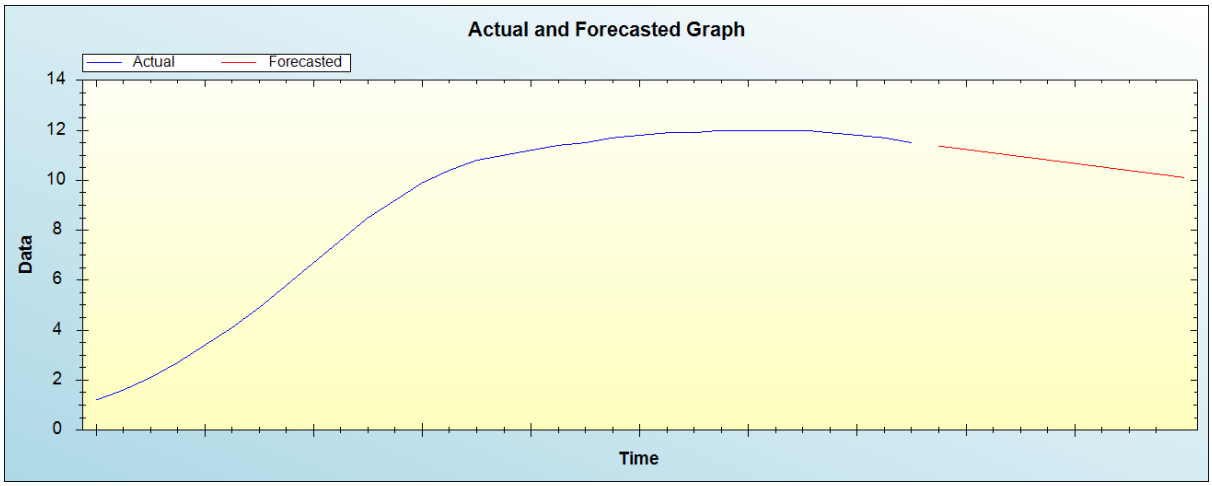

Figure 4: Out-of-sample forecast for X: actual and forecasted graph

Out-of-Sample Forecast for X: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Year	Forecasted HIV prevalence
2021	11.3715
2022	11.2315
2023	11.0915
2024	10.9514
2025	10.8114
2026	10.6714
2027	10.5314
2028	10.3914
2029	10.2513
2030	10.1113

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 slightly decline over the out of sample period.

Policy implications and conclusion

Our research findings indicate that annual HIV prevalence among individuals aged 15-49 years will slightly decline over the out of sample period but still remain high. Therefore, this paper calls for rapid scale up of HIV testing, ART coverage and prevention services among this age group. There is need to address top drivers of HIV spread among this age group.

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