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FORECASTING HIV PREVALENCE AMONG INDIVIDUALS AGED 15-49 YEARS FOR MALI 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 Mali 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 continue to decline over the out of sample period. Therefore, we encourage authorities to increase demand for HIV testing, prevention and treatment services among this age group. There is need to scale up HIV testing and prevention measures among key populations.

Keywords: - Exponential smoothing, Forecasting, HIV prevalence.

Introduction

The HIV epidemic in Mali is mainly concentrated among key populations such as men who have sex with men (MSMs) and Female sex workers. According to IBBS, HIV prevalence in Mali is around 1.1% among the general population, 24% among FSWs and 13% among men who have sex with men (MSM). As reported by Linkages Mali, stigma and discrimination toward MSM and FSWs remain high in the country even among health care workers in health facilities, resulting in reduced access to health services for KPs. Therefore HIV programs should aim to address this problem in order to improve testing and ART coverage among this important group. The purpose of this paper is to model and forecast HIV prevalence among individuals aged 15-49 years for Mali using Holt's linear method. The findings of this paper are expected to guide planning and allocation of resources towards targeted HIV programs for Key populations in the country.

Literature Review

Author (s)	Objective (s)	Methodology	Key finding (s)
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	nationally representative household survey	the law discouraged test uptake among HIV-positive females by reinforcing HIV stigma and/or fear of legal punishment

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	that exploits the enaction timing of such legislation in Mali		
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
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 Mali. In exponential smoothing forecasts are generated from the smoothed original series with the most recent historical values having more

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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

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

Smoothing equation

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

$0<\propto<1$

Trend estimation equation

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

$0<\beta<1$

Forecasting equation

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

Y_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 Mali 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	Y
Included Observations	31
Smoothing constants	
Alpha (α) for data	0.900
Beta (β) for trend	0.100
Forecast performance measures	

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Mean Absolute Error (MAE)	0.102110
Sum Square Error (SSE)	0.990924
Mean Square Error (MSE)	0.031965
Mean Percentage Error (MPE)	-1.094430
Mean Absolute Percentage Error (MAPE)	7.534643

Residual Analysis for the Applied Model

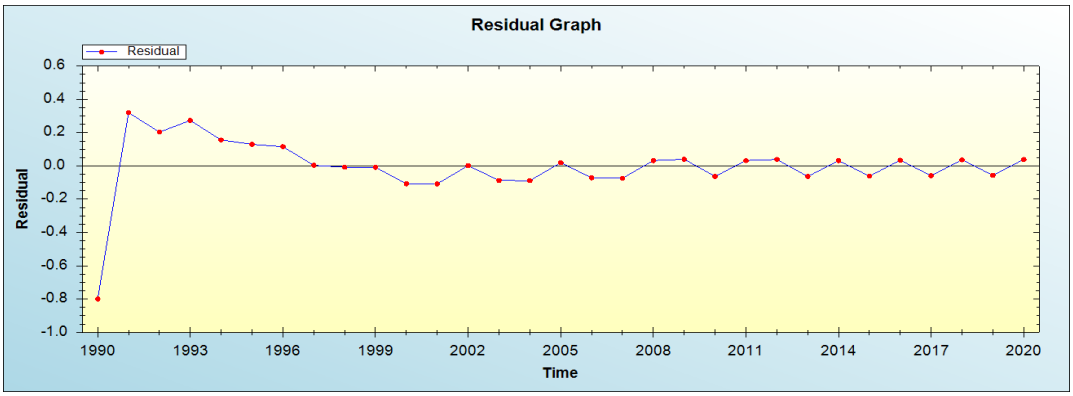

Figure 1: Residual analysis

In-sample Forecast for Y

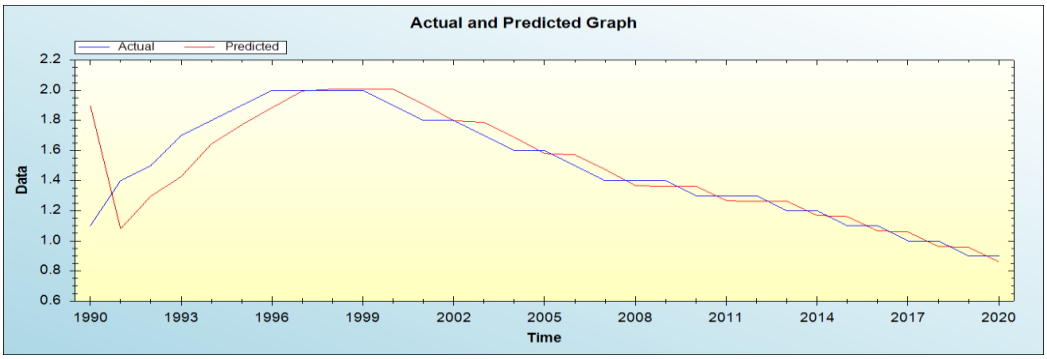

Figure 2: In-sample forecast for the Y series

Actual and Smoothed graph for Y series

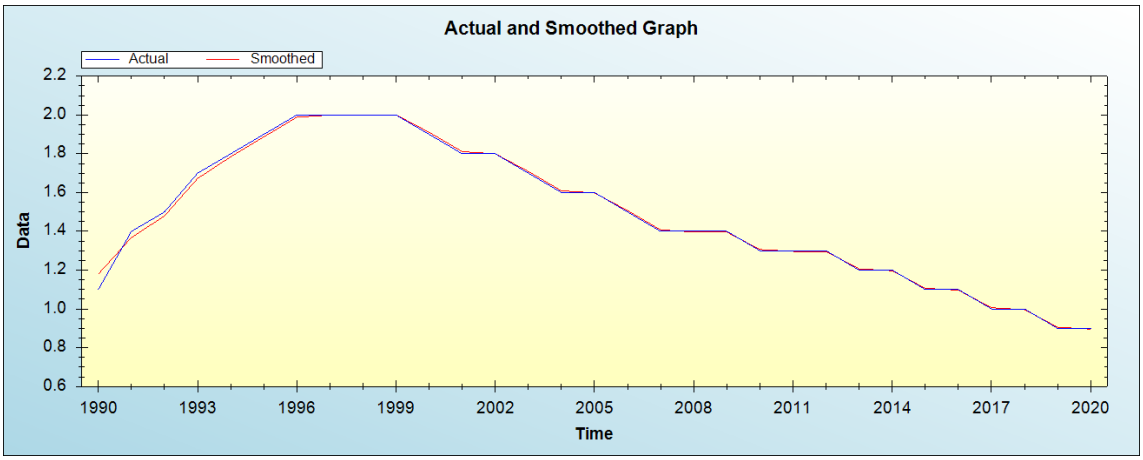

Figure 3: Actual and smoothed graph for Y series

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

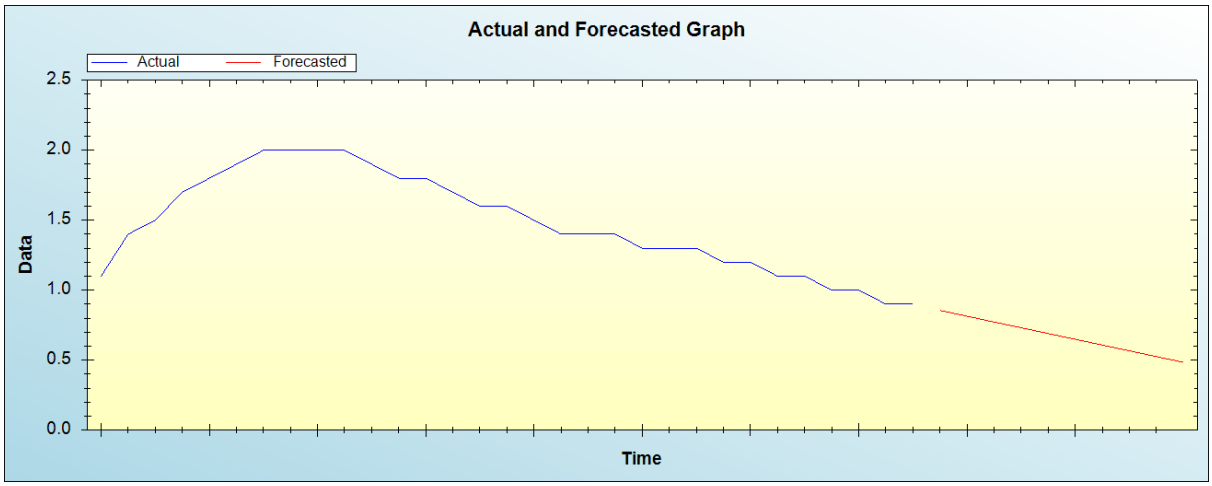

Figure 4: Out-of-sample forecast for Y: actual and forecasted graph

Out-of-Sample Forecast for Y: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Year	Forecasted HIV prevalence
2021	0.8549
2022	0.8136
2023	0.7724
2024	0.7312
2025	0.6900
2026	0.6488
2027	0.6075
2028	0.5663
2029	0.5251
2030	0.4839

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 establishes that annual HIV prevalence among individuals aged 15-49 years will continue to decline over the out of sample period. Therefore this paper calls for authorities to increase demand for HIV testing, prevention and treatment services among this age group. There is need to scale up HIV testing and prevention measures among key populations.

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