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FORECASTING HIV PREVALENCE AMONG INDIVIDUALS AGED 15-49 YEARS IN NAMIBIA 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 Namibia 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 be constant around 11% over the out of sample period. Therefore, we encourage authorities to scale up of HIV testing, increase in ART coverage and strengthening HIV prevention measures among this age group.

Keywords: Exponential smoothing, Forecasting, HIV prevalence.

Background

Namibia has an estimated population size of 2.3 million inhabitants with 50 percent of the population living in the rural areas (Katirayi *et al.* 2022; Angula *et al.* 2015; Namibia Ministry of Health and social services, 2010). People living with HIV (PLHIV) residing in remote areas often travel long distances to reach healthcare facilities, facing a substantial barrier in accessing HIV care and antiretroviral therapy (ART). According to NHIES 2015/2016 Report, approximately 56.2% of households are situated more than five kilometers from a healthcare facility, with some 5% of households even requiring travel greater than 40 km to reach the facilities. According to UNAIDS, Namibia has made significant progress towards controlling the HIV epidemic with a 22% drop in AIDS-related deaths and a 36% decrease in the number of new HIV cases over the last decade. In addition, UNAIDS 2019 data indicates that Namibia has one of the highest HIV prevalence rates in the world (11.5%), with an estimated 210,000 adults aged ≥ 15 years living with HIV. The Namibia country operational plan (COP) 21 revealed that as of December 2020, Namibia was estimated to be at 90–98-91, as defined by the UNAIDS 95–95-95 treatment cascade, making them one of the first high-burden countries to approach epidemic control. The aim of this paper is to model and forecast HIV prevalence among individuals aged 15-49 years for Namibia using Holt's linear exponential smoothing technique. The findings of this paper are expected to guide policy, planning and allocation of resources towards HIV programs targeting key populations in Namibia.

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Literature Review

Author(s)	Objective (s)	Methodology	Main finding (s)
Worku et al. (2022)	To investigate the pooled prevalence and associated factors of HIV testing among young women in east Africa.	multivariable analysis	Pooled prevalence of HIV testing among young women was 55.3%: 95% CI (54.97%, 55.69%). In the multilevel multivariable analysis: respondent age, marital status, educational level, occupation, media exposure, having higher and comprehensive knowledge about HIV / AIDS, having some and higher risky sexual behavior, visiting health care facilities, being rural dweller, being from rich households, having multiple sexual partners, early sex initiation and community-level education were significantly associated with HIV testing.
Katirayi et al. (2022)	To do qualitative evaluation of the acceptability and challenges of C-BART to guide program improvement in Namibia.	-qualitative descriptive study -Thematic analysis used	Patients and healthcare workers perceived that the community as a whole benefited from the C-BART sites not only due to the financial pressure lifted from friends and family members previously asked to help cover expensive transportation, but also due to the perception of diminished stigmatization of people living with HIV and improved health.
Low et al. (2021)	To examine the association between migration and HIV-related outcomes in Namibia.	Used data from the 2017 Namibia Population-based HIV Impact Assessment (NAMPHIA).	HIV prevalence was 12.6% and did not differ by migration status. Population VLS was 77.4%. Recent cross-community in-migration was associated with recent HIV infection (aOR: 4.01, 95% CI 0.99–16.22) after adjusting for community viremia
Kiderlen et al. (2015)	To assess the current status of HIV knowledge, attitudes, and behavior in	Cross sectional study	The range of correct answers to the survey concerning the knowledge of HIV transmission was

	private practice in Namibia		67—95%. Twenty percent of the employees had never been tested for HIV. Additionally, risky sexual behaviors were quite prevalent and included having multiple concurrent partners and the use of sex for incentives. This study revealed that drivers and laborers were especially at risk for such behaviors. The employees of companies with established WPPs were tested for HIV more often than those of companies with new WPPs; however, aside from this difference, only minor differences were observed between the two groups.
Angula et al. (2015)	To describe and measures the level of HIV/AIDS stigma in a rural community in Namibia.	Mixed methods study	The study found that stigma manifests in different ways and results revealed that verbal abuse (55%, n = 50, PLWHA), social isolation (73%, n = 67), negative self-perception (33%, n = 30), and household stigma (26% n = 19, family members) were the most common form of stigma experienced by PLWHA

Methodology

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

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

$0<\propto<1$

Trend estimation equation

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

$0<\beta<1$

Forecasting equation

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

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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 Namibia 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	0.100
Forecast performance measures	
Mean Absolute Error (MAE)	0.751989
Sum Square Error (SSE)	47.869503
Mean Square Error (MSE)	1.544178
Mean Percentage Error (MPE)	-6.261769
Mean Absolute Percentage Error (MAPE)	16.514533

Residual Analysis for the Applied Model

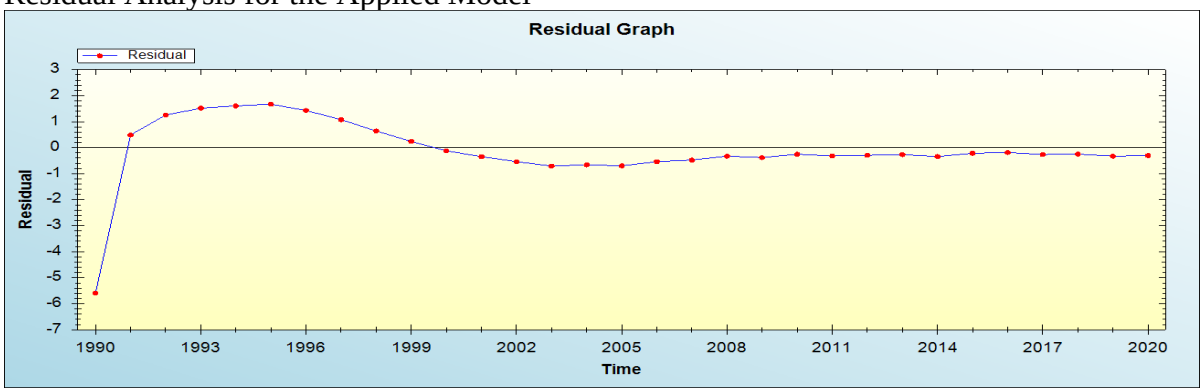

Figure 1: Residual analysis

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In-sample Forecast for A

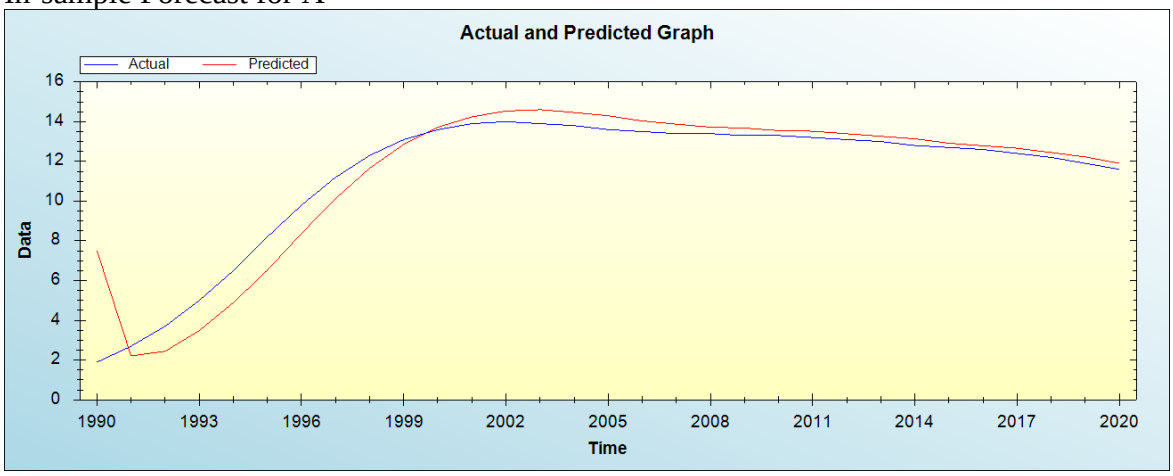

Figure 2: In-sample forecast for the A series

Actual and Smoothed graph for A series

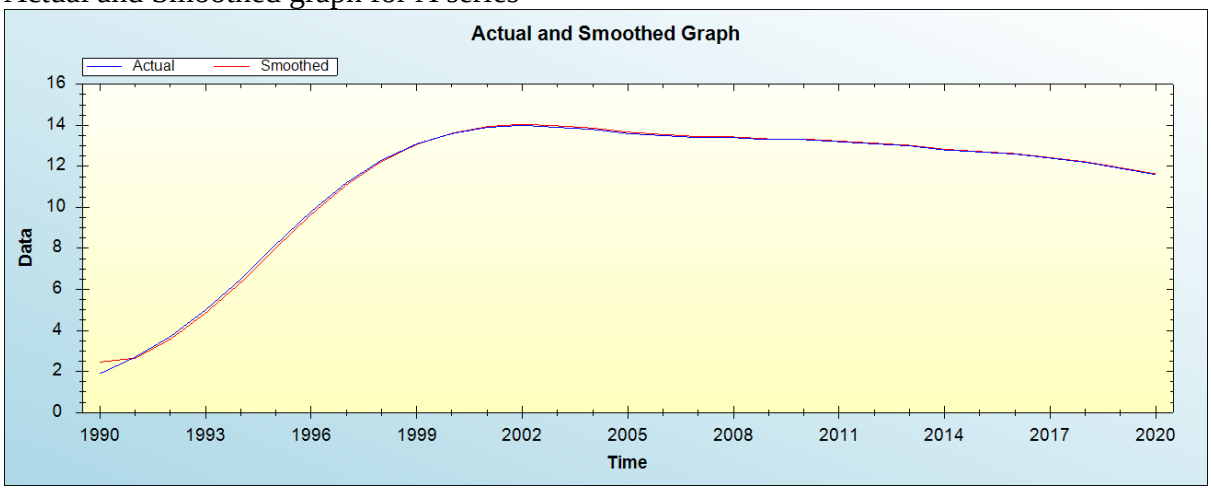

Figure 3: Actual and smoothed graph for A series

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

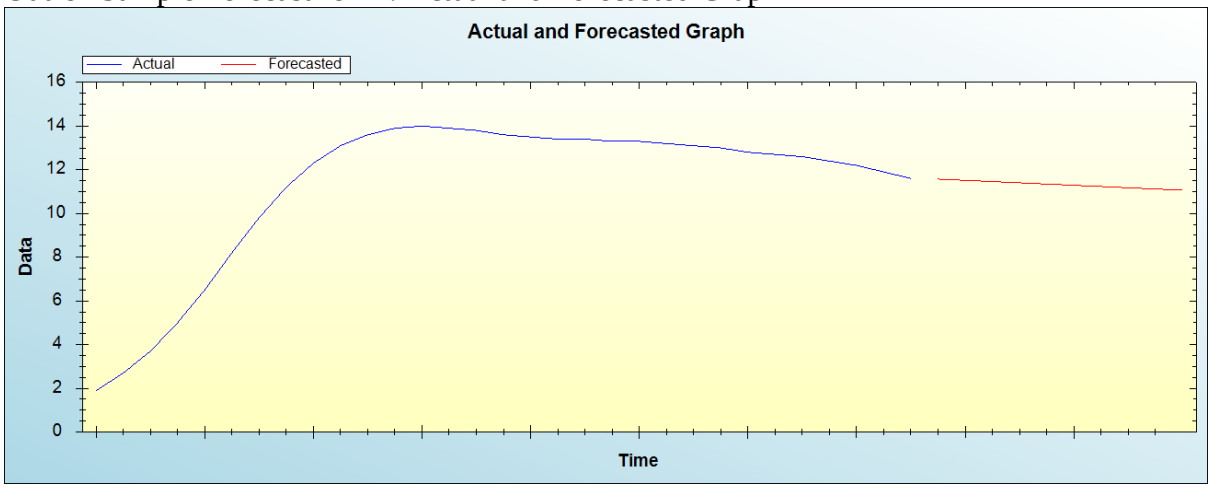

Figure 4: Out-of-sample forecast for A: actual and forecasted graph

Out-of-Sample Forecast for A: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Year	Forecasted HIV prevalence
2021	11.5734
2022	11.5165
2023	11.4596
2024	11.4027
2025	11.3459
2026	11.2890
2027	11.2321
2028	11.1752
2029	11.1183
2030	11.0615

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 hover around 11% throughout the out of sample period.

Policy implication and conclusion

Our research findings indicate that annual HIV prevalence among individuals aged 15-49 years will hover around 11% throughout the out of sample period. Therefore, this paper calls for the rapid scale up of HIV testing, increase in ART coverage and strengthening HIV prevention measures among this age group.

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