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Projection of HIV prevalence among individuals aged 15-49 years in Cambodia using Holt's double exponential smoothing technique

Dr. Smartson. P. NYONI[1], Thabani NYONI[2]
[1]ZICHIRe Project, University of Zimbabwe, Harare, Zimbabwe
[2]Independent Researcher & Health Economist, Harare, Zimbabwe

Abstract
This study uses annual time series data of HIV prevalence among individuals aged 15-49 years for Cambodia from 1990 to 2020 to predict future trends of HIV prevalence over the period 2021 to 2030. The study utilizes Holt's double exponential smoothing model. The optimal values of smoothing constants α and β are 0.9 and 0.6 respectively based on minimum MSE. The results of the study indicate that annual HIV prevalence among people aged 15-49 years will continue to decline significantly over the out of sample period. Therefore, we encourage authorities to strengthen preventive measures among key populations who are experiencing an increase in HIV seroprevalence.
Keyword (s): - *Exponential smoothing, Forecasting, HIV prevalence*

Background

HIV infection still remains a public health issue of importance in Cambodia. The HIV epidemic in this country is concentrated among, female sex workers, men who have sex with men (MSM) and transgender women (TGW) (MOH, 2019). The government has managed to successfully control the HIV epidemic (Charles *et al.* 2006; Kim *et al.* 2005; Saphonn *et al.* 2004; Ryan *et al.* 1998). Previous studies have revealed that the overall HIV incidence has declined and antiretroviral treatment access and coverage has increased in the past decades (Vun *et al.* 2014). According to the Ministry of Health, the national HIV prevalence among MSM has rose from 2.1% in 2010 to 4.0% in 2019, and among TGW it more than doubled from 4.2% in 2012 to 9.6% in 2019. However, interventions for MSM and TGW have not managed to increase levels of condom use and HIV testing uptake among their target populations (Yi *et al.* 2016). Therefore there is need to target key populations in the national HIV response. The purpose of this paper is to model and forecast future trends of HIV prevalence among individuals aged 15-49 years for Cambodia using Holt's linear method. This will facilitate allocation of scarce resources to targeted HIV prevention, treatment and care programs for this age group.

Literature Review

Author(s)	Objective (s)	Methodology	Main finding(s)
de Lind van Wijngaarden et al. (2021)	To reviews HIV epidemiological, social science and HIV program implementation studies conducted over the past 20 years to explore possible reasons for the rising HIV prevalence among these groups and to formulate recommendations for improved policies, HIV programmatic	Scoping review	Cambodia is unlikely to achieve control of the HIV epidemic among MSM and TGW without doing better in-depth social science research on its multiple sexual- and gender minority cultures, and without understanding what differentiated implementation modalities, strategies and approaches are most effective to

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	interventions and further research.		address HIV among its increasingly diverse MSM and TGW populations.
Eng et al. (2021)	To estimate the prevalence of HIV testing and examine factors associated with recent HIV testing among people who use drugs (PWUD) in Cambodia	Cross- sectional study	Recent HIV test uptake among PWUD in Cambodia was suboptimal
Tuot et al. (2020)	To explore the prevalence of HIV and identified factors associated with HIV infection among female entertainment workers (FEWs) in Cambodia	Applied logistic regression	The prevalence of HIV among FEWs in Cambodia remains much higher than that in the general population
Mburu et al. (2019)	To estimate the current prevalence of and factors associated with HIV infection among PWID in Cambodia.	Applied multiple logistic regression	The prevalence of HIV among PWID in Cambodia remains high, but is reducing compared with the 24.8% reported in the 2012 national survey
Sopheab et al. (2018)	To estimate the prevalence of HIV across PWUD groups and to identify factors associated with HIV infection.	Applied multivariate logistic regression	HIV prevalence remains high among PWIDs. Harm reduction efforts, such as needle and syringe provision programs, must improve their coverage
Chhim et al. (2018)	To investigate factors associated with viral non-suppression among adolescents living with HIV in Cambodia.	Applied multivariate logistic regression	The proportion of adolescents living with HIV with viral suppression in this study was relatively high at 76.8%, but falls short of the global target of 90%.
Yi et al. (2017)	To summarize descriptive findings from a national integrated biological and behavioral survey and discusses policy	Cross-sectional study was conducted between December 2015 and February 2016. Participants were recruited from	There is a high prevalence of HIV, STI, and related risk behaviors among transgender women in Cambodia

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	implications of the findings on HIV prevention among transgender women in Cambodia.	20 sites in the capital city and 12 provinces of Cambodia using Respondent Driven Sampling (RDS) method. Behavioral data were collected through structured questionnaire interviews, and rapid finger-prick HIV testing was performed. Descriptive data analyses were conducted using STATA.	

Methodology

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

$C_t=\mu_t + \rho_t \mathbf{t} + \varepsilon_t$……..…….[1]

Smoothing equation

$S_t= \alpha C_t + (1-\alpha) (S_{t-1} + b_{t-1})$……..[2]

$0<\propto<1$

Trend estimation equation

$b_t= \beta (S_t-S_{t-1}) + (1-\beta) b_{t-1}$…….[3]

$0<\beta<1$

Forecasting equation

$f_{t+h}= S_t + hb_t$…….[4]

C_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

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This study is based on annual HIV prevalence among individuals aged 15-49 years in Cambodia 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.

Study Results

Exponential smoothing Model Summary

Table 1: ES model summary

Variable	C
Included Observations	31
Smoothing constants	
Alpha (α) for data	0.900
Beta (β) for trend	0.600
Forecast performance measures	
Mean Absolute Error (MAE)	0.093890
Sum Square Error (SSE)	0.580714
Mean Square Error (MSE)	0.018733
Mean Percentage Error (MPE)	-0.719513
Mean Absolute Percentage Error (MAPE)	41.403207

Residual Analysis for the Applied Model

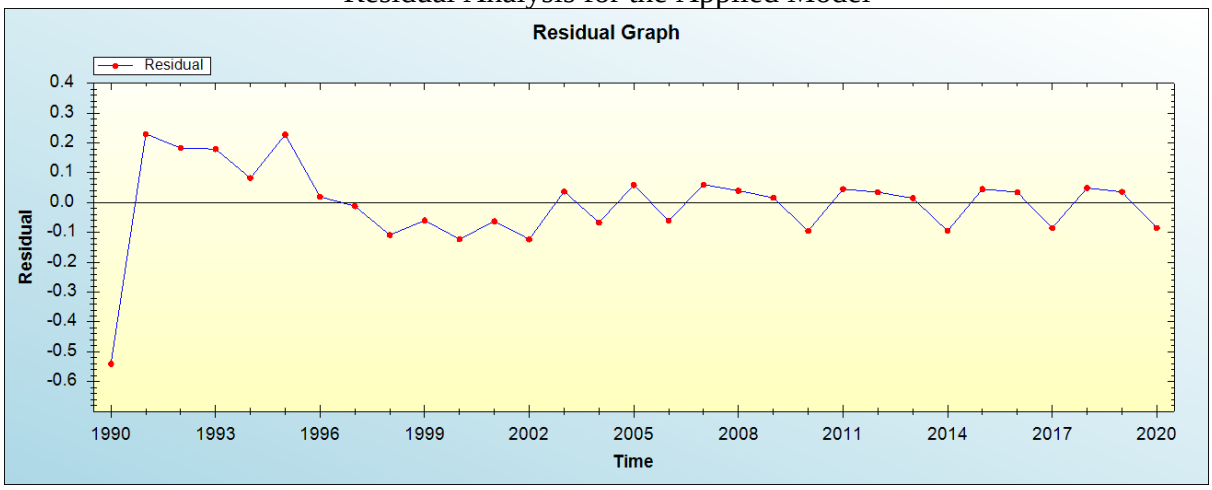

Figure 1: Residual analysis

In-sample Forecast for A

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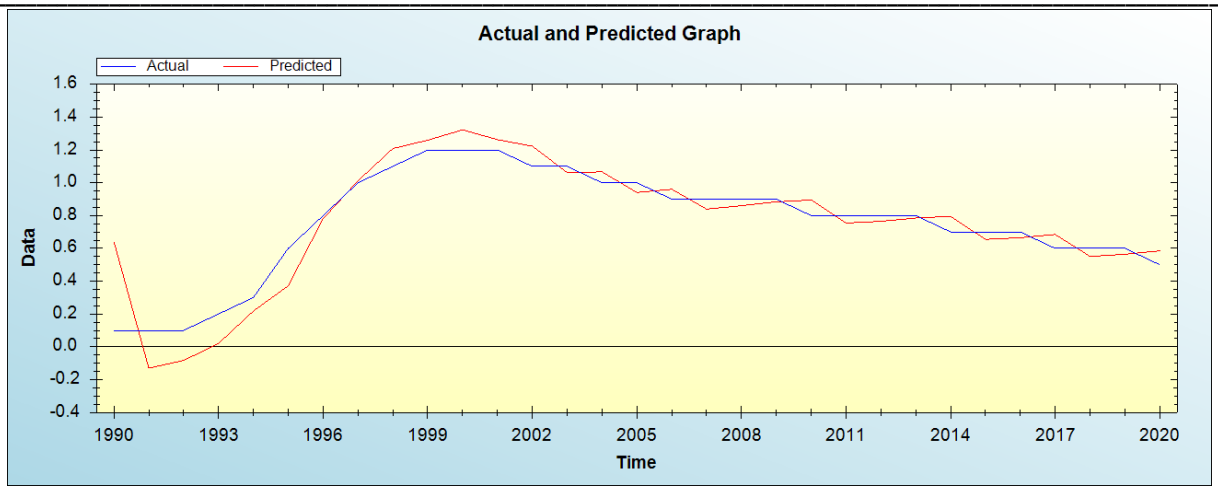

Figure 2: In-sample forecast for the A series

Actual and Smoothed graph for A series

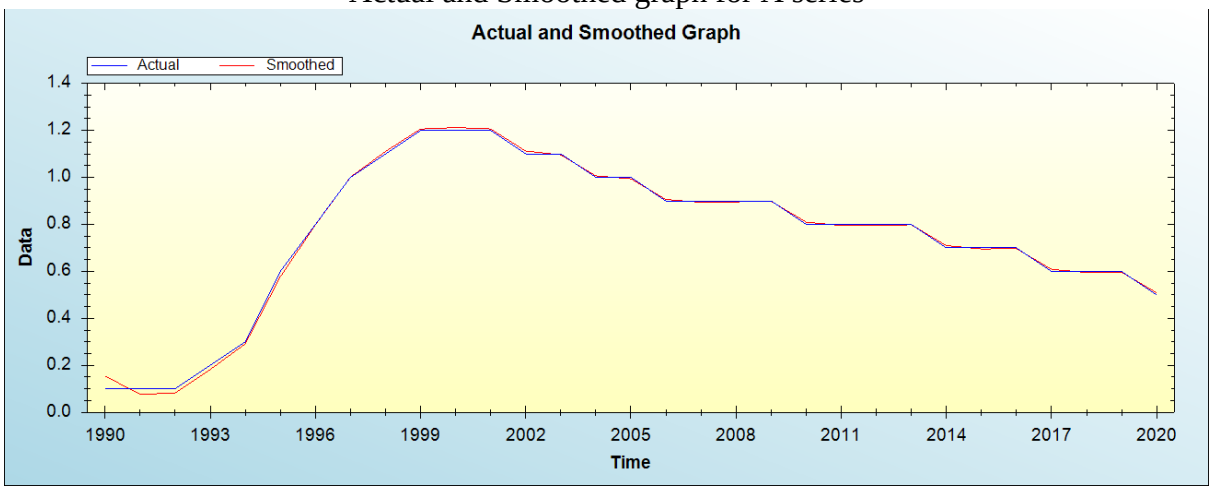

Figure 3: Actual and smoothed graph for A series

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

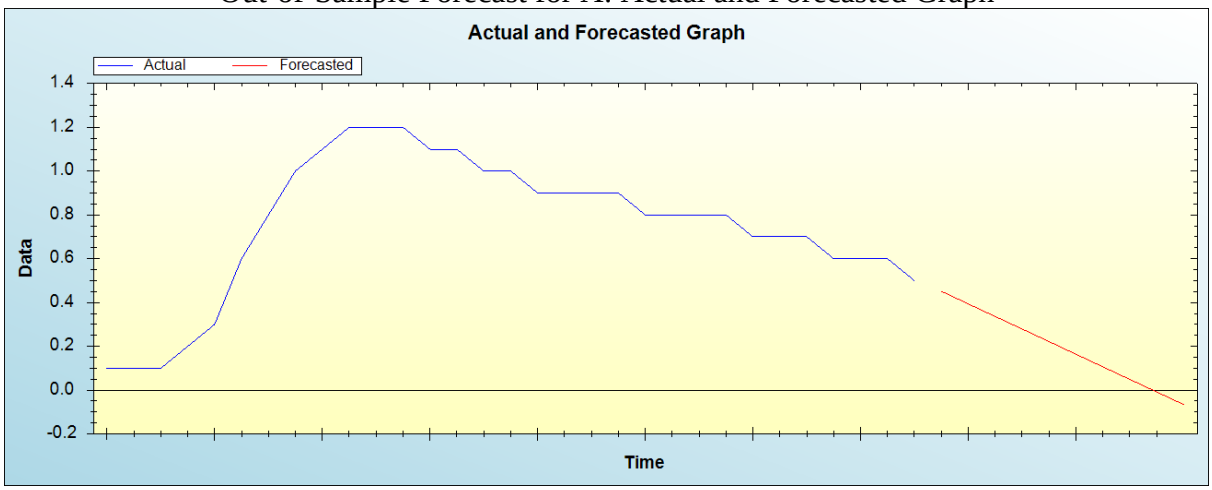

Figure 4: Out-of-sample forecast for A: actual and forecasted graph

Out-of-Sample Forecast for A: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Year	Forecasted HIV prevalence
2021	0.4511

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2022	0.3937
2023	0.3363
2024	0.2789
2025	0.2214
2026	0.1640
2027	0.1066
2028	0.0492
2029	-0.0082
2030	-0.0656

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 significantly over the out of sample period.

Policy implication and conclusion

The downward projected trend of HIV prevalence among individuals aged 15-49 years shows that Cambodia has done very well in controlling the HIV epidemic. Hence, policy-makers must strengthen preventive measures among key populations who are experiencing an increase in HIV seroprevalence.

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