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Forecasting HIV prevalence among individuals aged 15-49 years for Burundi using an exponential smoothing technique

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Abstract
This study uses annual time series data of HIV prevalence among individuals aged 15-49 years for Burundi 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 0.1 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 over the out of sample period. Therefore, we encourage authorities to improve HIV case detection and treatment among key populations and vulnerable groups.

Keyword (s): - Exponential smoothing, Forecasting, HIV prevalence

Background

According to the 2007 HIV seroprevalence survey, the prevalence of HIV in the general population in Burundi was reported to be 2.97% with rates varying between urban and rural areas, being higher in urban areas (4.59% vs. 2.82%). The 2016–2017 Burundi Demographic and Health Survey revealed that 0.9% of men and women between the ages of 15 and 49 are HIV-positive. HIV prevalence is slightly higher among women (1.2%) than men (0.6%), and is more than three times higher in urban (2.5%) compared to rural areas (0.7%). In Burundi, the national HIV response is prioritized as evidenced by the implementation and development of national strategic programs in 2002–2006, 2007–2011, 2012–2016, 2014–2017, and 2018–2022 to fight AIDS. These programs seek universal access to quality HIV/AIDS prevention, treatment, and support services (Njejimana et al. 2021). The government of Burundi has made significant progress in controlling the HIV epidemic with a decline in seroprevalence in the general population from 6% in 2002 to 0.6% in 2018 (Njejimana et al. 2021). This significant drop was attributed to the rapid scale up of HIV testing services, increase in antiretroviral therapy coverage and implementation of the combination HIV prevention strategy (WHO, 2016). The aim of this paper is to model and forecast HIV prevalence among the 15-49 year age group using Holt's linear method. The results of this paper are envisioned to detect likely future trends of HIV prevalence among the 15-49 year age group and this will then guide planning and allocation of resources towards HIV prevention and treatment initiatives in order to achieve zero new infections by the end of 2030.

Literature Review

Author (s)	Objective (s)	Methodology	Key finding (s)
Sonko et al. (2022)	To assess predictors that influence the uptake of HIV testing among youth aged 15~24 years in The Gambia	A cross-sectional study design was used on 6194 subjects, among which 4730 were female. The analysis employed Chi-squared tests and	The predisposing factors (socio-demographic and HIV knowledge) and the need-for-care factors (sexual risk behaviors) predict

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		hierarchical logistic regression.	healthcare utilization services (HIV testing)
Nshimirimana et al. (2022)	To assess HIV testing uptake and its determinants among adolescents and young adults	Cross- sectional design involving analysis of 2016 Demographic and Health Survey data	Despite the interventions implemented to reach the 90- 90- 90 UNAIDS goals, HIV testing among youth in Burundi was low
Gelibo et al. (2022)	To identify geographic locations and drivers of HIV transmission in Ethiopia	-used data from adults aged 15–64 years who participated in the Ethiopian Population-based HIV Impact Assessment survey (October 2017–April 2018	uncircumcised men in certain hotspot towns and divorced or widowed individuals in hotspot woredas/towns might have contributed to the average increase in HIV prevalence in the hotspot areas
Njejimana et al. (2021)	To determine and characterize this problem in Burundi.	-qualitative analysis based on an extensive series of 114 interviews	-the problem of HIV/AIDS stigma is widespread in Burundian society, as all participants in the research reported having experienced some kind of HIV stigma
Ouedraogo et al. (2019)	To determine the prevalence and correlates of HIV infection among MSM in Burkina Faso	A cross-sectional biological and behavioral survey was conducted from January to August 2013 among MSM in Ouagadougou and Bobo-Dioulasso	HIV prevalence among MSM under 25years old was 1.3% (95% CI: 0.6–2.8) and 0.9% (95% CI: 0.4–2.5) respectively in Ouagadougou and Bobo-Dioulasso, compared to 5.4% (95% CI: 2.2–12.5) and 6.6% (95% CI: 3.4–12.3) among those 25 years old or older in these cities (p=0.010 and p<0.001
Yé et al. (2018)	To improve equity of access to health care and information among women and PLWHAs by reinforcing	Using a quasi-experimental approach, a mobile telephone system was set up at five health centres to provide an automated reminder	A 7.34% increase in prenatal coverage, an 84% decrease in loss to follow-up for HIV (P < 0.001) and a 31% increase in assisted deliveries in 2016 (P

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	community participation.	service for health care consultation appointments. Performance evaluations based on key performance indicators were subsequently conducted.	< 0.0001) were observed in intervention areas.
Kirakoya-Samadoulougou et al. (2017)	To examine the influence of both individual and community-level determinants of HIV testing uptake in Burkina Faso	Applied modified Poisson regression models.	For both genders, age, education, religious affiliation, household wealth, employment, media exposure, sexual behaviors, and HIV knowledge were associated with HIV testing

Methodology

This study utilizes Holt's double exponential smoothing technique to model and forecast future trends of HIV prevalence among individuals aged 15-49 years in Burundi. 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

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

Smoothing equation

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

R_t is the actual value of HIV prevalence at time t

ε_t is the time varying **error term**

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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 Burundi 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 findings

Exponential smoothing Model Summary

Table 1: ES model summary

Variable	R
Included Observations	31
Smoothing constants	
Alpha (α) for data	0.900
Beta (β) for trend	0.100
Forecast performance measures	
Mean Absolute Error (MAE)	0.161177
Sum Square Error (SSE)	1.878896
Mean Square Error (MSE)	0.060610
Mean Percentage Error (MPE)	1.851341
Mean Absolute Percentage Error (MAPE)	5.664207

Residual Analysis for the Applied Model

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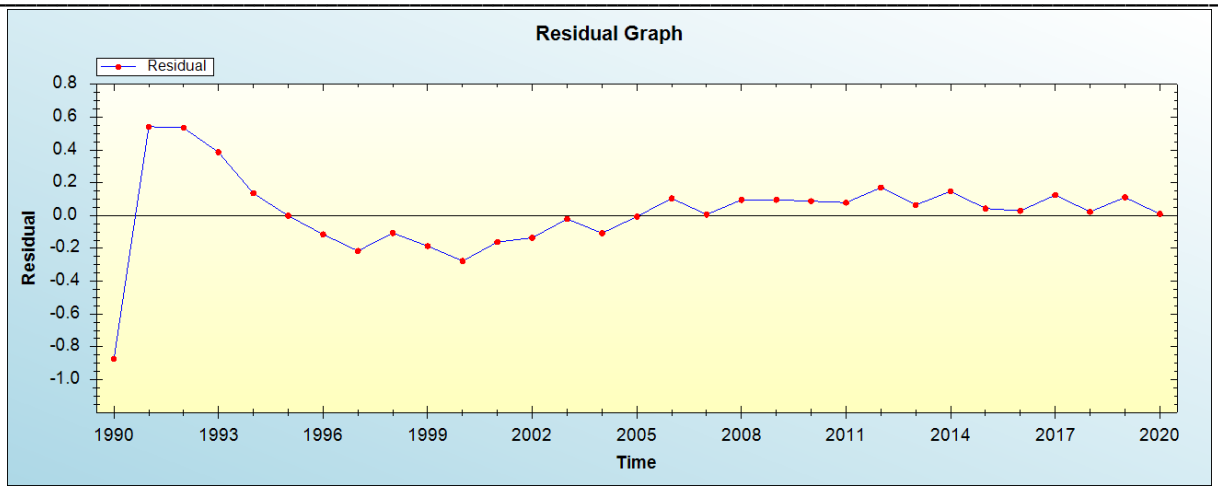

Figure 1: Residual analysis

In-sample Forecast for R

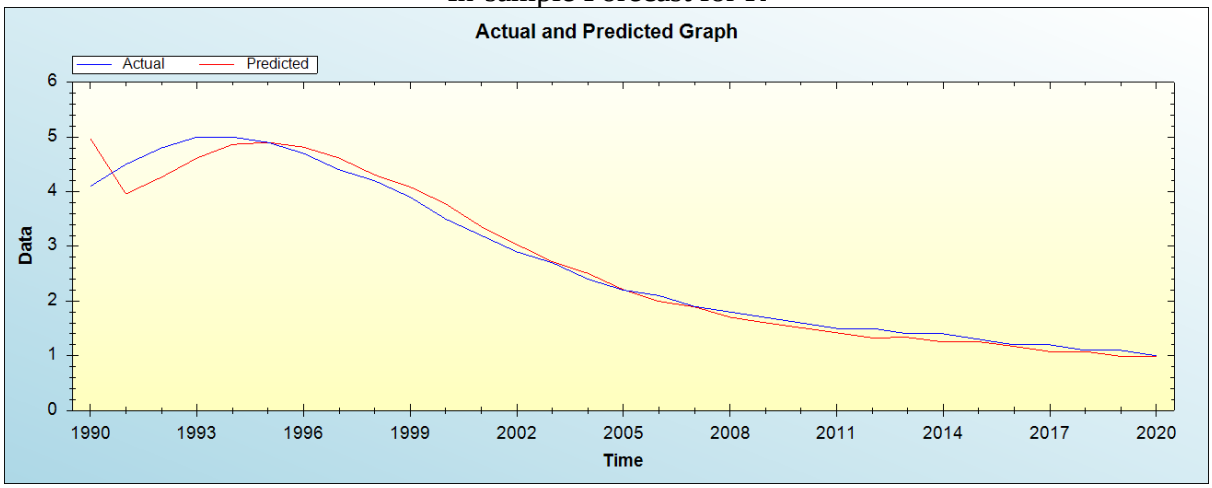

Figure 2: In-sample forecast for the R series

Actual and Smoothed graph for R series

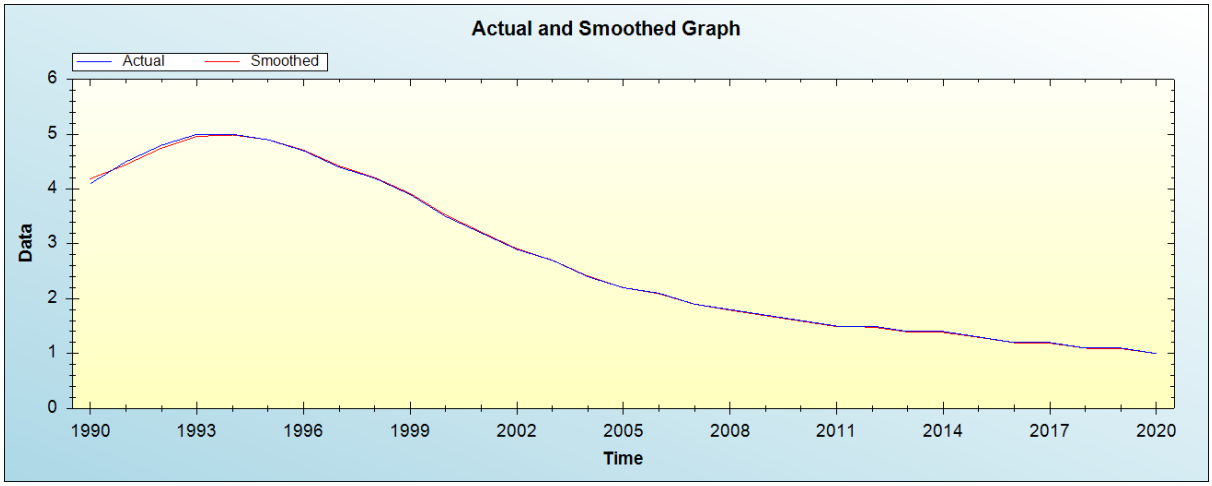

Figure 3: Actual and smoothed graph for R series

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

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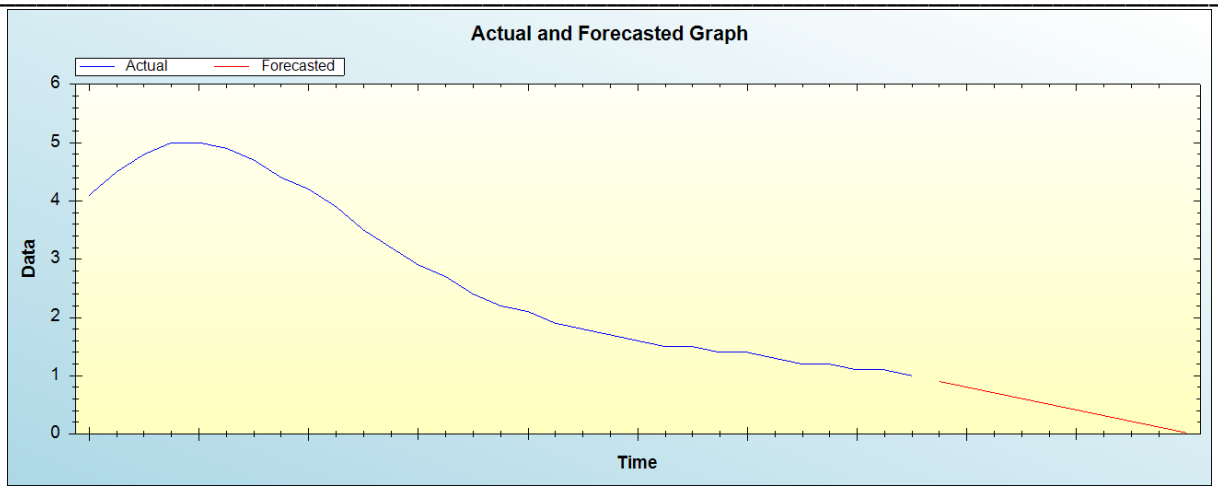

Figure 4: Out-of-sample forecast for R: actual and forecasted graph

Out-of-Sample Forecast for R: Forecasts only
Table 2: Tabulated out-of-sample forecasts

Year	Forecasted HIV prevalence
2021	0.9013
2022	0.8035
2023	0.7058
2024	0.6081
2025	0.5103
2026	0.4126
2027	0.3148
2028	0.2171
2029	0.1193
2030	0.0216

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

Our model projections indicate that Burundi will be able successfully control the HIV epidemic in the out of sample period, however there is still need to improve HIV case detection and treatment among key populations and vulnerable groups.

References

[1] Njejimana, N.; Gómez-Tatay, L.; and Hernández-Andreu, J.M (2021). HIV–AIDS Stigma in Burundi: A Qualitative Descriptive Study. Int. J. Environ. Res. Public Health 2021, 18, 9300. https://doi.org/10.3390/ ijerph18179300

[2] Ministere de la santé Publique et de la lutte Contre le SIDA [Burundi] (MSPLS); Conseil National de Lutte Contre le SIDA [Burundi] (CNLS). Plan Estratégique National de Lutte Contre le SIDA 2012–2016; MSPLS; CNLS: Burundi, 2012. Available online: https://www.ilo.org/wcmsp5/groups/public/---ed_protect/---protrav/---ilo_aids/documents/legaldocument/wc ms_202048.pdf (accessed on 2 September 2021).

[3] MinistèreàlaprésidenceChargédelaBonneGouvernanceetduPlan [Burundi](MPBGP);MinistèredelasantéPubliqueetdela lutte Contre le SIDA [Burundi] (MSPLS); Institut de Statistiques et d'études économiques du Burundi (ISTEEBU); et ICF. Enquête

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Démographique et de Santé au Burundi 2016–2017: Rapport de Synthèse; ISTEEBU; MSPLS; ICF: Rockville, MD, USA, 2018. Available online: https://dhsprogram.com/pubs/pdf/SR247/SR247.pdf (accessed on 2 September 2021)

[4] World Health Organization (WHO). Global Health Sector Strategy on HIV 2016–2021. Towards Ending AIDS; WHO: Geneva, Switzerland, 2016. Available online: https://apps.who.int/iris/handle/10665/246178 (accessed on 2 September 2021).