ISSN NO: 2770-2936
April 2024

Detecting future trends of HIV Prevalence among individuals aged 15-49 years in Belarus 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 Belarus 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 0.8 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 on an upward trend over the out of sample period. Therefore, we encourage authorities to strengthen HIV prevention strategies which include behavior change interventions, correct and consistent use of condoms, pre-exposure prophylaxis for high risk groups, post exposure prophylaxis and voluntary medical circumcision among other WHO recommended strategies.

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

Background

As of 2018, the Republic of Belarus had reported 25 0742 cases of HIV infection (Belarus, 2018). The reported prevalence of HIV infection in the general population is 0.4% (UNAIDS, 2018). According to the European CDC report, the incidence of HIV in the country increased from 10.4 per 100,000 people in 2007 to 26.0 per 100,000 people in 2017. The majority of new HIV infections were diagnosed among men aged 30-39 (Belarus, 2018). Sexual transmission of HIV accounts for 62% of all HIV cases. The parenteral transmission route accounts for 35% of new HIV cases. HIV infection is concentrated among vulnerable populations namely injecting drug users (IDUs), commercial sex workers (CSWs) and MSM. The HIV prevalence among IDUs is 30.8%, among CSWs 7%, and among MSM 9.8% (Belarus, 2018). The prevalence of HIV infection among MSM in neighboring countries is: 5.9% in Lithuania, 7.8% in Latvia, 7.5% in Ukraine; and 7.1% (Moscow) and 22.8 % (St. Petersburg) in the Russian Federation (ECOM, 2018). The country has witnessed a rapid increase in number of PLHIV receiving ART with 1262 people being started on antiretroviral therapy in 2012 (Lundgren & Raben, 2014). One of the weaknesses of the HIV response in Belarus is that it heavily relies on donor funding, with around USD 20 million being invested annually in HIV (Wilson *et al.* 2013). The national ART program is composed of demand creation activities in the community, HIV testing services in the community as well as in healthcare facilities, and treatment and care of HIV positive patients with evidence of TB/HIV collaboration. The purpose of this paper is to model and forecast HIV prevalence for the 15-49 year age group in Belarus using Holt's linear method. The findings of this piece of work are expected to inform HIV programming particularly allocation of funding towards HIV prevention and treatment services in the country.

Literature Review

Author (s)	Objective (s)	Methodology	Main finding (s)
Kirichenko et al. (2022)	To monitor circulating HIV-1 genetic variants, assess the prevalence of HIV DR among	-analyzed 1071 HIV-1 pol-gene fragment sequences (2253–3369 bp) from patients who were	The prevalence of PDR to any drug class was 2.8% in Uzbekistan, 4.2% in Azerbaijan, 4.5% in

ISSN NO: 2770-2936
April 2024

	patients starting antiretroviral therapy, and reveal potential transmission clusters among patients in six EECA countries: Armenia, Azerbaijan, Belarus, Russia, Tajikistan, and Uzbekistan.	initiating or reinitiating first-line ART in six EECA counties, i.e., Armenia (n = 120), Azerbaijan (n = 96), Belarus (n = 158), Russia (n = 465), Tajikistan (n = 54), and Uzbekistan (n = 178), between 2017 and 2019.	Russia, 9.2% in Armenia, 13.9% in Belarus, and 16.7% in Tajikistan
Kirilyuk & Kuhach (2017)	To determine ways to increase efficiency and accessibility of antiretroviral therapy (ART) in Belarus.	Utilized naive" approach, trend extrapolation method and pharmacoeconomic modeling.	To reduce the cost of ART it is advisable to start the treatment process at the level of CD4+ > 500 cells/μ l
Sergeeva & Porada (2007)	To study of the incidence and prevalence of HIV infection in Belarus	A retrospective analysis of the incidence of the population of the Republic of Belarus with HIV infection for the period 20062016 was carried out, the territorial features of the epidemic process of infection in the regions were studied.	Over the period of observation, a steady growth trend was revealed in the dynamics of the incidence of the population of the Republic of Belarus with HIV infection (R2 = 0, 88).
Vickerman & Watts (2002)	To assess the impact of an HIV prevention intervention for injecting drug users in Svetlogorsk, Belarus	Applied a deterministic epidemiological model 'IDU 2.4' that simulates the transmission of HIV among IDUs sharing injecting equipment, and between IDUs and their sexual partners	The model predicts that between 1997 and 2000 the intervention averted 414 HIV infections in Svetlogorsk (95% CI, 180/690) and caused a 6.5% decrease in IDU HIV prevalence compared to if there had been no intervention.

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 Belarus. In exponential smoothing forecasts are generated from the smoothed original series with the most recent historical values having more influence

ISSN NO: 2770-2936
April 2024

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

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

Smoothing equation

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

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

ISSN NO: 2770-2936
April 2024

This study is based on annual HIV prevalence among individuals aged 15-49 years in 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	A
Included Observations	31
Smoothing constants	
Alpha (α) for data	0.800
Beta (β) for trend	0.100
Forecast performance measures	
Mean Absolute Error (MAE)	0.025789
Sum Square Error (SSE)	0.045859
Mean Square Error (MSE)	0.001479
Mean Percentage Error (MPE)	-1.383000
Mean Absolute Percentage Error (MAPE)	15.519343

Residual Analysis for the Applied Model

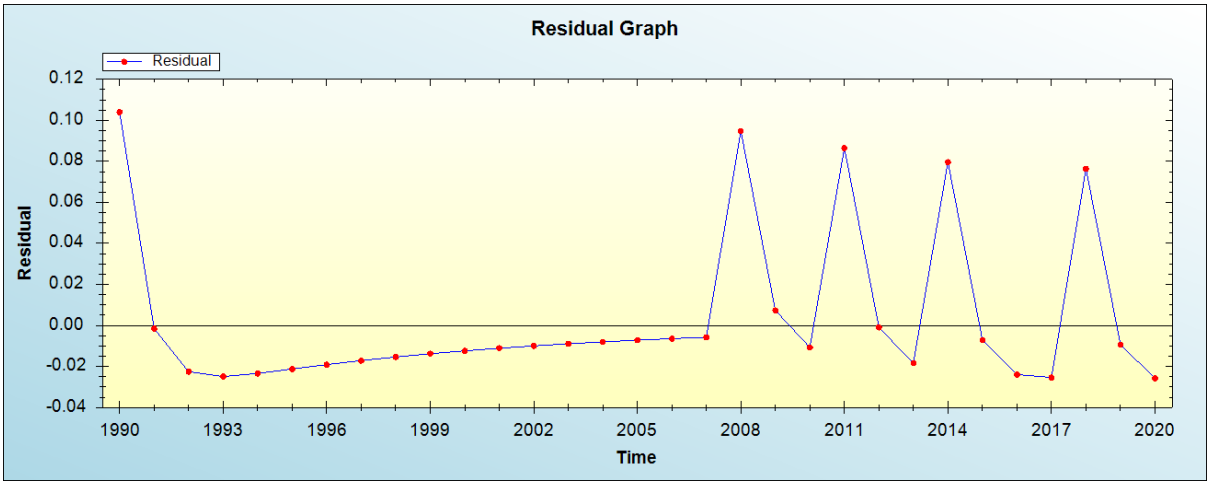


Figure 1: Residual analysis

In-sample Forecast for A

ISSN NO: 2770-2936
April 2024

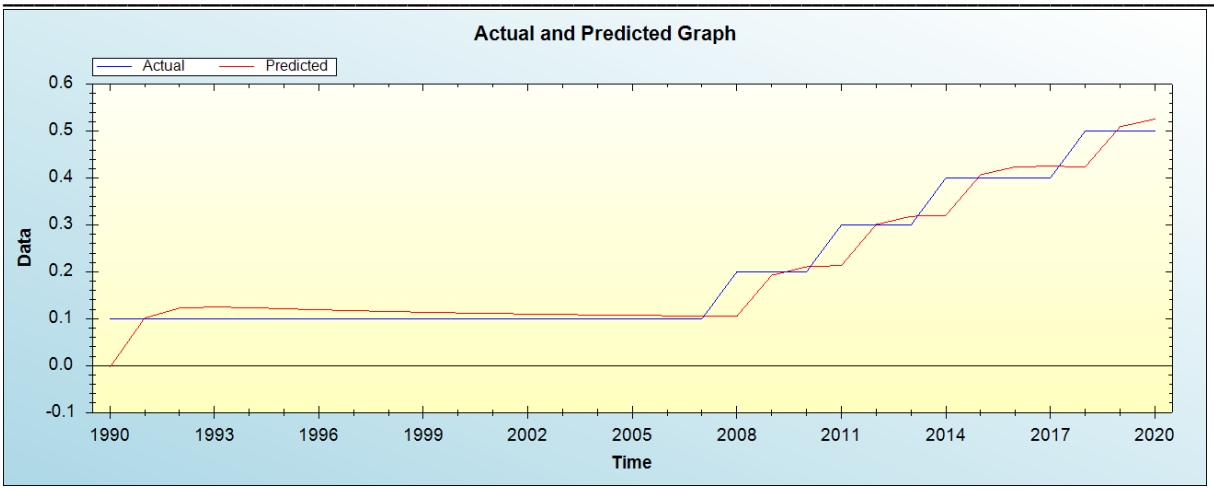


Figure 2: In-sample forecast for the A series

Actual and Smoothed graph for A series

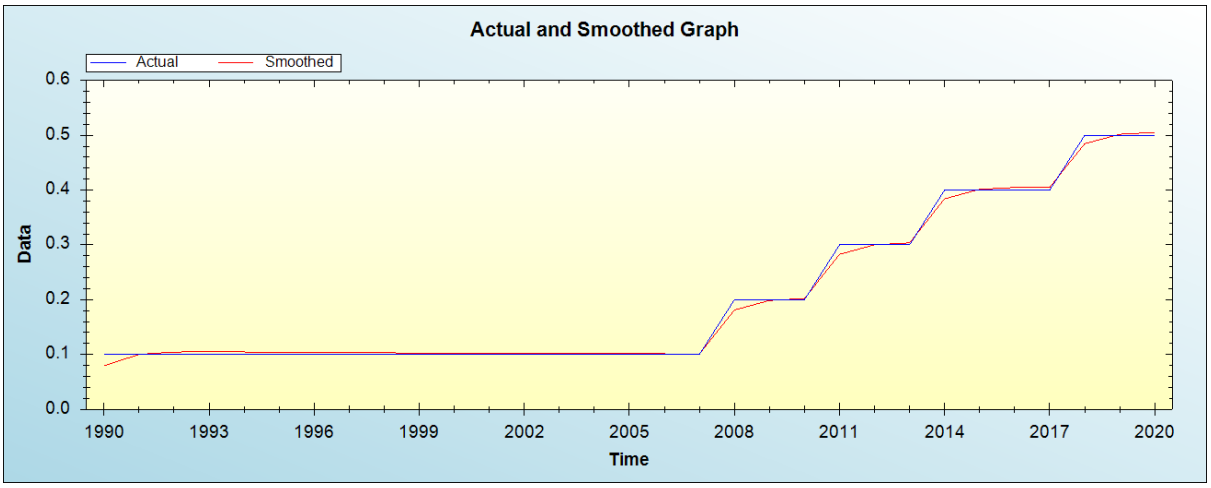
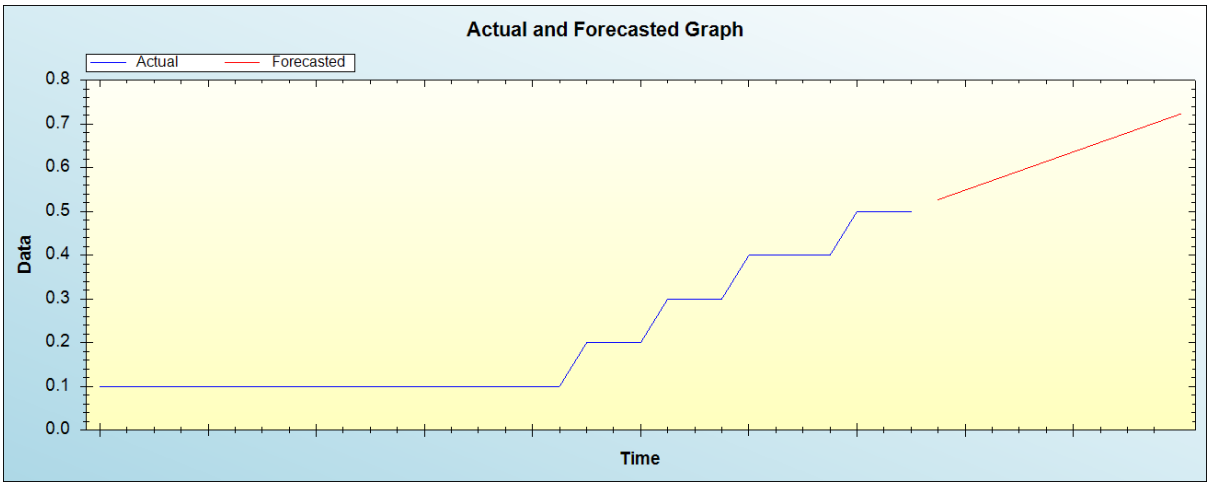


Figure 3: Actual and smoothed graph for A series

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



ISSN NO: 2770-2936
April 2024

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	0.5270
2022	0.5489
2023	0.5707
2024	0.5926
2025	0.6145
2026	0.6363
2027	0.6582
2028	0.6800
2029	0.7019
2030	0.7238

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 will continue on an upward trend over the out of sample period.

Policy implication and conclusion

HIV continues to be serious public health challenge in Belarus. The upward trajectory in HIV incidence and prevalence for the past 2 decades shows that a lot needs to be done in terms of curbing new HIV infections especially among key populations. The projected upward trend of HIV prevalence over the period 2021-2030 is an urgent call for policy makers in Belarus to come up with effective health interventions to reverse the undesirable upward trend. There is need for strengthening HIV prevention strategies which include behavior change interventions, correct and consistent use of condoms, pre-exposure prophylaxis for high risk groups, post exposure prophylaxis and voluntary medical circumcision among other strategies.

References

[1] UNAIDS (2018). UNAIDS data 2018. – Mode of access to the resource: http://www.unaids.org/sites/default/files/media_asset/unaidsdata-2018_en.pdf
[2] Belarus (2018). Brief on HIV Epidemic Situation among MSM and Trans people in Belarus, Eurasian Coalition on Male health, pp.1-6
[3] ECOM (2018). HIV among MSM in EECA. – ECOM. Mode of access to the resource: http://ecom.ngo/hiv-msm-eeca/
[4] Jens D. Lundgren and Dorthe Raben (2014). HIV/AIDS treatment and care in Belarus, Evaluation report January 2014

ISSN NO: 2770-2936
April 2024