JP Journal of Biostatistics

http://www.pphmj.com
http://dx.doi.org/10.17654/0973514323015
Volume 23, Number 3, 2023, Pages 263-279 **P-ISSN: 0973-5143**

TEMPORAL TRENDS OF HIV PREVALENCE IN SUB-SAHARAN AFRICA

Charles K. Mutai[1,6,*], Patrick E. McSharry[1,2,3], Innocent Ngaruye[4] and Edouard Musabanganji[5]

[1]African Center of Excellence in Data Science
University of Rwanda
Kigali BP 4285, Rwanda
e-mail: charlimtai@gmail.com

[2]College of Engineering
Carnegie Mellon University Africa
Kigali BP 6150, Rwanda

[3]Oxford Man Institute of Quantitative Finance
Oxford University
Oxford OX2 6ED, UK

[4]College of Science and Technology
University of Rwanda
Kigali, Rwanda

Received: April 15, 2023; Accepted: June 2, 2023

Keywords and phrases: temporal, HIV prevalence, trends.

[*]Corresponding author

How to cite this article: Charles K. Mutai, Patrick E. McSharry, Innocent Ngaruye and Edouard Musabanganji, Temporal trends of HIV prevalence in sub-Saharan Africa, JP Journal of Biostatistics 23(3) (2023), 263-279. http://dx.doi.org/10.17654/0973514323015

Published Online: August 4, 2023

[5]College of Business and Economics
University of Rwanda
Kigali, Rwanda

[6]Department of Mathematics, Physics and Computing
Moi University
Eldoret, Kenya

Abstract

Background. The HIV epidemic varies significantly across different groups in the SSA region, and complicates designing effective general interventions. We aim at uncovering temporal trends in HIV prevalence disaggregated by age, sex, and country.

Method. We determined HIV prevalence trends among males and females aged 15-49 years for surveys conducted from the years 2003-2007 (period 1) and 2013-2018 (period 2) in SSA. Countries were divided into three clusters based on their socio-behavioural characteristics, and age was categorized into ranges of 15 to 24 years, 25 to 34 years, and 35 to 49 years. A log-binomial regression model was employed in testing for a discrepancy in prevalence between these groups.

Results. Swaziland had the highest increase in HIV prevalence between the two periods among females, with a 3.18% rise, followed by Lesotho, Ethiopia and Tanzania females with 2.96%, 2.18% and 0.05%, respectively. Men of ages 15 and 24 experienced an increase from 0.29 (95% CI 0.1-0.84%) to 0.32 (95% CI 0.15-0.68%), 0.36 (95% CI 0.18-0.73%) to 0.47 (95% CI 0.32-0.7%) between the two periods in Cote d'Ivoire and Rwanda, respectively. Females of age 25 to 34 in Ethiopia had an increase in the prevalence of (3.26 (95% CI 2.6-4.08%) to 4.25 (95% CI 3.47-5.21%)).

Conclusions. There is a significant difference in HIV prevalence in the general population between the sexes and age categories. In general, females outperformed their male counterparts in every category.

Introduction

One of the most threatening infectious diseases and a burden on public health globally is HIV. Global estimates for 2019 show that 38 million people are living with HIV, while 1.7 million and 690,000 new infections and deaths are reported, respectively. This is despite the fact that diagnosis and access to antiretroviral therapy (ART) have made great strides in recent years. East and Southern Africa account for more than half of all HIV-positive individuals, 42.9% of new infections, and 43.5% of AIDS-related fatalities [1]. Various estimates of the number of people living with HIV in 2021 ranged from 220,000 to 1.7 million in Namibia and Tanzania, respectively; 4,300 and 54,000 new HIV infections in Rwanda and Tanzania, respectively; and 4,300 and 54,000 deaths from AIDS-related illnesses in Rwanda and Tanzania, respectively, [2]. By 2030, the Joint United Nations Program (UNAIDS) aimed to eradicate AIDS as a global health threat [3, 4]. The COVID-19 pandemic, nevertheless, has already reversed the gains made, and it may even have had a negative effect by raising the death toll from AIDS in sub-Saharan Africa [5].

Despite considerable HIV prevention programs in SSA, the HIV epidemic widely spread throughout the region [6, 7]. HIV incidence and prevalence vary significantly across age groups, sexes, and countries in SSA. Females between the ages of 15 and 19 account for around six out of every seven new infections, and those between the ages of 15 and 24 are twice as likely to be HIV positive as their male counterparts in the area. 63% of all new HIV infections in 2021 were among these demographics [1]. The variances may come from significant intra- and inter-national socio-behavioural, religious, socio-economic, and cultural variety [8, 9]. Because of the uneven distribution of the epidemic, it is difficult to design general interventions that are effective. Therefore, specific populations need specialized responses based on the HIV epidemic's finer details [10].

Past research has sought to determine the HIV prevalence at subgroup levels as well as suggest solutions to the problem in SSA. Among these are

Haeuser et al. [11], who from 2000 to 2018 estimated the prevalence of HIV among adults in sub-Saharan Africa by age and sex using model-based geostatistical methods. O'brien-Carelli et al. [12] performed a geospatial analysis on the prevalence of HIV infection, the use of ART, and the rate of viral load suppression among Nigerian adults. Their findings provided insight into the sub-state variations that call for action. An age-specific approach to estimating the prevalence of cervical cancer cases owing to HIV was established by Ibrahim Khalil et al. [13] and can guide the development of cervical cancer preventive initiatives in SSA. In sub-Saharan Africa from 2010 to 2019, Astawesegn et al. [14] established the trend and impact of ART coverage during pregnancy on mother-to-child HIV transmission. In population-based cohort studies conducted in Malawi, South Africa, Tanzania, Uganda, and Zimbabwe, Risher et al. [15] assessed trends in age-specific incidence over time, reporting changes in mean age at infection, the proportion of new infections in various age groups, and cumulative incidence in succeeding birth cohorts. Mabaso et al. [16] used national HIV population-based household surveys conducted in 2008, 2012, and 2017 to analyze trends and factors related to HIV prevalence among adolescents in South Africa. Using surveillance data from 2010 to 2019 in Côte d'Ivoire, Malawi and Mozambique, Godin et al. [17] inferred trends in the prevalence of HIV. Other studies that have done the distribution of HIV include [18-20].

This study aims to identify the temporal trends that are present in sub-Saharan Africa by utilizing the logit regression approach to analyze historical data in order to offer a statistical overview of HIV prevalence disaggregated by age, sex, and country.

Methods

Data description

This study incorporated data from the Demographic and Health Surveys (DHS) program and the Population-based HIV Impact Assessment (PHIA) project, which comprises cross-sectional household-based surveys made to evaluate health and HIV-related outcomes [21, 22]. The most recent surveys

of 12 counties in SSA with a generalized HIV epidemic were used (Table 1). Male and female data from each country were combined with their corresponding households and their HIV test results. The target variable was the HIV status of the individuals (0 for HIV negative and 1 for HIV positive). During the data pre-processing step, only individuals with positive or negative HIV status were included in the analysis and those with unknown status were discarded. Only those aged 15 to 49 were considered in this study and this range in age for the HIV prevalence trend assumes representativeness of the global HIV estimates [19]. To examine trends over time, surveys were divided into two time periods: 2003-2007: period 1 and 2008-2018: period 2. Also, countries were divided into clusters based on their socio-behavioural characteristics and associated incidences of HIV got classified by Merzouki et al. [23] in their study.

Table 1. The number of women and men surveyed per country at the period of the survey

		Number tested for HIV					
		period 1			**period 2**		
Countries	**Region**	**Survey yr**	**Females**	**Males**	**Survey yr**	**Females**	**Males**
Burundi	Cluster 2	2010	4,509	8,527	2016	3,631	6,538
Zambia	Cluster 2	2013	15,433	13,155	2018	12,450	10,569
Malawi	Cluster 2	2010	7,396	8,943	2016	6,176	6,302
Cameroon	Cluster 3	2011	7,253	12,321	2017	6,244	10,123
Cote d'Ivoire	Cluster 3	2010	4,655	80,16	2017	3,909	7,673
Ethiopia	Cluster 1	2011	15,505	10,512	2017	11,852	6,714
Kenya	Cluster 2	2009	3,811	13,646	2018	2,907	9,809
Lesotho	Cluster 2	2009	3,849	5,990	2016	2,772	4,199
Rwanda	Cluster 2	2010	6,952	14,659	2018	5,666	12,167
Swaziland	Cluster 2	2007	4,584	4,878	2017	3,602	3,655
Tanzania	Cluster 2	2011	10,299	14,629	2017	7,446	10,971
Zimbabwe	Cluster 2	2010	7,852	10,221	2016	5,731	7,241

Statistical analysis

The percentage of men and women who were sampled, as well as their HIV prevalence at the time of the survey, were calculated. The logit

approach was used to calculate 95% confidence intervals for proportions based on age and country (Table 2).

The variation in HIV prevalence trends between men and women was calculated using a log-binomial regression model [24-26]. Based on the model, the effect of each covariate on the outcome (HIV positive) can be expressed as a risk ratio. The regression model was also used to assess the HIV prevalence differences between men and women for age groups with ranges of 15 to 24 years, 25 to 34 years, and 35 to 49 years, respectively.

Results and Discussion

Prevalence of HIV by region in females and males between periods across all ages

Figure 1 shows the trend in HIV prevalence among all females and males aged 15 to 49 in each region between periods 1 and 2.

Between periods 1 and 2, the HIV prevalence shifted to older age groups. In all regions (Table 2), 30-34 years old saw an increase from period 1 (3.74 (95% CI 2.62-5.32%), 1.02 (95% CI 0.6-1.75%)) to period 2 (9.27 (95% CI 8.35-10.28%), 5.23 (95% CI 4.43-6.15%)); 35-39-years old saw an increase from period 1 (3.04 (95% CI 1.64-5.56%), 3.01 (95% CI 1.82-4.92%)) to period 2 (5.94 (95% CI 5.14-6.85%)); 40-44-years old saw (1.85 (95% CI 1.02-3.32%), 1.39 (95% CI 0.78-2.47%) in period 1 to 11.37 (95% CI 9.81-13.15%), 7.99 (95% CI 6.85-9.29%) in period 2) and 45-49 years old saw (1.85 (95% CI 1.02-3.32%), 1.39 (95% CI 0.78-2.47%) in period 1 to 11.37 (95% CI 9.81-13.15%), 7.99 (95% CI 6.85-9.29%) in period 2).

Cluster 3 exhibited a slight reduction in all ages for both sexes, ranging from (1.58 (95% CI 1.11-2.26%), 0.28 (95% CI 0.12-0.66%) in period 1 to 1.24 (95% CI 0.79-1.94%), 0.23 (95% CI 0.07-0.71%) in period 2) aged 15-24 to (8.23 (95% CI 6.58-10.25%), 5.42 (95% CI 4.12-7.1%) in period 1 to 7.97 (95% CI 6.35-9.96%), 3.04 (95% CI 2.09-4.39%) in period 2) aged 35-39 years. Overall, the HIV prevalence of female individuals is slightly higher than that of male counterparts in all survey periods across the regions.

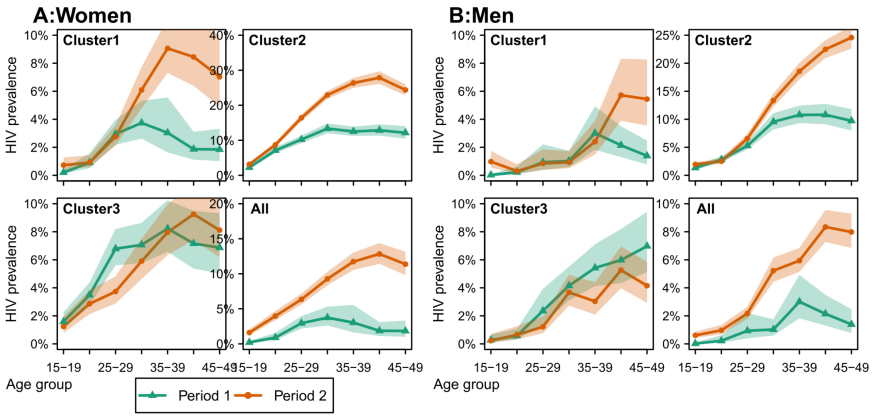

Figure 1. Age-specific HIV prevalence among males and females during periods 1 and 2 across regions.

Table 2. Region-specific HIV prevalence in females and males between periods across all ages

		Females		Males	
Region	**Age group**	**Period 1**	**Period 2**	**Period 1**	**Period 2**
Cluster 1	15-19	0.21 [0.1, 0.41]	0.73 [0.41, 1.27]	0.02 [0.01, 0.1]	0.98 [0.55, 1.74]
Cluster 2		2.24 [1.89, 2.65]	3.14 [2.74, 3.58]	1.34 [0.97, 1.85]	1.95 [1.64, 2.33]
Cluster 3		1.58 [1.11, 2.26]	1.24 [0.79, 1.94]	0.28 [0.12, 0.66]	0.23 [0.07, 0.71]
All		0.21 [0.1, 0.41]	1.61 [1.24, 2.09]	0.02 [0.01, 0.1]	0.61 [0.43, 0.87]
Cluster 1	20-24	0.9 [0.51, 1.57]	0.92 [0.58, 1.43]	0.22 [0.08, 0.62]	0.3 [0.12, 0.78]
Cluster 2		7.12 [6.29, 8.04]	8.7 [7.98, 9.47]	2.8 [2.32, 3.39]	2.51 [2.08, 3.04]
Cluster 3		3.49 [2.78, 4.38]	2.86 [2.13, 3.84]	0.58 [0.31, 1.06]	0.65 [0.33, 1.26]
All		0.9 [0.52, 1.57]	3.97 [3.36, 4.68]	0.22 [0.08, 0.62]	0.97 [0.69, 1.35]
Cluster 1	25-29	2.95 [2.19, 3.96]	2.76 [2.13, 3.57]	0.94 [0.39, 2.21]	0.85 [0.39, 1.85]
Cluster 2		10.22 [9.22, 11.32]	16.39 [15.43, 17.38]	5.28 [4.62, 6.02]	6.56 [5.81, 7.39]
Cluster 3		6.79 [5.6, 8.2]	3.73 [2.89, 4.82]	2.36 [1.4, 3.93]	1.22 [0.76, 1.95]
All		2.95 [2.19, 3.96]	6.35 [5.62, 7.17]	0.94 [0.39, 2.2]	2.17 [1.78, 2.64]
Cluster 1	30-34	3.74 [2.62, 5.32]	6.09 [4.78, 7.73]	1.02 [0.6, 1.75]	0.93 [0.5, 1.71]
Cluster 2		13.35 [11.99, 14.83]	22.94 [21.83, 24.09]	9.54 [8.19, 11.09]	13.35 [12.19, 14.6]
Cluster 3		7.07 [5.76, 8.64]	5.9 [4.63, 7.5]	4.15 [3.12, 5.5]	3.67 [2.73, 4.93]
All		3.74 [2.62, 5.32]	9.27 [8.35, 10.28]	1.02 [0.6, 1.75]	5.23 [4.43, 6.15]
Cluster 1	35-39	3.04 [1.64, 5.56]	9.06 [7.3, 11.19]	3.01 [1.82, 4.92]	2.4 [1.48, 3.87]
Cluster 2		12.52 [11.25, 13.91]	26.37 [24.99, 27.79]	10.78 [9.32, 12.43]	18.55 [17.13, 20.07]
Cluster 3		8.23 [6.58, 10.25]	7.97 [6.35, 9.96]	5.42 [4.12, 7.1]	3.04 [2.09, 4.39]
All		3.04 [1.64, 5.56]	11.74 [10.55, 13.03]	3.01 [1.82, 4.92]	5.94 [5.14, 6.85]

Cluster 1	40-44	1.87 [1.12, 3.11]	8.45 [6.39, 11.09]	2.14 [1.3, 3.5]	5.72 [3.9, 8.32]
Cluster 2		12.85 [11.33, 14.54]	27.86 [26.09, 29.7]	10.8 [9.11, 12.75]	22.49 [20.92, 24.14]
Cluster 3		7.16 [5.37, 9.49]	9.25 [7.42, 11.47]	5.98 [4.34, 8.19]	5.26 [3.97, 6.95]
All		1.87 [1.12, 3.1]	12.83 [11.42, 14.38]	2.14 [1.31, 3.5]	8.34 [7.27, 9.56]
Cluster 1	45-49	1.85 [1.02, 3.33]	7.03 [4.91, 9.97]	1.39 [0.78, 2.47]	5.44 [3.54, 8.27]
Cluster 2		12.14 [10.46, 14.05]	24.38 [22.85, 25.98]	9.73 [7.98, 11.81]	24.57 [22.63, 26.63]
Cluster 3		6.87 [5.03, 9.32]	8.12 [6.19, 10.58]	6.98 [5.13, 9.43]	4.15 [2.93, 5.85]
All		1.85 [1.02, 3.32]	11.37 [9.81, 13.15]	1.39 [0.78, 2.47]	7.99 [6.85, 9.29]

Relative changes in HIV prevalence trends between periods among females and males

Figure 2 shows the prevalence of HIV in females and males aged 15 to 49 years in each country. Point estimates (Table 3) showed that the prevalence of both sexes decreased significantly between the survey periods in most countries, except Ethiopia (2.18% for females and 0.7% for males), Lesotho (2.96% for females and 1.14% for males), Swaziland (3.18% for females), and Tanzania (0.05% for females). Ethiopia's prevalence increased from 1.86 (95% CI 1.53-2.27%), 1.01 (95% CI 0.77-1.31%) in period 1 to 4.04 (95% CI 3.48-4.67%), 1.71 (95% CI 1.35-2.17%) in period 2 for males and females, respectively, Lesotho increased from 26.73 (95% CI 24.97-28.58%), 17.99 (95% CI 16.22-19.9%) in period 1 to 29.69 (95% CI 28.45-30.96%), 19.13 (95% CI 17.87-20.456%) in period 2 for males and females, respectively, Swaziland increased from 31.15 (95% CI 29.44-32.91%) in period 1 to 34.33 (95% CI 32.57-36.12%) in period 2 for females only. Tanzania increased slightly from 6.16 (95% CI 5.57-6.79%) in period 1 to 6.21 (95% CI 5.67-6.79%) in period 2 for females. Consequently, between the two periods, point estimates showed a significant increase of (2.18% in females and 0.7% in males) in cluster 1 and (6.85% in females and 3.71% in males) in cluster 2.

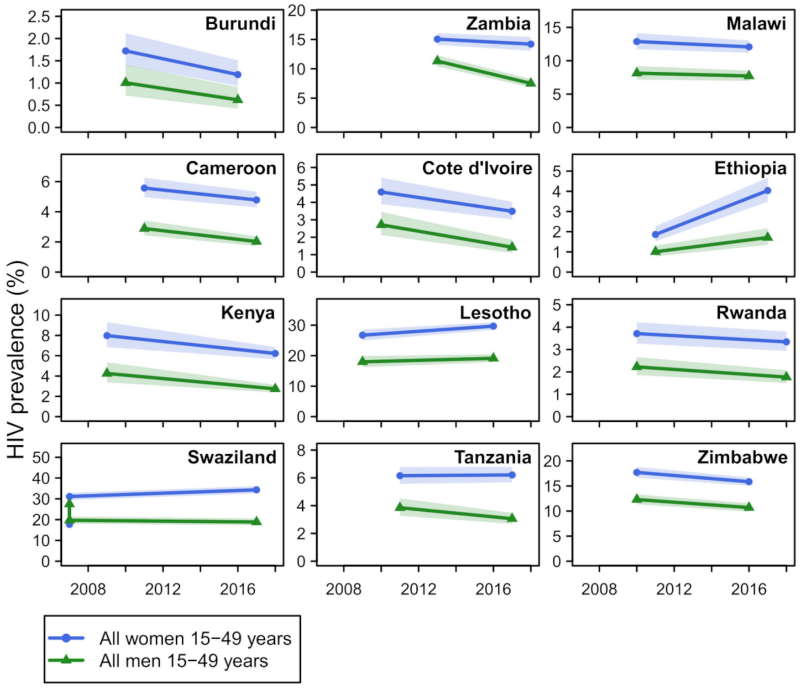

Figure 2. Country specific HIV prevalence among males and females between survey periods.

Table 3. HIV prevalence among all women and men in each period, and the absolute change in prevalence between periods 1 and 2 by country

	Women		Men		Change inprevalence (point estimates)	
Countries	Period 1	Period 2	Period 1	Period 2	Women	Men
Burundi	1.72 [1.4, 2.12]	1.19 [0.94, 1.51]	1.01 [0.72, 1.41]	0.62 [0.42, 0.91]	-0.53	-0.38
Zambia	15.06 [14.09, 16.08]	14.21 [13.07, 15.43]	11.32 [10.4, 12.31]	7.52 [6.83, 8.27]	-0.85	-3.8
Malawi	12.88 [11.72, 14.14]	12.08 [11.19, 13.03]	8.14 [7.18, 9.21]	7.72 [6.98, 8.53]	-0.8	-0.42
Cameroon	5.57 [4.96, 6.26]	4.79 [4.29, 5.33]	2.89 [2.44, 3.42]	2.03 [1.73, 2.37]	-0.79	-0.86
Cote d'Ivoire	4.59 [3.89, 5.41]	3.49 [3.02, 4.03]	2.71 [2.13, 3.45]	1.42 [1.09, 1.86]	-1.11	-1.29
Ethiopia	1.86 [1.53, 2.27]	4.04 [3.48, 4.67]	1.01 [0.77, 1.31]	1.71 [1.35, 2.17]	2.18	0.7
Kenya	7.98 [6.84, 9.3]	6.22 [5.65, 6.85]	4.26 [3.37, 5.36]	2.74 [2.39, 3.14]	-1.76	-1.52
Lesotho	26.73 [24.97, 28.58]	29.69 [28.45, 30.96]	17.99 [16.22, 19.9]	19.13 [17.87, 20.45]	2.96	1.14
Rwanda	3.71 [3.26, 4.22]	3.34 [2.93, 3.8]	2.22 [1.86, 2.66]	1.77 [1.51, 2.07]	-0.37	-0.46
Swaziland	31.15 [29.44, 32.91]	34.33 [32.57, 36.12]	19.7 [18.03, 21.48]	18.87 [17.29, 20.54]	3.18	-0.83
Tanzania	6.16 [5.57, 6.79]	6.21 [5.67, 6.79]	3.85 [3.27, 4.53]	3.06 [2.69, 3.47]	0.05	-0.79
Zimbabwe	17.71 [16.65, 18.83]	15.86 [15.06, 16.69]	12.3 [11.34, 13.32]	10.7 [9.89, 11.57]	-1.85	-1.6
Cluster 1	1.86 [1.53, 2.27]	4.04 [3.48, 4.67]	1.01 [0.77, 1.31]	1.71 [1.35, 2.17]	2.18	0.7
Cluster 2	8.96 [8.52, 9.43]	15.81 [15.34, 16.29]	5.94 [5.52, 6.39]	9.65 [9.26, 10.05]	6.85	3.71
Cluster 3	5.2 [4.72, 5.72]	4.77 [4.28, 5.32]	2.82 [2.45, 3.24]	2.02 [1.72, 2.36]	-0.42	-0.8
All countries	1.86 [1.53, 2.27]	7 [6.66, 7.37]	1.01 [0.78, 1.31]	3.42 [3.18, 3.68]	5.15	2.42

Age-specific prevalence trends in countries by survey periods

There is a discrepancy in the prevalence of HIV between age groups and sexes (Table 4, Figure 3). Except for Burundi, Ethiopia and Rwanda, there was a significant disparity in prevalence between men and women across all age categories in every country. Females generally had a substantially higher incidence than their male counterparts across all ages and countries.

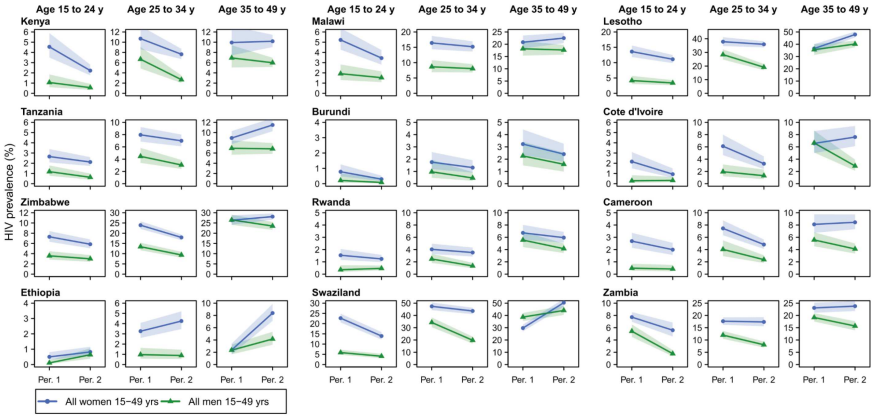

Figure 3. Age-specific prevalence trends among men and women in regions by age group.

Table 4. Age-specific HIV prevalence (with 95% confidence intervals) among men and women per country in each period

		Age 15 to 24 prev.		Age 25 to 34 prev.		Age 35 to 49 prev.	
Country	**Period**	**Women**	**Men**	**Women**	**Men**	**Women**	**Men**
All countries	per1	0.5 [0.31, 0.81]	0.11 [0.04, 0.28]	3.26 [2.6, 4.08]	0.97 [0.58, 1.63]	2.38 [1.65, 3.41]	2.34 [1.68, 3.26]
	per2	2.7 [2.35, 3.11]	0.77 [0.61, 0.99]	7.76 [7.24, 8.32]	3.58 [3.13, 4.09]	12.02 [11.21, 12.87]	7.27 [6.64, 7.96]
Burundi	per1	0.78 [0.48, 1.27]	0.21 [0.07, 0.68]	1.76 [1.19, 2.58]	0.97 [0.48, 1.96]	3.23 [2.35, 4.42]	2.26 [1.5, 3.41]
	per2	0.3 [0.17, 0.53]	0.09 [0.02, 0.37]	1.31 [0.9, 1.91]	0.47 [0.23, 0.94]	2.41 [1.78, 3.26]	1.58 [0.99, 2.53]
Cameroon	per1	2.69 [2.14, 3.37]	0.48 [0.28, 0.84]	7.45 [6.33, 8.76]	4.03 [2.94, 5.51]	8.11 [6.72, 9.75]	5.57 [4.54, 6.82]
	per2	1.99 [1.56, 2.55]	0.42 [0.23, 0.75]	4.82 [4.11, 5.65]	2.36 [1.81, 3.08]	8.45 [7.31, 9.74]	4.1 [3.36, 5]
Cote d'Ivoire	per1	2.16 [1.5, 3.1]	0.29 [0.1, 0.84]	6.11 [4.65, 7.99]	1.95 [1.21, 3.14]	6.57 [5, 8.59]	6.64 [5.08, 8.65]
	per2	0.94 [0.58, 1.5]	0.32 [0.15, 0.68]	3.26 [2.38, 4.45]	1.31 [0.74, 2.32]	7.6 [6.11, 9.42]	2.89 [2.12, 3.93]
Ethiopia	per1	0.5 [0.31, 0.81]	0.11 [0.04, 0.28]	3.26 [2.6, 4.08]	0.97 [0.58, 1.63]	2.38 [1.65, 3.42]	2.34 [1.68, 3.26]
	per2	0.82 [0.58, 1.16]	0.64 [0.38, 1.07]	4.25 [3.47, 5.21]	0.89 [0.54, 1.45]	8.39 [7.11, 9.88]	4.16 [3.23, 5.35]
Kenya	per1	4.55 [3.5, 5.89]	1.06 [0.6, 1.86]	10.69 [8.63, 13.17]	6.66 [4.86, 9.07]	9.93 [7.42, 13.17]	6.92 [5.06, 9.41]
	per2	2.22 [1.76, 2.81]	0.56 [0.33, 0.92]	7.64 [6.69, 8.71]	2.66 [2.02, 3.5]	10.18 [9.04, 11.44]	5.98 [5.14, 6.95]
Lesotho	per1	13.6 [11.82, 15.59]	4.15 [3.02, 5.68]	37.84 [34.62, 41.17]	28.35 [24.74, 32.27]	36.51 [33.11, 40.05]	35.55 [31.15, 40.21]
	per2	11.1 [9.83, 12.5]	3.38 [2.64, 4.31]	35.92 [33.64, 38.28]	19.12 [16.94, 21.51]	47.91 [45.48, 50.35]	40.16 [37.52, 42.85]
Malawi	per1	5.22 [4.26, 6.37]	1.92 [1.3, 2.82]	16.42 [14.36, 18.71]	8.65 [6.89, 10.81]	20.81 [18.31, 23.56]	18.14 [15.35, 21.3]
	per2	3.45 [2.8, 4.23]	1.53 [1.09, 2.15]	15.18 [13.58, 16.95]	8.05 [6.8, 9.5]	22.49 [20.43, 24.69]	17.64 [15.75, 19.71]

Rwanda	per1	1.54 [1.15, 2.05]	0.36 [0.18, 0.73]	4.04 [3.27, 4.98]	2.47 [1.83, 3.32]	6.72 [5.62, 8.03]	5.55 [4.41, 6.97]
	per2	1.24 [0.98, 1.57]	0.47 [0.32, 0.7]	3.52 [2.86, 4.34]	1.34 [0.96, 1.86]	5.95 [5.13, 6.89]	4.15 [3.44, 5]
Swaziland	per1	22.67 [20.56, 24.92]	5.85 [4.74, 7.21]	47.41 [44.28, 50.55]	34.27 [30.39, 38.37]	29.7 [26.99, 32.57]	38.67 [35.36, 42.08]
	per2	13.94 [12.18, 15.9]	4.07 [3.13, 5.28]	43.64 [40.99, 46.32]	19.76 [17.09, 22.75]	50.42 [47.17, 53.66]	44.08 [40.37, 47.85]
Tanzania	per1	2.66 [2.08, 3.39]	1.18 [0.78, 1.8]	7.96 [6.85, 9.24]	4.46 [3.39, 5.84]	8.94 [7.74, 10.3]	6.93 [5.67, 8.45]
	per2	2.12 [1.73, 2.6]	0.63 [0.4, 1]	6.99 [6.09, 8.02]	3.05 [2.41, 3.87]	11.49 [10.26, 12.84]	6.82 [5.85, 7.95]
Zambia	per1	7.72 [6.96, 8.56]	5.43 [4.49, 6.54]	17.65 [16.17, 19.24]	11.99 [10.48, 13.69]	23.07 [21.07, 25.2]	19.17 [17.52, 20.93]
	per2	5.59 [4.56, 6.85]	1.77 [1.33, 2.35]	17.36 [15.57, 19.31]	8.06 [6.92, 9.36]	23.78 [21.78, 25.9]	15.7 [13.92, 17.65]
Zimbabwe	per1	7.3 [6.32, 8.42]	3.58 [2.85, 4.49]	23.91 [22.06, 25.87]	13.42 [11.66, 15.38]	26.36 [24.11, 28.74]	26.51 [24.07, 29.09]
	per2	5.85 [5.04, 6.78]	3 [2.41, 3.73]	17.95 [16.59, 19.39]	9.37 [8.02, 10.93]	28.13 [26.59, 29.72]	23.52 [21.62, 25.53]

Table 5. Log-binomial regression estimating the relationship between HIV prevalence and sex and survey period

Age	15 to 24 years	25 to 34 years	35 to 49 years	all ages
Female versus not	4.74 (3.09, 7.26)	5.19 (3.83, 7.03)	4.36 (3.38, 5.61)	4.81 (4.00, 5.79)
Period 2 versus period 1	13.67 (9.30, 20.09)	13.10 (9.89, 17.34)	9.59 (7.65, 12.02)	11.48 (9.70, 13.58)
Male versus not	7.69 (2.87, 20.64)	5.54 (3.20, 9.59)	3.93 (2.73, 5.64)	4.82 (3.59, 6.47)
Period 2 vs period 1	24.32 (9.62, 61.48)	16.95 (10.19, 28.21)	12.91 (9.31, 17.90)	14.62 (11.20, 19.08)

All the countries saw a decline in the prevalence for those aged 15 to 24 years in both sexes, except for Cote d'Ivoire, Rwanda and Ethiopia men, where there is a noticeable rise in prevalence in both sexes. When compared to other countries, Kenya (4.55 (95% CI 3.5-5.89%) to 2.22 (95% CI 1.76-2.81%)), Malawi (5.22 (95% CI 4.26-6.37%) to 3.45 (95% CI 2.8-4.23%)), Swaziland (22.67 (95% CI 20.56-24.92%) to 13.94 (95% CI 12.18-15.9%)), and Cote d'Ivoire (2.16 (95% CI 1.5-3.1%) to 0.94 (95% CI 0.58-1.5%)) saw the most significant decline in the prevalence among females in the same age range.

All the countries exhibited a considerable drop in prevalence among both sexes aged between 25 and 34 years, except for Ethiopia, which had a spike in female prevalence (3.26 (95% CI 2.6-4.08%) to 4.25 (95% CI 3.47-5.21%)). Except for Burundi (3.23 (95% CI 2.35-4.42%) to 2.41 (95% CI 1.78-3.26%)) and Rwanda (6.72 (95% CI 5.62-8.03%) to 5.95 (95% CI 5.13-6.89%)), all the other countries had an increase of HIV prevalence among females aged 35 to 49 years. All countries had a considerable decrease in the HIV prevalence among males aged 35 to 49 during the two periods, except Ethiopia (2.34 (95% CI 1.68-3.26%) to 4.16 (95% CI 3.23-5.35%)), Swaziland (38.67 (95% CI 35.36-42.08%) to 44.08 (95% CI 40.37-47.85%)),

and Lesotho (35.55 (95% CI 31.15-40.21%) to 40.16 (95% CI 37.52-42.85%)), where it increased.

Discussions

To determine the temporal patterns of HIV prevalence in the region, historical survey datasets collected (from 2007 to 2020) on more than 80,000 women and men aged 15 to 49 in 12 countries from the SSA region were examined. A statistical overview of HIV prevalence disaggregated by age, sex, and the country was determined. This was achieved by the use of the logit regression approach in analyzing the data and deriving a ninety-five percent (95%) confidence interval for the estimations of HIV prevalence.

The analysis established that older females and males have a higher HIV prevalence than younger individuals. For both sexes, there was a slight decrease in HIV prevalence in Cluster 3 across all age groups. The Western African countries of Cote d'Ivoire and Cameroon make up this cluster. Enhanced mitigating measures put in place in Cameroon and a drop in risky sexual conduct have been suggested as possible causes for this reduction [27]. In a similar manner, the decline in prevalence in Cote d'Ivoire could be credited with having a favourable effect on HIV self-testing [28].

By comparing the two periods, the study discloses that Swaziland had the highest relative change in the prevalence among females with a 3.18% rise, followed by Lesotho women with 2.96%, Ethiopia women had 2.18%, and Tanzania women with 0.05%. It has been established that resistance to behaviour change, including instances of casual sex, irregular condom use, and early sexual debut, among others, may be to blame for the spike in Swaziland estimations [29]. Similarly, it was shown that HIV infection was substantially linked with both males' and females' socioeconomic status, education level, marital status, usage of condoms during first sex, and circumcision for men in Lesotho [30].

A significant decline of the estimates in males was also discovered to have occurred in every country between the two periods, with the exception of Ethiopia and Lesotho, where there was a slight increase. The situation in Ethiopia is in line with earlier research that showed that starting in 2008, the incidence rate of HIV began rising by 10% and that, overall, the number of new infections detected each year increased by 36% and doubled among adults [19].

A significant disparity in HIV prevalence was also established between the age groups and sexes in the general population. Females generally exhibited a higher prevalence than their male counterparts in all aspects. Between the ages of 15 and 24 years old, males in Cote d'Ivoire and Rwanda displayed a noticeable increase, while Ethiopia experienced an increase in both sexes. Recent studies have attempted to identify the causes of the discrepancy between young men and women, including [31-33].

In Swaziland, the prevalence decreased significantly between the ages of 15 and 24 years, whereas Ethiopian women's prevalence increased between the ages of 25 and 34 years. Except for Burundi and Rwanda, all countries saw an increase in HIV prevalence in women aged 35 to 49. Men in Lesotho, Swaziland, and Ethiopia who were 25 to 49 years old also experienced a comparable rise in the prevalence.

To investigate the effects of age groups, sex, and survey period on HIV prevalence, a binomial logistic regression model was utilized. This helped to give an intuitive understanding of the variables contributing to HIV positivity. Age, followed by sex and the period of the survey, had the greatest overall impact on HIV prevalence in both sexes, and any change in age can have a more notable impact on the prevalence. Infection risk increases with ageing for both sexes. Improving targeted preventative care and treatment for this demographic as well as integrating older persons into solutions to the HIV epidemic are urgently needed.

Our findings could help targeted interventions by revealing the temporal patterns of HIV prevalence among the age groups, regions, and sexes in the general population. Strategies for HIV prevention need to be modified to properly target women, adults, and particular geographic areas.

References

[1] UNAIDS data 2022 | UNAIDS, Accessed: Feb. 1, 2023. [Online]. Available: https://www.unaids.org/en/resources/documents/2023/2022_unaids_data.

[2] Countries (accessed March 20, 2023). https://www.unaids.org/en/regionscountries/countries.

[3] Fast-track commitments to end AIDS by 2030 | UNAIDS. Accessed: March 23, 2023. [Online]. Available: https://www.unaids.org/en/resources/documents/2016/fast-track-commitments.

[4] 2016 United Nations Political Declaration on Ending AIDS Sets World on the Fast-track to End the Epidemic by 2030. Accessed: March 23, 2023. [Online]. Available: https://www.unaids.org/en/resources/presscentre/pressreleaseandstatementarchive/2016/june/20160608_PS_HLM_PoliticalDeclaration.

[5] B. L. Jewell et al., Potential effects of disruption to HIV programmes in sub-Saharan Africa caused by COVID-19: results from multiple mathematical models, Lancet HIV 7(9) (2020), e629-e640. doi: 10.1016/S2352-3018(20)30211-3.

[6] D. F. Cuadros et al., Mapping the spatial variability of HIV infection in sub-Saharan Africa: effective information for localized HIV prevention and control, Sci. Rep. 7(1) (2017), 9093. doi: 10.1038/s41598-017-09464-y.

[7] L. C. Zulu, E. Kalipeni and E. Johannes, Analyzing spatial clustering and the spatiotemporal nature and trends of HIV/AIDS prevalence using GIS: the case of Malawi, 1994-2010, BMC Infect. Dis. 14(1) (2014), 285. doi: 10.1186/1471-2334-14-285.

[8] G. Murewanhema, G. Musuka, P. Moyo, E. Moyo and T. Dzinamarira, HIV and adolescent girls and young women in sub-Saharan Africa: a call for expedited action to reduce new infections, IJID Reg. 5 (2022), 30-32. doi: 10.1016/j.ijregi.2022.08.009.

[9] R. C. Dellar, S. Dlamini and Q. A. Karim, Adolescent girls and young women: key populations for HIV epidemic control, J. Int. AIDS Soc. 18(2) (2015), 19408. doi: 10.7448/IAS.18.2.19408.

[10] H. Huerga et al., Who needs to be targeted for HIV testing and treatment in KwaZulu-Natal? Results from a population-based survey, J. Acquir. Immune Defic. Syndr. 73(4) (1999), 411-418. doi: 10.1097/QAI.0000000000001081.

[11] E. Haeuser et al., Mapping age- and sex-specific HIV prevalence in adults in sub-Saharan Africa, 2000-2018, BMC Med. 20(1) (2022), 488. doi: 10.1186/s12916-022-02639-z.

[12] C. O'brien-Carelli et al., Mapping HIV prevalence in Nigeria using small area estimates to develop a targeted HIV intervention strategy, PLoS ONE 17(6) (2022), e0268892. doi: 10.1371/journal.pone.0268892.

[13] A. Ibrahim Khalil et al., Age-specific burden of cervical cancer associated with HIV: a global analysis with a focus on sub-Saharan Africa, Int. J. Cancer 150(5) (2022), 761-772. doi: 10.1002/ijc.33841.

[14] F. H. Astawesegn, V. Stulz, E. Conroy and H. Mannan, Trends and effects of antiretroviral therapy coverage during pregnancy on mother-to-child transmission of HIV in sub-Saharan Africa. Evidence from panel data analysis, BMC Infect. Dis. 22(1) (2022), 134. doi: 10.1186/s12879-022-07119-6.

[15] K. A. Risher et al., Age patterns of HIV incidence in eastern and southern Africa: a modelling analysis of observational population-based cohort studies, Lancet HIV 8(7) (2021), e429-e439. doi: 10.1016/S2352-3018(21)00069-2.

[16] M. Mabaso et al., Trends and correlates of HIV prevalence among adolescents in South Africa: evidence from the 2008, 2012 and 2017 South African national HIV prevalence, incidence and behaviour surveys, AIDS Res. Ther. 18(1) (2021), 97. doi: 10.1186/s12981-021-00422-3.

[17] A. Godin et al., Inferring population HIV incidence trends from surveillance data of recent HIV infection among HIV testing clients, AIDS Lond. Engl. 35(14) (2021), 2383-2388. doi: 10.1097/QAD.0000000000003021.

[18] T. Gelibo et al., Spatial distribution and determinants of HIV prevalence among adults in urban Ethiopia: findings from the Ethiopia population-based HIV impact assessment survey (2017-2018), PLoS ONE 17(7) (2022), e0271221. doi: 10.1371/journal.pone.0271221.

[19] T. Girum, A. Wasie and A. Worku, Trend of HIV/AIDS for the last 26 years and predicting achievement of the 90-90-90 HIV prevention targets by 2020 in Ethiopia: a time series analysis, BMC Infect. Dis. 18(1) (2018), 320. doi: 10.1186/s12879-018-3214-6.

[20] L. F. Johnson et al., The effect of HIV programs in South Africa on national HIV incidence trends, 2000-2019, JAIDS J. Acquir. Immune Defic. Syndr. 90(2) (2022), 115-123. doi: 10.1097/QAI.0000000000002927.

[21] The DHS Program - Demographic and Health Survey (DHS) (accessed February 2, 2023). https://dhsprogram.com/methodology/survey-Types/dHs.cfm.

[22] PHIA Data Manager (accessed March 23, 2023). https://phia-data.icap.columbia.edu/datasets.

[23] A. Merzouki, J. Estill, E. Orel, K. Tal and O. Keiser, Clusters of sub-Saharan African countries based on sociobehavioural characteristics and associated HIV incidence, Peer J. 9 (2021), e10660. doi: 10.7717/peerj.10660.

[24] S. Wacholder, Binomial regression in GLIM: estimating risk ratios and risk differences, Am. J. Epidemiol. 123(1) (1986), 174-184. doi: 10.1093/oxfordjournals.aje.a114212.

[25] M. Nurminen, To use or not to use the odds ratio in epidemiologic analyses? Eur. J. Epidemiol. 11(4) (1995), 365-371. doi: 10.1007/BF01721219.

[26] S. Greenland, Interpretation and choice of effect measures in epidemiologic analyses, Am. J. Epidemiol. 125(5) (1987), 761-768. doi: 10.1093/oxfordjournals.aje.a114593.

[27] C. E. Bekolo et al., The declining trend in HIV prevalence from population-based surveys in Cameroon between 2004 and 2018: myth or reality in the universal test and treat era? BMC Public Health 23(1) (2023), 479. doi: 10.1186/s12889-023-15374-8.

[28] A. Simo Fotso et al., Routine programmatic data show a positive population-level impact of HIV self-testing: the case of Côte d'Ivoire and implications for implementation, AIDS 36(13) (2022), 1871. doi: 10.1097/QAD.0000000000003328.

[29] J. A. Belle and N. N. Gamedze, Behavioral factors contributing to the transmission of HIV and AIDS amongst young women of Mbabane in Swaziland, Afr. Health Sci. 19(3) (2019), 2302. doi: 10.4314/ahs.v19i3.2.

[30] A. Schwitters et al., High HIV prevalence and associated factors in Lesotho: results from a population-based survey, PLoS ONE 17(7) (2022), e0271431. doi: 10.1371/journal.pone.0271431.

[31] T. Girum et al., Gender disparity in epidemiological trend of HIV/AIDS infection and treatment in Ethiopia, Arch. Public Health 76(1) (2018). doi: 10.1186/s13690-018-0299-8.

[32] R. K. Sing and S. Patra, What factors are responsible for higher prevalence of HIV infection among urban women than rural women in Tanzania? Ethiop. J. Health Sci. 25(4) (2015). doi: 10.4314/ejhs.v25i4.5.

[33] M. Monod et al., Growing Gender Disparity in HIV Infection in Africa: Sources and Policy Implications, medRxiv, 2023. doi: 10.1101/2023.03.16.23287351.