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Original article

Cluster Analysis of HIV/AIDs Incidence in Sub-Saharan Africa (1990 – 2018)

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Abstract

Background: The HIV/AIDS epidemic has had a negative impact on Sub-Saharan Africa's development and has contributed to discrimination against those on the margins of society or those who are at risk of contracting the virus due to their behaviors, race, ethnicity, gender, sexual orientation, or social characteristics. Against this backdrop, the purpose of this study is to examine the countries that could be considered in the same category and to investigate the concentration of diseases in relation to the socioeconomic status of Sub-Saharan African countries.

Methods: HIV prevalence rates in Sub-Saharan African countries were studied using Cluster Analysis techniques. It was implemented using hierarchical (Agglomerative nesting) and partitioning methods (K-Means) in general. For cluster validation (a mechanism for evaluating the correctness of clustering), the relative type of validation was used.

Results: HIV/AIDS prevalence increased steadily from 1990 (6.74) to 1995 (9.13), after which it began to fall to (2.60) in 2018. The analysis produced three clusters based on the 44 observations provided. After clustering, only Lesotho and Eswatini are in the third cluster. Over the course of the study, South Africa, Zambia, Zimbabwe, Namibia, Malawi, Mozambique, and Botswana had the highest HIV/AIDS prevalence. The rest of the world is classified as part of the first cluster.

Conclusion: The high prevalence of HIV/AIDS in Sub-Saharan African countries has had a far-reaching impact. Understanding the variables that have influenced the path of the HIV/AIDS scourge is therefore critical, both from a humanitarian and economic standpoint, because it is a significant step toward eradicating the virus.

Keywords: Cluster Analysis, HIV/AIDS, Sub-Saharan Africa, K-Means, Agglomerative Nesting, Nigeria

Introduction

Over the years, the world has lost several people to a virus known as HIV; several institutes, governments, and international organizations have invested heavily in providing measures to combat the spread of this disease; however, HIV remains a significant challenge among other diseases, particularly in Africa. According to the World Health Organization (WHO) and the Joint United Nations Program on HIV and AIDS (UNAIDS), active HIV sero-surveillance using pregnant women attending antenatal clinics as the survey population is used in Sub-Saharan Africa. Across the Commonwealth, HIV prevalence varies greatly between countries and between urban and rural areas. Due to differences in location and number of survey sites, data from sentinel surveys may be inconclusive for direct comparisons between aggregate figures obtained in several surveys.

According to Meylakhs (1), the aftermath of the HIV epidemic in the 1980s was marred by skepticism and denial in Africa. As a result of burdensome structural adjustment programs and declining populations in the world's industrialized countries, some local and national leaders in Africa saw HIV/AIDS as a western ploy to prevent Africans from increasing demographically. This contributed to the popularization of the acronym AIDS as a 'American invention idea to discourage/decrease sex' or, in its French equivalent, SIDA, as 'syndrome imaginaire pour decourager les amoureux' (imaginary syndrome to discourage lovers) (1). Thus, in the absence of many competing sources of information, this made sense to people who toiled and suffered every day to make ends meet. However, it slowed the type of response that was required, and the consequences were tragic. According to Frange (2), the refusal of some authorities in many parts of Africa, including South Africa, to use lifesaving antiretroviral drugs for HIV treatment resulted in the loss of many lives.

Although the attempt to deny the existence of HIV/AIDS is fading, it has not gone away among younger generations. This is because many young people in Africa today do not believe in the existence of HIV and instead believe in the ancient idea that "what one does not know, cannot affect one." The Archbishop of Maputo was reported to have claimed in 2007 that the West was exporting condoms tainted with the virus to kill Africans (3). Some molecular epidemiological studies of HIV are now common in Europe and North America, owing primarily to the post-hoc use of pol genotypes (gene sequences) obtained from routine antiretroviral therapy resistance screening (4). The most common approach identifies genetic clusters (groups of closely related sequences) and bases subsequent analyses on these clusters. Phylogenetic studies of clusters in North America and Europe, for example, have revealed (and confirmed) the importance of the men-who-have-sex-with-men (MSM) subgroup and early HIV infection (7) in driving HIV transmission.

A review of the literature revealed that there are few studies on cluster analysis of HIV/AIDS incidence in Sub-Saharan African countries. To fill gaps in the literature, this study will look into the countries that could be classified as being in the same category, as well as the disease concentration in relation to the socioeconomic status of the countries in Sub-Saharan Africa. The second section of this study presents a literature review on HIV/AIDS prevalence in Sub-Saharan African countries. Section 3 contains information on the study's materials and methods. The result of the analysis using cluster analysis was presented in section 4, and the discussion of findings and conclusion was presented in the final section.

Review of related literature on HIV prevalence in sub-saharan Africa

According to UNAIDS (8), there were an estimated 19 million HIV-positive people in Eastern and Southern Africa, 78% more than in Western and Central African subregions. According to their most recent reports, there were an estimated 960000 (830000-1.1 million) new HIV cases in 2015 alone, with a 14% decrease in new HIV cases between 2010 and 2015. More than half of the HIV patients in this sub-region were women, and this sub-region accounts for 46% of the global total of new HIV infections. At the end of 2015, 470 000 people died from AIDS-related causes, a 38% decrease from 2010 to 2015.

At the end of 2015, only 10.3 million (54%) of all HIV patients in this sub-region were receiving antiretroviral therapy. It is also reported that this region had a higher percentage of adult women (59%) than men (44%) accessing therapy during the same period (9-11). In general, the eastern and southern regions of Africa have shown numerous signs of gradual, modest declines in the mode of HIV occurrence in recent years. HIV rates are still rising in some countries (where the epidemic is the most severe in the world). There is some hope that the epidemic will naturally reach its average limit, after which it will not be able to rise again. As a result, it has been assumed that the extremely high HIV prevalence rates in some countries have reached a plateau (12). Regrettably, this does not appear to be the case right now. South Africa has the highest number of people living with HIV (7 million), followed by Kenya (1.5 million), Uganda (1.5 million), Mozambique (1.5 million), Tanzania (1.4 million), Zimbabwe (1.4 million), and Zambia (1.2 million), according to a recent WHO report (WHO, 2015) (Tables 4 and 5).

In 2015, Swaziland had the highest HIV prevalence rate in the world, at 28.2% of people aged 15 to 49. Since 1995, this has been steadily increasing. According to a 2015 WHO report, HIV prevalence rates were also high in other countries such as Lesotho (22.7%), Botswana (22.2%), South Africa (19.2%), Zimbabwe (14.7%), Namibia (13.3%), Zambia (12.9%), Mozambique (10.5%), Malawi (9.1%), Uganda (7.1%), and Kenya (5.9%). These HIV prevalence rates are higher in these countries than in any other region.

Despite global efforts to reduce HIV transmission, prevalence rates in Kenya (from 5.3% in 2014 to 5.9% in 2015), Swaziland (from 27.0% in 2008 to 28.8% in 2015), and South Africa (from 18.0% in 2005 to 19.2% in 2015) continue to rise year after year. HIV prevalence rates are falling in Namibia, Botswana, Zimbabwe, and Malawi. These high-prevalence countries also had the highest number of HIV-infected women and children, as well as the highest number of AIDS-related deaths and orphans (aged 0-17) (13).

As the search for the primary cause of HIV's spread and high prevalence in Sub-Saharan Africa continues, there are two schools of thought that are thought to have contributed to the virus's spread. First, western countries were accused of facilitating the spread of HIV among the black race, particularly in Africa. Researchers from the West, on the other hand, have identified various African sexual practices as facilitators or promoters of HIV transmission in the region (14). Furthermore, history will never forget that African and international leaders were slow to respond to the epidemic.

Furthermore, Africans' lack of understanding of HIV transmission mechanisms, combined with certain harmful cultural beliefs, tends to overshadow the enormous strides being made by African and international stakeholders to eradicate the virus in Africa. The main factor fueling the epidemic in Africa is people's ignorance of the disease. Even though generalizations are frequently debatable and occasionally misleading, Africa has a wide range of beliefs, habits, spiritual and healing practices. Several have been practiced for centuries. It is also true that cultural differences exist both within and between countries. Common practices that an ethnic group or community is known for are essential in preserving their cultural identity and continuity. However, some have negative aspects and should be discontinued or modified. The nature, process, and outcome of the epidemic in Sub-Saharan Africa (15-20) are formed by an intricate interplay of social, cultural, material, and behavioral factors.

The HIV pandemic in Sub-Saharan Africa is exacerbated by unrelenting discrimination against HIV patients, even in clinical settings. These patients face discrimination, stigma, and low acceptance in their respective communities (21, 22). In these parts of the world, HIV containment is hampered by inadequate health infrastructure (23). In Sub-Saharan Africa, public discussion of sex-related issues limits the dissemination of HIV information, particularly from teachers to their students. While most young people are unwilling to undergo HIV serological testing, HIV-infected patients in this region are afraid to reveal their serological status to their loved ones. This could be because they are afraid of being misunderstood, accused, stigmatized, or abandoned (24). Deaf people and other physically challenged people may be affected by poor communication and access to HIV-related information and prevention measures due to observed low literacy and lack of inclusion in community plans. Though accidental cuts from public-salon use have been identified as a potential risk to HIV transmission (25), there is little or no monitoring of hair-dressing saloons to ensure compliance with universal practices and HIV prevention measures.

Materials and methods

Data

The dataset used in this study is derived from the United Nations AIDS (UNAIDS) data 2020. For the period 1990 to 2018, monthly HIV/AIDS prevalence data from forty-four (44) Sub-Saharan African countries were collected.

Agglomerative nesting (Hierarchical)

Agglomerative nesting, also known as AGNES, employs a bottom-up algorithm to generate a single rooted tree-like diagram (dendogram). The following is the algorithm:

i. At first, place each article in its own cluster.
ii. Choose the two clusters with the shortest distance from all current clusters.
iii. Replace the two original clusters with a new cluster formed by merging the two original clusters.
iv. Repeat the previous two steps until there is only one cluster left in the pool.

Distance Measure

A measure of dissimilarity between sets of observations is required to compute clustering. This is also known as a proximity matrix (a distance measure matrix that can be either similarity or dissimilarity in the case of hierarchical clustering). The proximity matrix is created by employing an appropriate metric, such as the Euclidean and Manhattan distance measures.

Euclidean distance

The Euclidean distance is an interpoint distance that considers the magnitude of the expression data and thus preserves more information about the data. When used, Euclidean distance is the length of the shortest path between two points and necessitates standardization. Given mathematically as:

$$\|a-b\|_2 = \sqrt{\sum_i (a_i - b_i)^2} \quad (1)$$

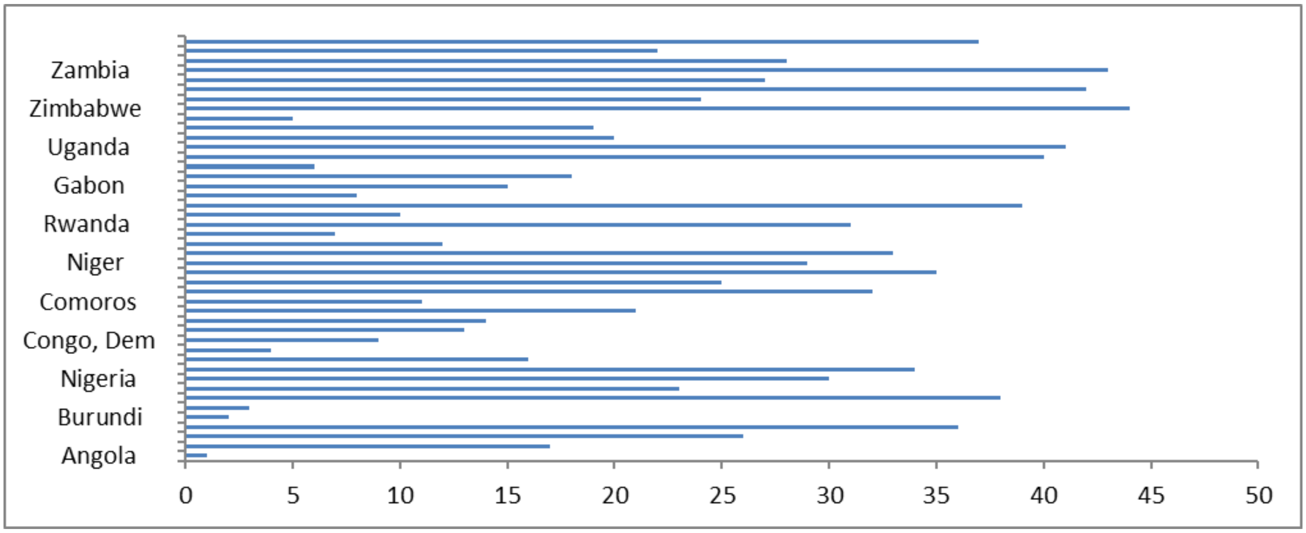

Figure 1. Banner plot of the incidence of HIV/AIDs Sub-Saharan Africa

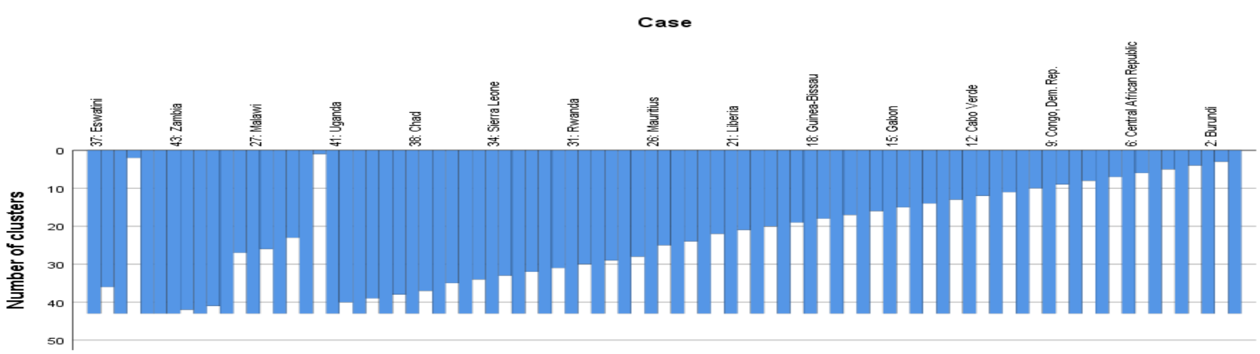

Figure 2. Icicle Plot of the incidence of HIV/AIDs Sub-Saharan Africa

Table 1. Descriptive Statistics of the incidence of HIV/AIDs Sub-Saharan Africa

	1990	*1991*	*1992*	*1993*	*1994*	*1995*	*1996*	*1997*	*1998*	*1999*	*2000*
Mean	6.74	7.55	8.17	8.69	9.04	9.13	8.99	8.61	8.10	7.52	6.96
Std.Error	1.46	1.59	1.68	1.78	1.88	1.93	1.92	1.84	1.71	1.57	1.44
Median	2.80	3.35	3.75	3.65	3.83	3.70	3.30	3.15	3.20	3.05	2.95
Mode	2.70	0.70	2.50	5.90	2.70	2.00	3.30	1.60	1.50	1.70	1.60
Std.Dev.	9.71	10.55	11.13	11.81	12.46	12.81	12.76	12.21	11.33	10.41	9.57
Variance	94.30	111.20	123.87	139.50	155.33	164.04	162.91	149.15	128.41	108.39	91.66
Kurtosis	11.72	9.82	6.87	4.59	3.68	3.76	3.91	4.00	3.85	3.78	3.77
Skewnes	3.03	2.81	2.45	2.19	2.09	2.11	2.14	2.15	2.12	2.09	2.08
Range	53.13	55.75	54.48	51.22	48.69	49.99	49.29	47.88	44.08	40.88	38.18
Jarque-Bera	257.0	189.8	106.8	61.3	47.9	49.5	51.9	53.1	50.5	49.1	48.6
Prob.	0.00	0.00	0.00	0.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
Minimum	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02
Maximum	53.14	55.76	54.49	51.23	48.70	50.00	49.30	47.90	44.10	40.90	38.20
Sum	296.45	332.01	359.53	382.51	397.77	401.78	395.65	378.84	356.27	330.75	306.12
Count	44	44	44	44	44	44	44	44	44	44	44

	2001	*2002*	*2003*	*2004*	*2005*	*2006*	*2007*	*2008*	*2009*	*2010*	*2011*
Mean	6.42	5.98	5.60	5.28	5.00	4.74	4.56	4.39	4.24	4.05	3.86
Standard Error	1.32	1.22	1.14	1.08	1.03	0.99	0.96	0.93	0.91	0.87	0.83
Median	2.85	2.70	2.50	2.25	2.10	2.05	2.00	2.00	1.91	1.83	1.74
Mode	1.40	1.90	0.70	1.00	4.40	4.20	2.00	2.00	0.50	1.30	0.40
Standard Dev.	8.73	8.10	7.56	7.15	6.81	6.56	6.38	6.19	6.05	5.79	5.50
Samp.Variance	76.22	65.53	57.15	51.18	46.31	43.04	40.65	38.33	36.61	33.57	30.21
Kurtosis	3.67	3.72	3.77	3.94	4.25	4.67	5.07	5.28	5.80	5.81	5.74
Skewness	2.05	2.05	2.05	2.06	2.11	2.18	2.25	2.29	2.37	2.36	2.35
Range	35.67	33.67	31.97	30.87	29.77	29.17	28.37	27.47	27.37	26.48	24.98
Jarque-Bera	46.81	47.26	47.66	49.89	54.93	62.01	69.67	74.03	84.65	84.49	83.11
Probability	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Minimum	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.02	0.02
Maximum	35.70	33.70	32.00	30.90	29.80	29.20	28.40	27.50	27.40	26.50	25.00
Sum	282.53	262.92	246.20	232.31	219.93	208.73	200.51	193.25	186.36	178.33	169.73
Count	44	44	44	44	44	44	44	44	44	44	44

	2012	2013	2014	2015	2016	2017	2018
Mean	3.69	3.52	3.36	3.19	3.00	2.79	2.60
Std. Error	0.80	0.77	0.74	0.70	0.65	0.59	0.54
Median	1.64	1.55	1.47	1.38	1.29	1.20	1.25
Mode	0.30	0.30	0.30	0.30	0.20	0.20	0.20
Std. Dev.	5.32	5.14	4.91	4.62	4.28	3.90	3.55
Variance	28.28	26.42	24.14	21.39	18.33	15.24	12.62
Kurtosis	6.25	6.69	6.96	6.41	5.74	5.09	4.56
Skewness	2.43	2.50	2.54	2.47	2.37	2.25	2.16
Range	24.48	23.99	23.09	21.19	19.19	17.19	15.39
Jarque-be	94.36	104.72	111.39	98.51	83.68	7021	6022
Probability	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Minimum	0.02	0.01	0.01	0.01	0.01	0.01	0.01
Maximum	24.50	24.00	23.10	21.20	19.20	17.20	15.40
Sum	162.35	154.97	147.80	140.35	132.20	122.83	114.49
Count	44	44	44	44	44	44	44

Table 2. Cluster Summary

Row	*Label*	*Cluster*	*Row*	*Label*	*Cluster*
1	Angola	1	23	Mali	1
2	Burundi	1	24	Mozambique	2
3	Benin	1	25	Mauritania	1
4	Burkina Faso	1	26	Mauritius	1
5	Botswana	2	27	Malawi	2
6	Central African Republic	1	28	Namibia	2
7	Cote d'Ivoire	1	29	Niger	1
8	Cameroon	1	30	Nigeria	1
9	Congo, Dem. Rep.	1	31	Rwanda	1
10	Congo, Rep.	1	32	Sudan	1
11	Comoros	1	33	Senegal	1
12	Cabo Verde	1	34	Sierra Leone	1
13	Eritrea	1	35	Somalia	1
14	Ethiopia	1	36	South Sudan	1
15	Gabon	1	37	Eswatini	3
16	Ghana	1	38	Chad	1
17	Gambia, The	1	39	Togo	1
18	Guinea-Bissau	1	40	Tanzania	1
19	Equatorial Guinea	1	41	Uganda	1
20	Kenya	1	42	South Africa	2
21	Liberia	1	43	Zambia	2
22	Lesotho	3	44	Zimbabwe	2

Table 3. Membership Table, Clustering Method: Group Average and Distance Metric: Euclidean

Cluster	*Members*	*Percent*
1	35	79.55
2	7	15.91
3	2	4.55

Centroids

Cluster		*1990*	*1991*	*1992*	*1993*	*1994*	*1995*	*1996*	*1997*
1		3.97571	4.15029	4.154	4.05143	3.88743	3.69943	3.49571	3.30514
2		19.7143	22.2929	24.0629	25.5443	26.2729	26.3286	25.8571	24.5371
3		9.65	15.35	22.85	30.95	38.9	44.0	46.15	45.7

Cluster	*1998*	*1999*	*2000*	*2001*	*2002*	*2003*	*2004*	*2005*
1	3.12686	2.92743	2.72371	2.54286	2.37886	2.23457	2.11143	2.006
2	22.9614	21.1843	19.47	17.9329	16.6229	15.5414	14.6157	13.6886
3	43.05	40.0	37.25	34.0	31.65	29.6	28.05	26.95

Cluster	*2006*	*2007*	*2008*	*2009*	*2010*	*2011*	*2012*	*2013*
1	1.89114	1.82514	1.76829	1.69457	1.62029	1.56057	1.49914	1.42114
2	12.8629	12.0757	11.4657	10.9357	10.5029	9.91571	9.29714	8.80429
3	26.25	26.05	25.55	25.25	24.05	22.85	22.4	21.8

Cluster	*2014*	*2015*	*2016*	*2017*	*2018*
1	1.36886	1.31086	1.25686	1.18571	1.13314
2	8.28429	7.89571	7.48714	7.03286	6.57571
3	20.95	19.6	17.9	16.05	14.4

Table 4. Agglomeration Schedule, Clustering Method: Group Average, Distance Metric: Euclidean

Stage	*Combined Cluster 1*	*Combined Cluster 2*	*Distance*	*Previous Stage Cluster 1*	*Previous Stage Cluster 2*	*Next Stage*
1	25	35	0.0527855	0	0	4
2	29	33	0.102587	0	0	4
3	30	34	0.121647	0	0	10
4	25	29	0.129919	1	2	7
5	9	13	0.168138	0	0	11
6	11	32	0.187879	0	0	7
7	11	25	0.22521	6	4	9
8	3	38	0.244584	0	0	14
9	11	12	0.262619	7	0	24
10	23	30	0.280922	0	3	14
11	4	9	0.283516	0	5	17
12	1	17	0.293437	0	0	19
13	14	21	0.338533	0	0	17
14	3	23	0.338733	8	10	15
15	3	16	0.411864	14	0	20
16	8	15	0.471242	0	0	21
17	4	14	0.493312	11	13	20
18	7	31	0.504877	0	0	22
19	1	26	0.56922	12	0	25
20	3	4	0.572308	15	17	24
21	8	18	0.594171	16	0	30
22	7	10	0.756533	18	0	26
23	6	40	0.791847	0	0	29
24	3	11	0.823963	20	9	27
25	1	36	0.880727	19	0	28
26	7	39	0.950176	22	0	30
27	2	3	1.16062	0	24	28
28	1	2	1.20936	25	27	32
29	6	41	1.25798	23	0	33
30	7	8	1.35488	26	21	32
31	27	43	1.46219	0	0	35
32	1	7	1.81026	28	30	36
33	6	20	2.15423	29	0	36
34	24	42	2.83174	0	0	39
35	27	28	2.85491	31	0	39
36	1	6	3.27158	32	33	38
37	22	37	3.3495	0	0	0
38	1	19	4.14505	36	0	0
39	24	27	5.46313	34	35	41
40	5	44	5.92212	0	0	41
41	5	24	8.10489	40	39	0

Cluster Number	*Smallest Row*
1	1
2	5
3	22

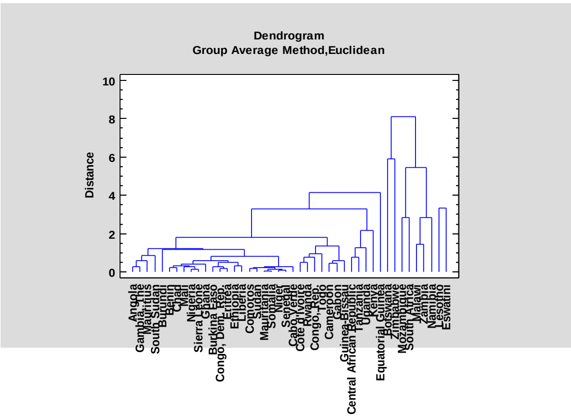

Figure 3. The 2D Cluster Scatterplot

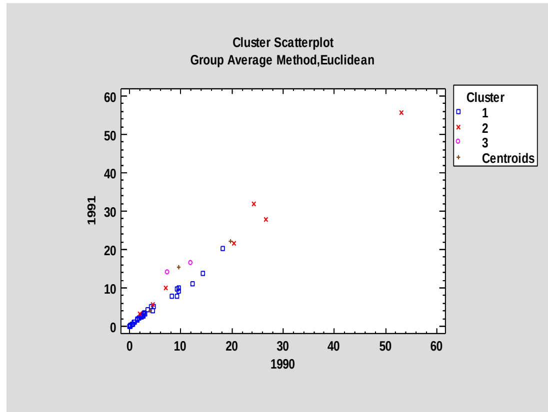

Figure 4. The 3D Cluster Scatterplot

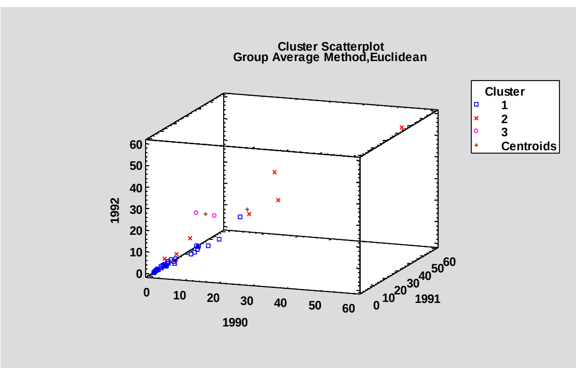

Figure 5. The 4D Cluster Scatterplot

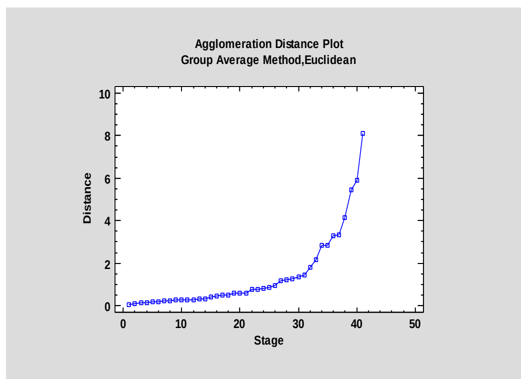

Figure 6. The Agglomeration Distance Plot

Manhattan Distance

The Manhattan distance, also known as the City-Block distance, is the total of all distances measured along each dimension. This distance measurement corresponds to the travel distance between two points. Using the formula:

$$\|a-b\|_1 = \sum_i |a_i - b_i|$$

(2)

The Manhattan distance is used in this work's cluster analysis computation.

Ward's Linkage Criterion

The distance between clusters is computed using the linkage criterion, which determines how clusters should be formed. Ward's methods is a hierarchical cluster analysis criterion. Ward's minimum variance method is a subset of Joe H. Ward, Jr.'s objective function approach, which he first presented in 1963. Ward proposed a general agglomerative hierarchical clustering procedure in which the criterion for selecting which pair of clusters to merge at each step is the optimal value of an objective function. Ward's minimum variance criterion reduces the total within-cluster variance to a minimum. At each step, the pair of clusters with the shortest cluster distance is merged.

$$d_{ij}=d(\{X_i\},\{X_j\})=\|X_i - X_j\|^2 \quad (3)$$

This method differs from others in that it employs an analysis of variance approach to determining the distances between clusters. In general, this method is thought to be very efficient.

Exclusion Criteria

The exclusion criteria are the characteristics used to identify potential research participants who should not be included in this study. This study's exclusion criteria include ethical considerations such as being a minor or being unable to provide informed consent, practical considerations such as being unable to read and write, medical conditions, and pregnancy.

Results

To investigate the spatial structure of HIV prevalence rates in Sub-Saharan Africa, countries with similar prevalence rates were grouped into clusters. Table 1 displays descriptive statistics for each year in all Sub-Saharan African countries. The prevalence of HIV/AIDS increased steadily from 1990 (6.74) to 1995 (9.13), after which it began to decline to (2.60) in 2018.

The summary result of the clustered analysis is shown in Table 2. From the 44 observations provided, this procedure generated three clusters. The clusters are groups of observations that have similar properties. The procedure began with each observation in a separate group to form the clusters. It then combined the two observations that were the most closely related to form a new group. The two groups that were closest together were combined after recalculating the distance between them. This process was repeated until there were only three groups left.

Examine the Agglomeration Distance Plot in Figures 3 and 4 to determine a reasonable number of clusters.

Table 3 shows the cluster to which each observation belongs. Only Lesotho and Eswatini are members of the third cluster. South Africa, Zambia, Zimbabwe, Namibia, Malawi, Mozambique, and Botswana are among the countries with the highest HIV/AIDS prevalence over the course of the study. The rest of the world is divided into two groups.

Figures 5 and 6 show banner plots, which are an alternative to dendograms. Although interpreting the banner plot would result in the same conclusion, we preferred the dendogram. It depicts the formation of the three clusters. The plot's columns show how the observations were divided into a specific number of clusters. An unbroken string of Xs connects all cluster members in that column. A row devoid of an X denotes a break between two clusters.

The agglomeration schedule is shown in Table 4. It demonstrates which observations were combined at which stages of the clustering process. In the first stage, for example, observation 25 was combined with observation 35. When the groups were combined, the distance between them was 0.0527855. It also demonstrates that the fourth stage was where this combined group was further combined with another cluster.

Discussion

The prevalence of HIV/AIDS increased steadily from 1990 (6.74) to 1995 (9.13), after which it began to decline to (2.60) in 2018. From the 44 observations provided, the analysis generated three clusters. The clusters are groups of observations that have similar properties. The procedure began with each observation in a separate group to form the clusters. It then combined the two observations that were the most closely related to form a new group. The two groups that were closest together were combined after recalculating the distance between them. This process was repeated until there were only three groups left. Only Lesotho and Eswatini are members of the third cluster. South Africa, Zambia, Zimbabwe, Namibia, Malawi, Mozambique, and Botswana are among the countries with the highest HIV/AIDS prevalence over the course of the study. The findings of (26, 27) confirm that all other countries fall into the first cluster.

To combat HIV infection in Sub-Saharan Africa, both governments and the international community must commit to long-term sustained efforts and planning. Furthermore, any successful HIV prevention campaign in the past must be replicated and scaled up, particularly in line with the 2015 WHO vision. This article has presented the current trends of HIV, the interacting variables that have contributed to the improvement of HIV/AIDS in Sub-Saharan Africa, and healthy living. The region's high prevalence of HIV/AIDS has had an unprecedented impact. Understanding the variables that have influenced the path of the HIV/AIDS scourge is therefore critical for Sub-Saharan Africa, both in terms of humanitarian and economic aspects, because it is a long way from eradicating the virus. Amuche (28) confirms that HIV continues to spread throughout Sub-Saharan African countries, accompanied by increasing challenges due to poverty and poor healthcare service in various communities and localities throughout Sub-Saharan Africa. The HIV/AIDS epidemic has had a negative impact on Sub-Saharan Africa's development and has contributed to discrimination against those living on the outskirts of society or those who are at risk of contracting the virus due to their behaviors, race, ethnicity, gender, sexual orientation, or social characteristics. It has been demonstrated that the HIV/AIDS epidemic is deeply rooted in human behavior, driven by cultural, economic, and social factors that must be identified and possibly eradicated.

Conclusion

This article has examined the countries that could be considered in the same category, as well as the concentration of diseases in relation to the socioeconomic status of Sub-Saharan African countries. The region's high prevalence of HIV/AIDS has had an unprecedented impact. As a result, studying the variables that have influenced the path of the HIV/AIDS scourge is an important stake, both on a local and international level in Sub-Saharan Africa, because it is a far step toward eradicating the virus. Even though the epidemic in this region has advanced, and contrary to popular belief, it is still not too late to take concrete action. A careful consideration of how gender, culture, and race, as well as other discussed factors, interact to influence risk perceptions and risk behaviors is required for effective prevention and education programs to work.

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