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A Geographical Analysis of HIV/AIDS Infection in Nigeria, 1991–2001

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Objectives: Within the extensive literature accumulating on HIV/AIDS in Nigeria, investigations concerning the spatial dimensions of the infection are virtually nonexistent. An understanding of the spatial dimensions of the HIV/AIDS epidemic is central to the development and implementation of appropriate intervention strategies. This study is a geographic analysis of HIV/AIDS infection in Nigeria from 1991 to 2001. The three objectives of this study were (1) to determine the geographic pattern of HIV prevalence rates in Nigeria, from 1991 to 2001 (2) to determine if the observed pattern of the epidemic is influenced by transportation factors, and (3) to examine the diffusion pattern of the epidemic.
Methods: Data was spruced from HIV/AIDS sentinel surveys conducted in Nigeria 1991–2001. Data analyses involved descriptive cartographic analysis, spatial autocorrelation analysis, spatial-temporal analysis, and comparative data analysis.
Results: Geographic analyses revealed distinctive regional differences in the spatial pattern and intensity of HIV/AIDS infection within the country. Spatial autocorrelation analyses indicated that HIV/AIDS rates were strongly autocorrelated. The epidemic's epicenter was located in a narrow contiguous band bypassed by a major highway in the eastern part of the country. The diffusion processes indicated a general trend of increasing spread to rural Nigeria.
Conclusion: This study provides one of the first in-depth geographic analyses of the HIV/AIDS infection in Nigeria in the first decade of the epidemic. More detailed and comprehensive HIV/AIDS data is required for further study of the spatial epidemiology of the infection.

Keywords: *epidemiology, HIV/AIDS, Nigeria*

Introduction

After two decades of fighting the HIV/AIDS epidemic in Nigeria, results from national HIV/AIDS surveillance program show that the HIV/AIDS prevalence rate in the country has declined. The Federal Ministry of Health (FMOH) reports that the national HIV/AIDS rate rose from 1.8% in 1991 to 5.8% in 2001(Federal Ministry of Health [FMOH], 2004). The rate fell to 5.0% in 2003 and then to 4.4% in 2005 (FMOH, 2004, 2006).

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Currently, the HIV/AIDS prevalence rate in Nigeria is 3.6% and approximately 3.3 million people are living with the infection (United Nations Joint Program on HIV/AIDS, 2009). Although these numbers indicate that the epidemic appears to be in a decline, it is important to note that millions of people are already infected and thousands, especially young people, remain at very high risk of contracting the disease. This situation calls for further research on the factors underlying the spread of the epidemic in the country.

Within the extensive literature accumulating on the HIV/AIDS epidemic in Nigeria, investigations concerning the spatial dimensions of the infection are virtually nonexistent. Most studies on the spread of HIV/AIDS in Nigeria have focused on investigating the prevalence of behavioral risk factors associated with the spread of the infection in small sociogeographic areas (see Obidoa, M'Lan, & Schensul, 2012; Fatusi &Wang, 2009; Akinwande & Brieger, 2006). Although these studies provide useful information on the risk behaviors associated with HIV/AIDS in Nigeria, they do not provide much information regarding the spatial epidemiology and the processes underlying the spread of the infection in the country.

An understanding of the spatial dimensions of the epidemic is central to the development and implementation of appropriate intervention strategies. The examination of the spatial epidemiology of the epidemic will provide valuable insight on the social, economic, political, cultural, population, and demographic dynamics that shape the pattern and progression of the epidemic. The knowledge obtained by studying the processes underlying the spread of the infection will assist with identifying where to channel prevention/intervention efforts and resources. Ultimately, in-depth study of the spatial epidemiology of the epidemic will help tell the story of the HIV/AIDS epidemic.

This study is a geographical analysis of the HIV/AIDS epidemic in Nigeria. It examines the geographic pattern, spatial diffusion, and spatial/temporal trend of the infection and explores the possible factors that explain the pattern of the infection in the country from 1991 to 2001. This time period is very important in the history of the Nigerian HIV/AIDS epidemic because it represents the first decade of the HIV/AIDS surveillance and monitoring in the country. Lessons learned from this study will provide background information on the recent history of the HIV/AIDS epidemic in Nigeria.

Background of Study

HIV/AIDS, unlike many other infectious diseases, has a significant spatial component. The spatial epidemiology of the disease varies remarkably across the world, making the study of its spatial aspects intimidating. Geographical investigations on the spread of the epidemic have, however, led to a better understanding of the spatial dimensions of the disease. Geographical studies on the spatial epidemiology of this infectious disease have been focused on identifying its geographic pattern, agents of diffusion, and spatial-temporal inclination. This section presents a brief review of some of these studies.

Geographers began by describing the global patterns of the infection. Wood (1988), in his pioneer work on the diffusion patterns of HIV/AIDS, identified three major global patterns of the epidemic, which he referred to as AIDS North, AIDS South, and AIDS North/South. The descriptions of these patterns were based on the way the epidemic had evolved in the different regions in the world. According to Wood (1988), the AIDS North pattern was primarily predominant in the wealthiest regions of the world (North America and Europe), with the highest number of reported cases of HIV/AIDS. In these areas, HIV/AIDS was more prevalent among homosexuals and intravenous drug users, and was most common in the urban areas.

The AIDS South pattern encompassed the poorest countries in the world; Central Africa and the Caribbean were the most affected areas. In these regions, the highest HIV/AIDS cases were recorded among mobile heterosexuals, urban elites, truck drivers, and prostitutes (Wood, 1988). The AIDS North/South pattern is a hybrid of the two initial patterns. Further classifications of the global pattern of the HIV/AIDS pandemic during its first decade by Piot et al. (1988); Shannon, Pyle, and Bashshur (1991); and Smallman-Raynor, Cliff, and Haggett (1992) were very similar to Wood's (1988) classification.

Results from research carried out by geographers on the spatial diffusion of HIV/AIDS reveal that HIV/AIDS diffuses in two main patterns, namely hierarchically and contagiously. In the hierarchical diffusion pattern, AIDS diffuses in an ordered sequence affecting major urban areas or big cities, while the contagious or expansive diffusion process involves the spread of the infection from an epidemic epicenter to surrounding areas (Wood, 1988; Gould, 1993; Loytonen, 1991; Gardner et al., 1989; Lam, Fan, & Liu, 1996). Abler, Adams, and Gould (1970), however, assert that at regional or larger scales, spatial diffusion processes are characterized by a combination of hierarchical and contagious diffusion with variation in time of the elements of the two diffusion patterns.

Wood (1988) identified that in the AIDS South diffusion pattern, AIDS diffuses from urban areas with high numbers of people at risk of contracting HIV/AIDS to small truck or market towns along major highways, then to villages housing people commuting to towns or cities. In the AIDS North/South pattern, the disease diffuses from urban areas with people at risk of contracting HIV/AIDS to other urban areas that have strong international connections. It then diffuses across international boundaries to urban areas that also have strong international connections and people at risk of contracting HIV/AIDS. The infection subsequently diffuses to a small market town or city along a major highway, then to another urban area and to a village with migrants commuting to cities and towns as well.

Most empirical studies on the spatial-temporal spread of HIV/AIDS have been carried out in the United States. Findings from these studies collectively point out, "The epidemic follows a classical, albeit complex spatial diffusion pattern [that] is characterized by a combination of the hierarchical and expansion patterns" (Golub, Gorr, & Gould, 1993, p. 86). Similar findings have also been made regarding the pattern of diffusion of the HIV/AIDS epidemic in other parts of the world. Loytonen (1991)—in his work on the spatial diffusion of immunodeficiency virus type 1 in Finland from 1982 to 1997—identified that the epidemic diffused hierarchically in its initial stages. Ouma (1996), who worked on the spatial-temporal diffusion of HIV/AIDS in Kenya from 1986 to 1993, pointed out that the epidemic spread hierarchically from Nairobi, the biggest city in Kenya, to Mombassa, the second biggest city, and then to Kisumu. She noted that the epidemic subsequently spread both hierarchically and contagiously as it progressed.

These studies collectively show that the spread of HIV/AIDS over a geographic area occurs in phases: the first phase is characterized by the hierarchical spread of the infection from urban areas to other urban areas, and a second phase is marked by the contagious spread of the epidemic to areas close to the epidemic focus. Gould (1993) reports that local diffusion follows a similar pattern. A linear diffusion—in which transportation routes and infrastructures aiding population mobility play very crucial roles in the spread of the disease—is more evident. Air, road, rail, and water transport present varying risks for the spread of HIV/AIDS from one geographic location to another. The movement of large numbers of people along transport networks facilitates the spread of HIV/AIDS from a high intensity area to a low HIV/AIDS intensity area. Population mobility has, therefore, been identified as a major predictor of the spread of the infection throughout the world.

In most developing countries and in smaller geographic spaces in developed countries, road transportation has been associated with the spread of HIV/AIDS. For example, in Thailand, the transportation network has played a very dramatic role in shaping the pattern of the plague in the country. The pattern of the HIV/AIDS infection in Thailand is characterized by high prevalence rates in urban and rural area and subsequently areas of moderate prevalence rates strongly following the pattern of circulation of the major roads and rivers throughout the country (Gould, 1993). In sub-Saharan Africa, transportation routes have also been identified as crucial passageways for the spread of HIV/AIDS (Wood, 1988; Gould, 1993; Shannon, Pyle, & Bashshur, 1991).

Research conducted in different parts of the world on the spread of HIV/AIDS, however, have shown that the movement of people along transportation networks does not exclusively determine the pattern or rate of spread of the HIV/AIDS epidemic (Caldwell & Caldwell, 1993; Gould, 1993; Cohen & Trusell, 1996; Setel, Lewis, & Lyons, 1999). The global variation in the pattern of HIV/AIDS transmission has been shaped (to a large extent) by a combination of social and economic changes occurring at both global and local scales. Such changes have been attributed to the effects of globalization. As a multidimensional phenomenon, globalization continues to foster the intensification of economic, social, and cultural interconnectedness across the globe, consequently shaping and reshaping livelihoods throughout the world. Globalization has not only played roles in determining the spread of the epidemic in different parts of the world, but has also contributed significantly in determining the factors that shape HIV/AIDS risk in sub-Saharan Africa (Obidoa, 2010); Kalipeni, Oppong, & Ghosh, 2008; Friedman, Rossi, & Phaswana-Mafuya, 2008).

While geographic research on the spatial aspects of the HIV/AIDS pandemic have focused on the patterns of diffusion of the disease at the global scale, very sketchy work exists on the spatial patterns and diffusion of HIV/AIDS at local scales or in smaller geographic spaces. Numerous studies have been conducted on the factors associated with the spread of HIV/AIDS in sub-Saharan Africa, but little or nothing exists on the spatial diffusion of HIV/AIDS in the region. This study, as an exploratory work, examines the spatial dimensions of the HIV/AIDS epidemic in Nigeria. Findings from this study will provide pertinent knowledge not only on the spatial epidemiology of the HIV/AIDS epidemic in Nigeria, but will also serve as an example of how the epidemic has evolved in West Africa.

Data

HIV Data

The HIV data used in this study comes from the different sentinel surveys carried out by the National Agency for the Control of AIDS under the FMOH in Nigeria. Sentinel surveys are cross-sectional surveys conducted among pregnant women attending antenatal clinics in selected antenatal sites. Blood samples are collected form a random sample of pregnant women who meet the eligibility criteria at the antenatal clinics. The blood samples are subsequently tested for HIV. The HIV prevalence rates for states are computed by aggregating the results from the selected sentinel sites. The HIV/AIDS surveillance sentinel system using pregnant women attending antenatal clinics is the primary system through which the HIV epidemic is monitored in the African region. This method of HIV surveillance was recommended by the World Health Organization and the United Nations Joint Program on HIV/AIDS and has been identified as an appropriate method for estimating the prevalence of HIV/AIDS in the population. The Nigerian sentinel surveys have been carried out among pregnant women aged 15–49 years attending antenatal clinics in selected sites. The FMOH sentinel surveys were carried out in 1991, 1993/94, 1995/96, 1999, 2000, and 2001. Prior to 1999, the sentinel surveys were carried out in selected states.

The Nigerian HIV/AIDS surveillance system has also included other target groups: commercial sex workers, tuberculosis patients, sexually transmitted disease patients, and long-distance truck drivers. Summary statistics for these surveys are shown in Table 1.

Table 1: *Summary of HIV/AIDS Surveillance Activity in Nigeria, 1991–2001*

Year	# of States	Sample Size	Sample Population	# Positive	HIV/AIDS Rate %
1991/92	11	11,907	CSW, TB, ANC, STD	482	1.4
1993/94	16	22,589	CSW, TB, ANC, LDTD, STD	1,470	3.8
1995/96	17	23,401	CSW, TB, STD, ANC	2,133	4.5
1999	37	20,989	ANC	1,118	5.4
2000	12	4,948	STD, TB	798	17.0/11.5
2001	37	24,243	ANC	1,388	5.8

Note: CSW: commercial sex workers, TB: tuberculosis patients, ANC: antenatal clinic attendees, STD: sexually transmitted disease patients, LDTD: long-distance truck drivers. Sources: FMOH, 1995, 1997, 1999, 2000, 2001.

Geographic Data

Digital geographic data, which includes shapefiles for states and major rivers in Nigeria and the Nigeria country boundary map, were obtained from the Environmental Systems Research Institute. The road network map was digitized manually.

Methods

There were three objectives for this study: (1) to determine the geographic pattern of the HIV prevalence rates in Nigeria, (2) to determine if the observed pattern of the epidemic is influenced by transportation factors, and (3) to examine the diffusion pattern of the epidemic.

The geographic pattern of HIV prevalence rates in Nigeria was examined both qualitatively and quantitatively. Descriptive/cartographic analyses were employed to describe the pattern of HIV prevalence rates. These analyses involved mapping the HIV prevalence rates at the state level and describing their pattern. Spatial autocorrelation analyses were conducted subsequently to ascertain if the HIV rates are significantly clustered or randomly distributed at the state level across the country. The results show a positive or negative correlation in the distribution of HIV prevalence rates at the state level. For this analysis, the Moran's index was computed for spatial weight matrix based on the adjusted first-order contiguity (based on the closest neighbor or common boundary) using S-Plus in ArcView, GIS (geographic information systems). This analysis was performed for the geographic distribution of HIV rates for 1999 and 2001 respectively.

Local indicators of spatial association were computed to identify local patterns of spatial association or local pockets of nonstationarity, usually called hotspots. In an attempt to identify the epicenter (hottest spots) of HIV infection in Nigeria during its first decade, indices of the G(d)* statistic were computed for the 1999 and 2001 HIV rates. The G(d)* statistic, described by Getis and Ord (1992), "measures the degree of association that results from the concentration of weighted points (or area represented by a weighted point) and all other weighted points included within a radius of distance (d) from the original weighted point" (p. 190). This analysis is used to test if there is a significant degree of clustering in the distribution of phenomena as well as to uncover isolated hotspots of increased incidence for any occurrence. Positive values indicate spatial clustering of high values, whereas negative values show the spatial clustering of low values (Anselin, 1995). For this analysis, three distance bands were tested: 100km, 150km, and 200km; however, only the 200km band was used because it was the only distance within which all parts of Nigeria could be included. This statistical test was carried out using the HIV rates from the 1999 and 2001 sentinel surveys.

Statistical analyses were performed to determine if the major rivers and the major highway network in Nigeria could help to explain the spatial and regional variation of HIV/AIDS infection in Nigeria. A two-way ANOVA was conducted to ascertain if states that had a major highway passing through them had higher HIV rates than other states, and if the states that had a major river passing through them had higher HIV rates than states without a major river. The influence of these transportation routes was quantified based on a presence/absence criterion.

Diffusion analysis focused on determining if there was significant spatial-temporal change in the pattern of HIV infection in Nigeria over a period of two years (1999–2001). For this analysis, line graphs were plotted to compare the temporal changes in HIV prevalence rates between the rural and urban areas. The results of the spatial diffusion of HIV rates in different geographic areas in Nigeria were evaluated against the HIV/AIDS spatial diffusion model.

All mapping and spatial statistical analyses were conducted using the ArcView GIS software. The ANOVA was performed in SPSS (Statistical Package for the Social Sciences; IBM).

Results

Spatial Pattern of HIV/AIDS in Nigeria

In 1991, the sentinel survey was carried out in only 11 states in Nigeria. In 1993, it was carried out in 16 states, and in 1995, the survey was conducted in 20 states. It is difficult to identify any marked pattern in the 1991 state HIV prevalence rates (see Figure 1). In 1993, the highest HIV rates were recorded in states in the northeast, central, and southeastern parts of the country.

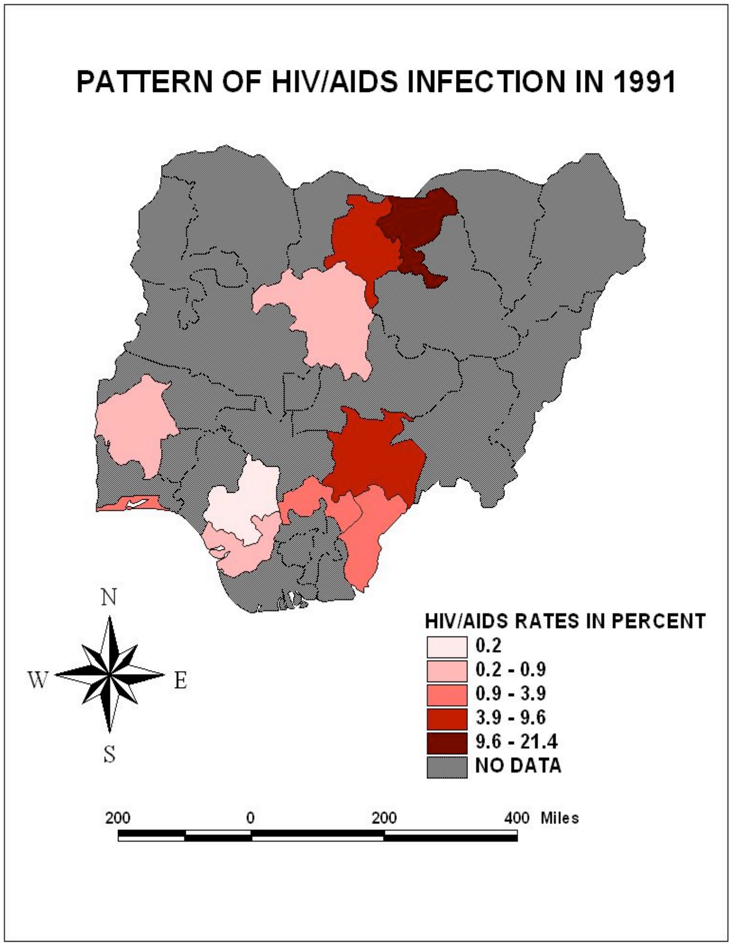

Figure 1: *Pattern of HIV/AIDS Infection in 1991 (Data source: FMOH, 1995)*

The pattern of the epidemic in 1995/96 is somewhat similar to that of 1993/94. Despite the fact that this survey was conducted in only 20 states (by this time there were 37 states in the country), the same spatial pattern of infection was observed (see Figures 2 and 3). Once again, the highest rates were recorded in states in the northeast and southeast, while the lowest rates were recorded in states in the southwest.

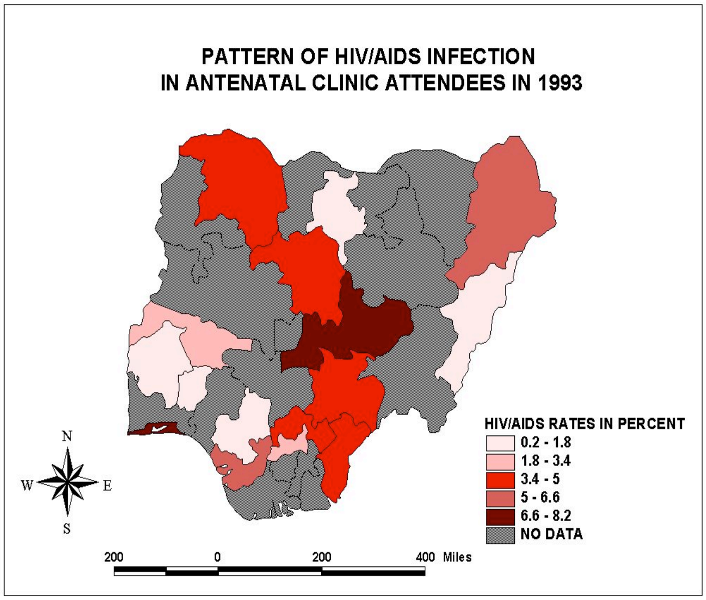

Figure 2: *Pattern of HIV/AIDS Infection in Antenatal Clinic Attendees in 1993 (Data source: FMOH, 1995)*

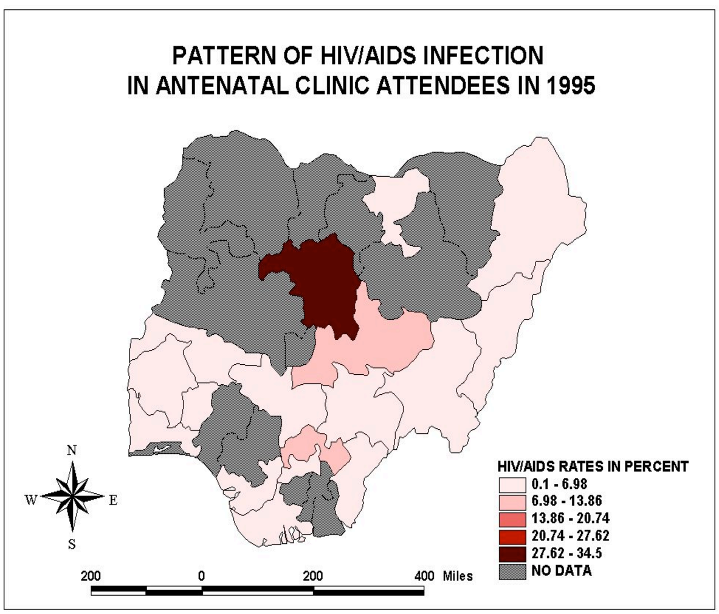

Figure 3: *Pattern of HIV/AIDS Infection in Antenatal Clinic Attendees in 1995 (Data source: FMOH, 1997)*

The spatial pattern of the HIV/AIDS epidemic in Nigeria is inferred from HIV prevalence rates reported in the 1999 and 2001 sentinel surveys. Figures 4 and 5 show a marked regional pattern in the spatial distribution of HIV prevalence rates in Nigeria in those two years.

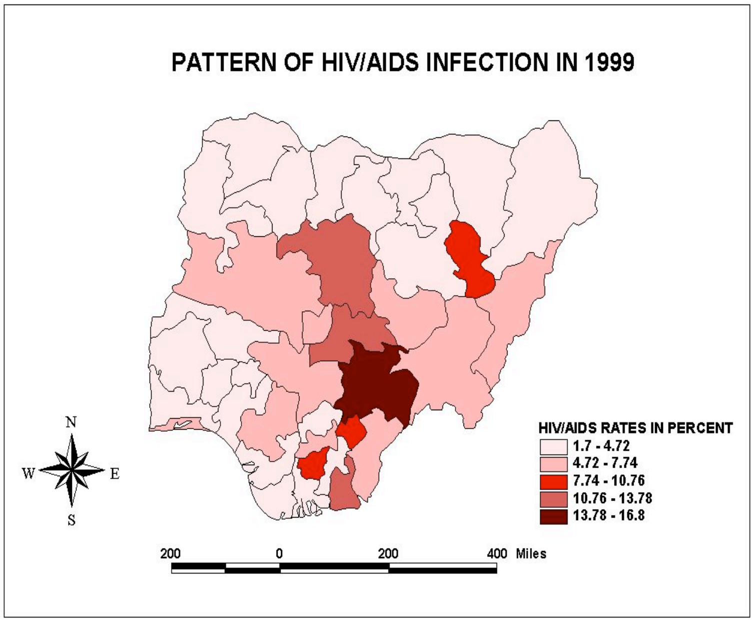

Figure 4: *Pattern of HIV/AIDS infection in 1999 (Data source: FMOH, 1999)*

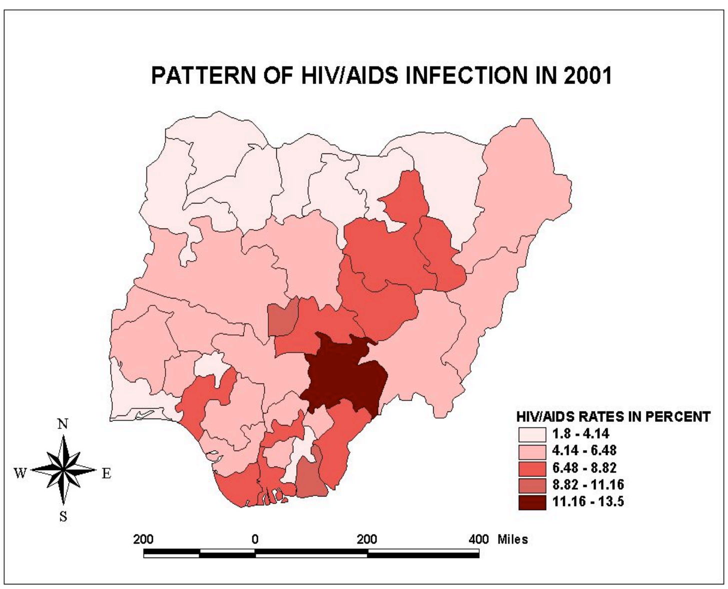

Figure 5: *Pattern of HIV/AIDS infection in 2001 (Data source: FMOH, 2001)*

Higher rates of HIV were clustered in the central and southeastern parts of the country in both 1999 and 2001. In 1999, the highest rates were recorded in the states of Kaduna, Benue, Nasarawa, and Akwa Ibom. Relatively high rates were also recorded in Ebonyi, Gombe, the Federal Capital Territory, and Imo. These states are all located in the central and southeastern part of the country. The lowest rates were recorded in states in the north and some in the southwest. The spatial distribution of HIV rates in 2001 also indicates that the highest rates were recorded in Benue, the Federal Capital Territory, Plateau, and Akwa Ibom, while the lowest rates were recorded in Sokoto, Jigawa, Abia, and Ekiti. Once again, infection rates were higher in the central and southeastern parts of Nigeria. This consistent pattern of HIV infection in Nigeria over these years raises questions about the factors that are responsible for the point of adoption, transmission and spread of the infection in the country.

Results from the spatial autocorrelation analysis showed normal Z (standardized) values of 5.405 (p = .004) for 1999 and 5.479 (p = .005) for 2001. These positive and significant standard normal Z values provide strong evidence of both strong and positive spatial autocorrelation. These results indicate that HIV rates are strongly spatially autocorrelated over small spatial scales as well as on a large spatial scale. This shows that a positive and direct relationship exists between HIV/AIDS rates at the state level, revealing that spatial contiguity (sharing a similar boundary) plays a very important role in the spread of HIV/AIDS in Nigeria.

Hotspot Analysis

Results from the hotspot analysis (shown in Figure 6) reveal that there is a significant spatial clustering of both high and low values in 1999 and 2001. The values of the Z(G*) range from –2 to +4. Some of the Z(G*) scores are significant at the .05 level of significance. Significant clustering of high values as well as low values can easily be discerned by a simple visual analysis of the map (see Figure 6).

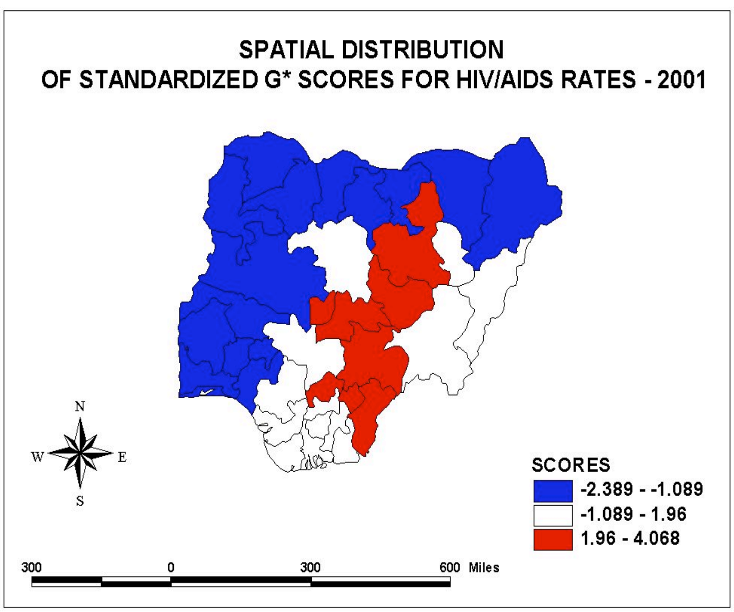

Figure 6: *Pattern of G(d)* Statistics (Data source: Results from G[d]* analysis)*

The highest values were recorded in states in a contiguous band stretching from the north-central area, through some parts of the central region, and down to the southeastern parts of the country. Most of these states display numbers greater than 1.96 (see Figure 6). This area can be considered the hottest (most affected) area of HIV infection. States with values less than –1.089 are clustered in the southwestern, northwestern, and northeastern parts of the country. The spatial pattern of Z(G*) values observed in 1999 is slightly different from that observed in 2001. In 1999 (map not shown), the clustering of high values was observed in 13 states in a contiguous band located in the eastern part of the country. These areas recorded HIV rates above the expected rate. In the southwest, northwest, and northeast, states recorded values lower than expected, while only eight states randomly distributed across the country recorded expected HIV prevalence rates. In 2001, however, more states recorded HIV rates above the expected values and fewer states recorded expected HIV rates. Of the states that recorded HIV rates above the expected (i.e., an increase in HIV rates) in 2001, all share boundaries with states that originally recorded HIV rates above the expected in 1999.

This observed spatial-temporal change in HIV rates is indicative of contagious diffusion of HIV. The similar borders shared by states in these two categories are indicative of a strong regional pattern of the HIV infection in Nigeria. Generally, HIV infection is concentrated in the eastern part of the country. Based on the spatial distribution of these values, it can be implied that in Nigeria, one is either in an HIV hotspot or not.

In summary, this spatial autocorrelation and cluster analysis confirms the findings made in the cartographic analysis. Apart from confirming that there is a significant pattern in distribution of HIV prevalence rates in Nigeria, results from this analysis suggest that the pattern of the infection did not change significantly, either spatially or temporally between 1999 and 2001.

Transport Analysis

Results from the ANOVA (see Table 2) show that states with major highways passing through them, as well as states bordering major rivers, do not have statistically higher HIV rates than states that do not have these major transport routes. When the map showing the pattern of HIV/AIDS clustering (Z scores from the hotspot analysis) is overlaid with the major highway network map, however, one can observe that the major highway in the eastern part of the country that connects the southeast region with the central, north-central, and northeast regions passes through the epicenter (i.e., hottest area) of the epidemic (see Figure 7).

Table 2: *ANOVA Analysis of Transport Routes*

Source	Type III Sum of Squares	*df*	Mean Square	*F*	Sig.	Partial Eta Squared
Corrected Model	30.681	5				
Intercept	499.982	1				
Rivers	11.041	1	6.136			
Highways	.347	2	499.982	1.011	.428	.140
Rivers x Highways	6.123	2	11.041	82.370	.000	.727
Error	188.169	31	.173	1.819	.187	.055
Total	1402.810	37	3.062	.029	.972	.002
Corrected Total	218.851	36	6.070	.504	.609	.032

Although the mere presence of a major transport route is not sufficient for the spread of HIV/AIDS, the role major highways play in the spread of the HIV/AIDS epidemic in this region requires further investigation. It is important to note that HIV prevalence rates of 21.0% and 13.7% (the highest ever recorded in Nigeria from 1991 to 2001) were recorded in sentinel sites in Benue and Nasarawa. Some of the largest truck stops along this major highway can be found in these two states.

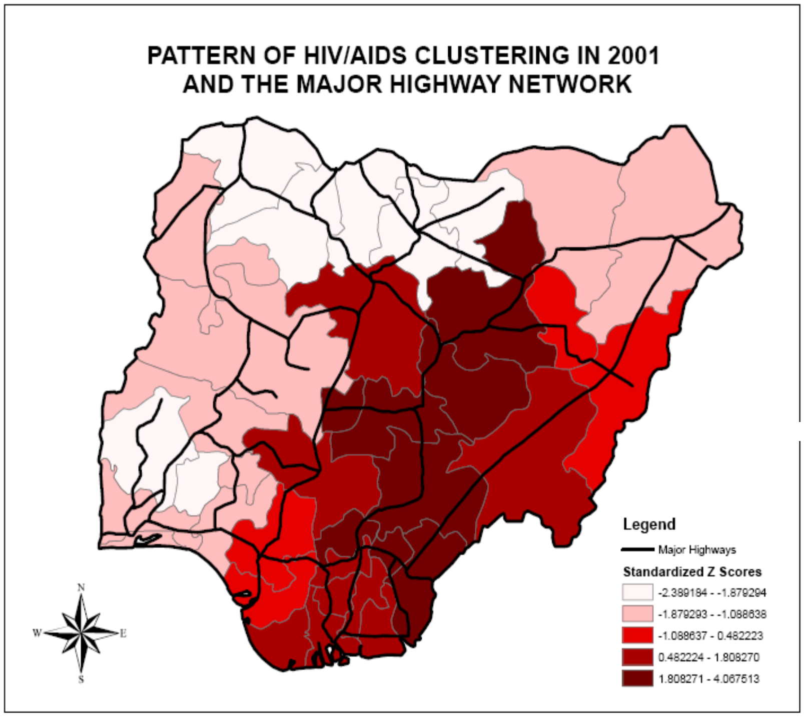

Figure 7: *Pattern of HIV/AIDS Clustering in 2001 and Major Highways (Data source: Standardized Z scores from hotspot analysis)*

Urban/Rural Diffusion

Urban and rural HIV prevalence rates in Nigeria were estimated by the FMOH for 1999 and 2001 based on the sentinel surveys conducted at various urban and rural sites. Fluctuations in infection rates were recorded in different parts of the country.

The overall urban HIV/AIDS prevalence rate in 1999 was listed at 5.7%, while the rural HIV prevalence rate was recorded as 4.6%. In 2001, urban and rural HIV prevalence rates increased to 5.9% and 6.0%, respectively. The increase in HIV prevalence rates in these areas confirms that there is a general increase in HIV infection rates across the country; however, a higher increase was recorded in the rural areas. Between 1999 and 2001, a 1.3% increase in rural HIV rates was recorded, while only a 0.3% increase was recorded in urban areas.

Urban and rural HIV rates increased in 14 states and decreased in only 6 states. Rural HIV rates increased in 9 states and decreased in 6, while urban HIV rates increased in 6 states and decreased in 9. Although the highest HIV rate (21.0%) in 1999 was recorded in a rural area, the infection was more evident in urban areas throughout the country (Figure 8). In 2001, however, HIV prevalence rates in rural areas increased substantially, exceeding urban HIV prevalence rates in 18 states (Figure 9).

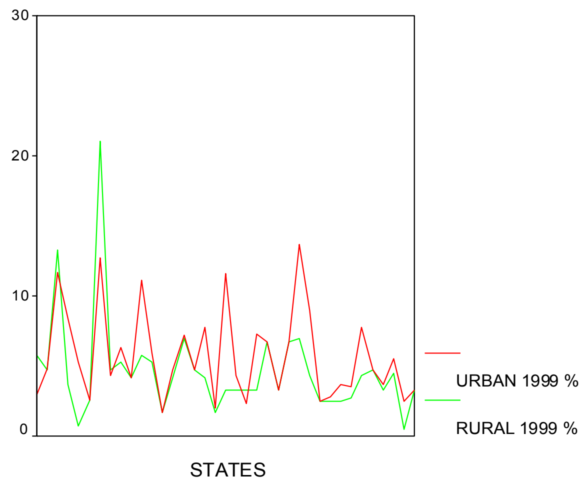

Figure 8: *Urban/ Rural HIV/AIDS Prevalence Rates in 1999 (Data source: FMOH, 2001)*

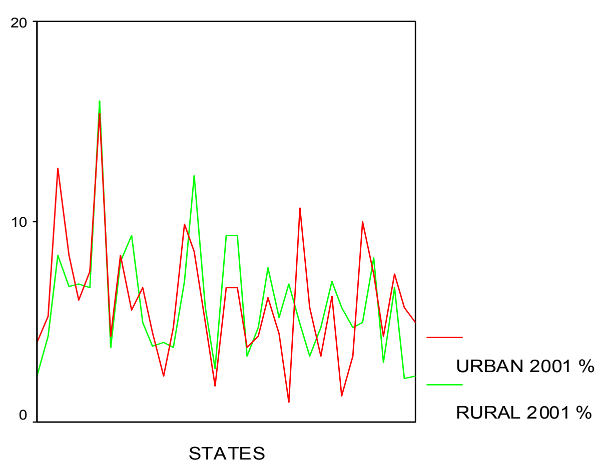

Figure 9: *Urban/Rural HIV/AIDS Prevalence Rates in 2001 (Data source: FMOH, 2001)*

The spatial-temporal variation of HIV prevalence rates in urban and rural areas provides some evidence indicating that the HIV/AIDS epidemic in the country initially diffused hierarchically. Despite the fact that the initial point of adoption of the epidemic in the Nigeria is unknown, the concentration of high HIV rates in urban areas in 1999 is indicative of a hierarchical diffusion pattern. In 2001, prevalence rates in rural areas increased noticeably, denoting a contagious process in the diffusion of the infection; therefore, the epidemic seems to be following a spatial diffusion pattern similar to that identified in other countries in the world.

Discussion and Implications of Results

Results from HIV/AIDS surveillance activities in Nigeria reveal that the Nigerian HIV/AIDS epidemic is a mature epidemic, which became generalized (rates exceeded 1% in all states) long before 1999. Given the spatial extent of the epidemic, understanding the processes that have shaped the geographic spread of the infection throughout the nation is crucial for comprehensive and sustainable response to the epidemic at the national scale.

Spatial analysis conducted in this study revealed that the infection followed a marked regional and spatial pattern in its first decade in Nigeria. This pattern was characterized by a concentration of high HIV rates in the central and southeastern regions and relatively low rates in the northern and southwestern regions of the country. The epicenter of the epidemic was located in a narrow contiguous band stretching from the north-central region through some parts of central region and down to the southeastern parts of the country. This area cuts across ethnic, cultural, administrative, regional, and environmental/physical boundaries, indicating that the forces propelling the epidemic are not regionally, culturally, or environmentally constrained. The epidemic diffused hierarchically and contagiously, and the geographic range of HIV infection in Nigeria increased steadily, particularly across the northeastern and southeastern parts of the country.

Despite the fact that there was no statistically significant link between the major highways or the river systems and HIV prevalence rates at the state level, the role these transportation routes play in influencing the overall pattern of the infection in the country requires further investigation. The clustering of high rates in a narrow contiguous band following the direction of a major highway in the eastern part of the country raises many questions about activities that may have facilitated the spread of the epidemic in that region. Research efforts aimed at exploring the role of major highways in the spread of HIV/AIDS in this region should be multidisciplinary in scope, examining how historical events have shaped socioeconomic, sociopolitical, and sociocultural processes in this part of the country. These factors are important predictors of HIV/AIDS spread in any geographic space.

Studies carried out in other parts of sub-Saharan Africa have identified long-distance truck drivers and commercial sex workers as major agents in the spread of the epidemic along highways. HIV/AIDS intervention programming should therefore continue to focus on reducing HIV risk in these populations—not just within the epicenter of the epidemic, but throughout the country. Such programs should be comprehensive in nature, combining HIV/AIDS prevention and transmission education with programs that address economic empowerment for women and unemployment among young people.

The rapid expansion of the epidemic into the rural areas also requires attention. The majority of the HIV/AIDS prevention and intervention activities have taken place in urban areas, while more remote, underdeveloped parts of the country have been left out. Since a greater proportion of Nigeria's population lives in rural areas and HIV/AIDS prevalence rates are higher in rural sites than urban sites in many states, it is recommended that location- and population-specific HIV/AIDS information, education, and communication programs be extended to rural areas.

The unavailability of adequate and complete HIV/AIDS data in the country constrains the effort to provide comprehensive analysis of the epidemic in Nigeria. A major implication of this shortcoming is the inability of experts to conduct in-depth spatial epidemiological analyses (including spatial pattern analysis, diffusion analysis, and associative/predictive analysis) of the epidemic. Consequently, our understanding of the nature and characteristics of the Nigerian HIV/AIDS epidemic has been insufficient.

Despite the limitations created by data inadequacies encountered in this study, some inferences regarding the geographic pattern of the disease have been made with implications for efforts towards curtailing the further spread of the epidemic in Nigeria.

Conclusion

This research was an exploratory study aimed at providing a geographical assessment of the HIV/AIDS infection in Nigeria from 1991 to 2001. As the most populous country in the region of the world most affected by the HIV/AIDS pandemic, there remains a large potential for a cataclysmic health disaster—yet data regarding the spread of this disease in Nigeria is spotty. Results from this study emphasize the need for better data collection and storage in Nigeria. Until adequate and better quality data are collected at the proper unit level, it will be very difficult to carry out an in-depth analysis of HIV/AIDS infection in Nigeria. This study provides a springboard for further research on HIV/AIDS in Nigeria. As the Nigerian HIV/AIDS epidemic enters its third decade, it is hoped that the study of the second phase of HIV/AIDS surveillance 2001–2011, as well as future studies on the spatial epidemiology of the disease, will provide more knowledge on how the epidemic has progressed over time and possibly provide insight on how to monitor and reverse the epidemic.

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