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Research Article

Aggregating Loss to Follow-Up Behavior in People Living With HIV on ART: A Cluster Analysis Using Unsupervised Machine Learning Algorithm in R

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ABSTRACT

Background: This study aimed to aggregate Loss to Follow Up (LTFU) behavior in People Living with HIV (PLHIV) into clusters to examine and describe PLHIV clusters havings similar characteristics and patterns according to their risk profile.

Objectives/methods: This was a retrospective, cross-sectional study that randomly reviewed 11,589 records of LTFU adult patients initiated on first-line ART from 313 USAID/PEPFAR-supported HIV clinics spread across 5 of Nigeria's 6 geographical regions between July 1, 2008, and June 30, 2020. LTFU, was defined for PLHIV on ART as >28 days without an encounter since the last scheduled ART refill appointment. Using the Minkowski method and ward. D2 clustering technique for unsupervised machine learning algorithm "agglomerative hierarchical clustering" in R, we identified 6 clusters associated with patients LTFU behavior.

Results: Within the review period, 497,620 patients were ever enrolled on ART. 324,225 (65.2%) remained on treatment, 101,716 (20.4%) had an LTFU event captured, 36,021 (7.2%) were transferred out to other facilities, 25,633 (5.2%) died and 10,025 (2.0%) self-terminated treatment. Majority (66.7%) of the clusters consist of female LTFUs. LTFU doubled steadily by age among adolescents (15-19 years), but as age increased above 40-years the rate of LTFU decreased. High rate of LTFU was reflective of shorter duration on ART. Viral load test was low, with only half (50.0%) of the clusters having a documented viral load test result.

Conclusion: LTFU rates in HIV-positive patients receiving ART in our clinical sites have varied by the duration of ART, with rates declining in recent years.

Keywords: Loss to follow-up; Antiretroviral therapy; Hierarchical clustering; Viral load test; Nigeria

Abbreviations: LTFU: Loss to Follow Up; PLHIV: People Living with HIV; ART: Antiretroviral Therapy; MMD: Multi-Month Dispensing; WHO: World Health Organization; GIS: Geographic Information System; HRQoL: Health-Related Quality of Life; NAIIS: Nigeria HIV/AIDS Indicator and Impact Survey

INTRODUCTION

For both the individual and population-wide benefits of Antiretroviral Therapy (ART) to be realised, people with HIV need to be diagnosed promptly, to engage with HIV care, and to initiate and to adhere to lifelong therapy. The HIV continuum of care has become a widely used approach to describe the benchmark stages along the HIV care pathway to viral suppression. The rapid expansion of the utilization of ART has made a major contribution to enhancing the quality of life of People Living with HIV (PLHIV) [1]. Most of the efforts to combat the AIDS epidemic is focused on access to antiretroviral treatment. Patient adherence to the treatment and retention in care emerged as a critical concern for the health sector to achieve

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the optimal desired outcome of combined ART treatment regimen. Loss To Follow-Up (LTFU) of clients from ART negatively impacts on the immunological benefits of ART, increases AIDS related morbidity, mortality, and hospitalization. LTFU of patients from ART can result in serious consequences such as discontinuation of treatment, drug toxicity, treatment failure due to poor adherence, and drug resistance [2].

PLHIV who are taking lifelong ART with no clinical contact or ARV pick-up for greater than 28 days since their last expected clinical contact or ARV pick-up are labelled as LTFU, a general term that amalgamates several possible outcomes including death, stopped/refused treatment, and self-transfer to another clinic. Failure to account for the true outcomes of patients deemed LTFU leads to as much as five-fold underestimation of retention because silent (undocumented) transfers are not taken into account [3]. According to WHO's global update on ART, the average retention for people on ART decreases over time, from about 86% at 12 months to 72% at 60 months. Previous studies have documented some challenges related to tracing patients in HIV programmes in sub-Saharan Africa including organisational challenges, health worker shortages, and high costs which continue to limit the ability of HIV programmes to trace patients who are missing or LTFU. Any successful HIV program must target the right populations in the right places at the right times [4].

A myriad of factors that impact LTFU are well documented including those related to poverty e.g. lack of food or transportation, poor health communication, such as non-disclosure of HIV status, health systems inefficiencies such as drug stock-outs [5]. For example, the primary determinant for disrupting ART for 57% of confirmed LTFUs among PLHIVs in a Swaziland report was hunger and no transit funds to reach the health facility. Recent predictive analytical study explored potential parameters associated with LTFU in Malawi. The study reported that viral load, distance index, education, and presence of a maternal figure in the household were predictive of LTFU [6]. People Living with HIV (PLHIV), frequently contend with psychological and social issues which may affect their adherence to clinic visits and ART [7]. In these settings, apart from coping with the primary fears and distress of living with a life-threatening disease, discrimination and stigmatizing behaviour complicates their successful management [8].

The aim of our study was to include a representative sample of LTFUs among PLHIV into smaller, homogenous groups, named clusters, to identify which PLHIV, have similar characteristics and patterns according to their risk profile. In this paper, we employed the Exploratory Data Analysis (EDA) technique to maximize insights from our data and summarize loss to follow-up behavior among PLHIV. EDA is an approach for data analysis that employs a variety of techniques for summarizing and visualizing important characteristics of a dataset. This will be the first study to use the unsupervised machine learning algorithm "agglomerative hierarchical clustering" in R to aggregate and group demographic and clinical characteristics of patients reported as LTFU into clusters or distinct groups in Nigeria.

MATERIALS AND METHODS

Setting, design and population

Nigeria is organized into six geo-political regions, which encompass neighbouring states. The study was conducted in 16 focus states organized into 5 of the 6 geo-political regions excluding the South-East (Annex 1). At the time of the study, data from the South-East region was not available for analysis. The five geo-political regions and 16 states are North-central (Niger and Kwara), North-east (Adamawa, Borno, Bauchi and Yobe), North-West (Kano, Jigawa, Kebbi, Sokoto and Zamfara), South-South (Akwa Ibom, Bayelsa, Cross River and Edo) and South-West (Lagos). Under the national HIV treatment program, these states were prioritized for prevention and comprehensive HIV/AIDS treatment interventions due to the high population density, high HIV seroprevalence and the high number of PLHIV. This retrospective, cross-sectional study examined 12 years of data gathered from laboratory-confirmed HIV-infected adult patients (aged 15 years and older) who initiated first-line ART across three-hundred and thirteen HIV clinics in the 16 focus states. Precisely eleven percent of the total number of patients ever reported as LTFU between July 1, 2008 and June 30, 2020 were randomly selected and included in the analysis using simple random sampling technique in Microsoft Excel. The optimal sample size required for hierarchical clustering in R is 10% of the total eligible study population. All adult patients who were initiated on first-line ART and reported as LTFU by June 30, 2020 was the sampling frame.

Definition of variables and data collection

We define LTFU as patients with no clinical contact or Antiretroviral (ARV) drug pick-up for greater than 28 days since their last expected clinical contact or ARV pick-up by June 30, 2020. Clinical contact is defined as reporting to the clinic for ART pick-up or clinical assessment, or a documented community visit with a community health worker or peer from an ART refill group. Under the national HIV/AIDS treatment program, when a patient has missed their most recent expected clinical contact or ARV drug pick-up, the clinic or other related staff repeatedly attempts to re-engage the patient and return them to treatment. De-identified patient level data collected across ART health care facilities in the study areas was obtained from the Retention and Audit Determination Tool (RADET) and used for the analysis. RADET is an excel-based reporting tool for USAID/PEPFAR implementing partners in Nigeria to track the number and relevant information of clients on ART. The tool uses an appointment calendar to track clients' LTFU. The focus variables in the dataset were patient demographic characteristics (state, location of health facilities, sex, and age) and clinical characteristics (ART start date, last ARV pick up date, months of ARV refill, current ART regimen line, current viral load (c/ml), and current ART status). Georeferenced raster data from the 2013 National Demographic and Health Survey (NDHS) on household wealth index and maternal educational levels was obtained from the NASA Earth Science and Information System (ESDID) project [9] for spatial analysis. For household wealth index, DHS separates the categorical variables

into five wealth groups: Poorest, poorer, middle, richer, and richest, and for maternal educational levels into four groups namely, no education, primary, secondary, and higher [10].

Statistical analysis

Data was sorted, coded, transformed and exported to R version 4.0.2 for statistical analysis. Results were presented using charts, graphs, and tables. Descriptive statistics such as 5 number summary, mean, standard deviation, frequencies and percentages were used to summarize findings. We performed a GIS overlay analysis using ArcGIS v.10.8 to explore the spatial distribution of LTFUs in the study area. We used an agglomerative hierarchical clustering algorithm in R to classify a set of demographic and clinical characteristics of patients LTFU into subsets or clusters. Hierarchical clustering is one of the most popular clustering methods, a type of unsupervised machine learning technique used to look for similarities or dissimilarities among unlabelled data points (no predetermined set of classes). Unlike other data mining techniques or parametric statistical procedures, the original dataset doesn't need the distinct specification of a target variable (*i.e.*, the dependent variable) and, respectively, of predictor ones (independent variables). All variables have the same importance, because the analysis's goal is not to predict a certain value, but instead, to identify the presence of specific patterns or correlations among variables, to include the different variables or cases into more homogenous groups. To compute agglomerative hierarchical clustering in R, we executed five iterative stages. First, we reviewed the data frame to ensure that no missing data was present in the dataset. Second, the dataset was scaled (standardized) to make variables comparable. Scaling involved transforming the variables such that they have a mean zero (0) and standard deviation one (1). Third, we used the Minkowski distance metric to measure the dissimilarity values. Fourth, we specified the ward D2 cluster method and used the 'hclust' function in R to plot the dendogram. In hierarchical clustering, the dendrogram is a diagram used to visualize the relationship between clusters reflecting a tree-based approach. Finally, we used the aggregate function in R to summarize the profiles of LTFUs according to their means to their clusters.

RESULTS

Descriptive analysis of patient socio-demographic and clinical characteristics

Of all the 497,620 adult patients ever enrolled in first-line ART between July 1, 2008 and June 30, 2020, 324,225 (65.2%) remained on treatment, 101,716 (20.4%) had an LTFU event captured, 36,021 (7.2%) were transferred out to other facilities, 25,633 (5.2%) died and 10,025 (2.0%) stopped or self-terminated treatment (Annex 2). Of the overall 101,716 LTFU patients, approximately 11 percent (11,589) were randomly sampled and included in the hierarchical cluster analysis. The LTFU rate differed overwhelmingly by region. The highest proportion of LTFUs was recorded in the South-South region (33.3%), while the lowest (2.5%) was recorded in the North-central region. In the North-East region, a quarter of LTFUs (25.7%), 20.4% in the North-West and 18.1% in the South-West (Figure 1a) were reported. 7,799 (66.0%) more females than 3,890 (34.0%) males were reported as LTFU (Figure 1b). Slightly more than half of 52.7% (6,113) of patients received 2 months of ARV supply in terms of months of ARV refill. The proportion of patients that received an ARV refill for 1 month, 3 months, 4 months, 5 months, and 6 months was 25.8%, 17.5%, 1.72%, 0.9% and 2.1%, respectively (Figure 1c). Approximately one third of patients had a confirmed viral load test result in their medical records, 32.0 percent (3,701), while 68.0 percent (7,888) had no reported viral load test results (Figure 1d).

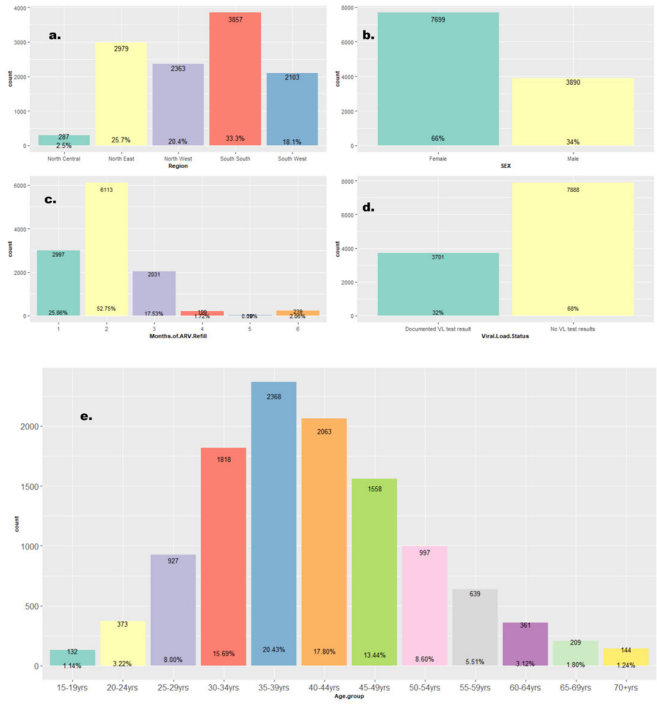

Figure 1: Bar charts showing distribution of demographic and clinical characteristics of patients reported as LTFU by (a): Region; (b): Sex; (c): Months of ARV refill; (d): Viral load status; (e): Age group.

In terms of age group, the results show that the number of LTFU patients grew gradually with an increase in age among 132 (1.1%) adolescents aged 15-19 years and 2,368 (20.4%) middle-aged adults aged 35-39 years, making it the highest recorded age group for LTFU. The number of LTFUs, on the other hand, decreased dramatically from 2,063 (17.8 percent) in older adult patients aged 40-44 years to 144 (1.2 percent) in older patients aged 70 years and older least (Figure 1e). Overall, the age distribution of patients by sex and viral load status revealed Gaussian properties with a nearly exact mean and median (Figures 2a and 2c). The median age of the study population was 40 years (IQR: 15 to 80) (Figure 2e). The male patients were older on average than the female patients in Figure 1a (44.7 ± 11.1 years *vs.* 39.2 ± 10.2 years). The mean age of patients with a recorded viral load test result was close to that of patients without a recorded viral load test result (40.3 ± 10.6 years *vs.* 41.4 ± 10.2 years) (Figure 2c). The histogram graph indicates how long patients were on ART by sex and viral load status in Figures 2b and 2d. Overall, the finding shows that as the

patient's duration increases on ART, LTFU decreases, and the findings reflect good success in program retention interventions. The median ART duration was 35 years (16 to 69 years). In male and female patients, this was identical (Figure 2f).

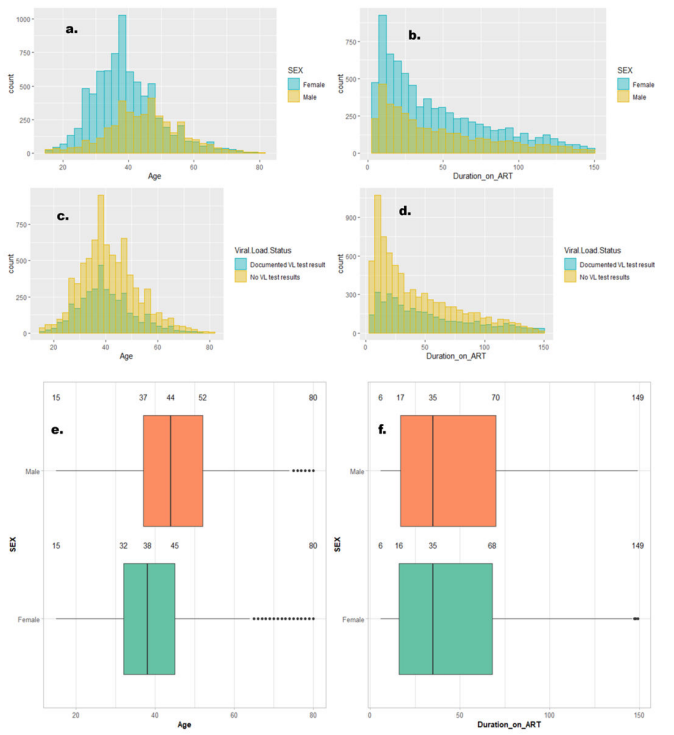

Figure 2: Top panel: Histogram showing distribution of patients deemed as LTFU (a): Age disaggregated by sex; (b): Duration on ART disaggregated by sex; (c): Age disaggregated by viral load status; (d): Duration on ART disaggregated by viral load status.

Bottom panel: Boxplots showing 5-number summary distributions for patients' age and duration on ART by sex.

Spatial analysis of PLHIV loss to follow-up

The distribution of the household wealth index and the reported volume of LTFUs across the study regions are seen in the top panel of the interpolated map in Figure 3. Overall, LTFUs tend to be higher in states that presented the moderate and richest household wealth index. In Jigawa and Yobe, LTFUs were low (less than 500 PLHIV), and lowest were Zamfara, Sokoto, and Kebbi (less than 100 PLHIV), and their states confined in the region with the poorest household wealth index. In the bottom panel of Figure 3, maternal education levels were disproportionately higher in the South-South, South-West, and North-Central and were moderately distributed in the North-East. On average, LTFUs tend to be higher in states such as Lagos, Edo, Akwa Ibom, Cross River, Adamawa, Kano, Bauchi, and Borno, confined to regions with secondary and higher levels of maternal education.

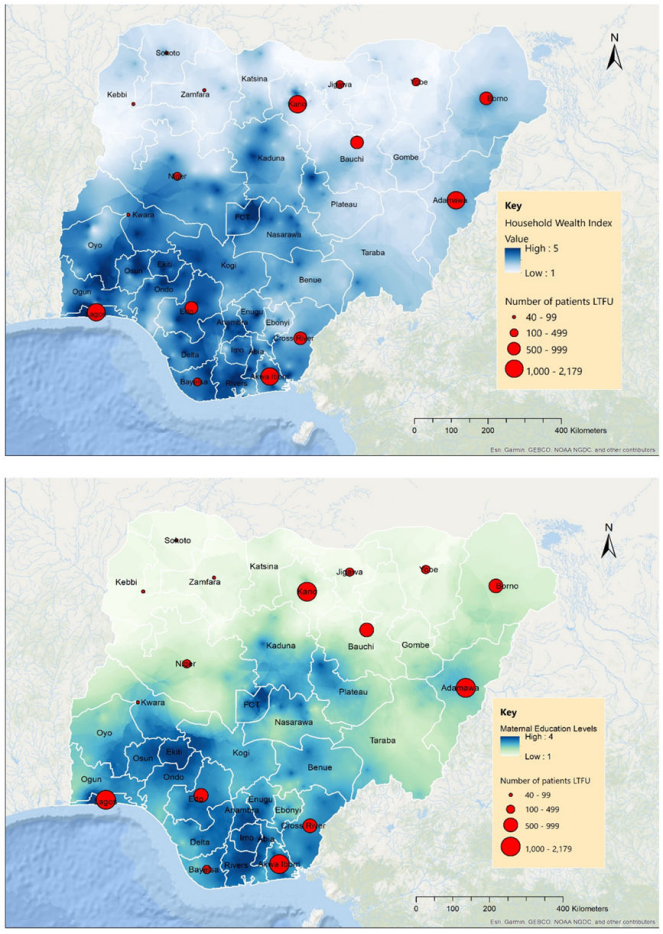

Figure 3: Top panel: Distribution of household wealth index and patient's loss to follow-up by state. Bottom panel: Distribution of maternal educational levels and patient's loss to follow-up by state.

Hierarchical cluster analysis

The cluster dendogram plot in Figure 4a shows the results of the hierarchical cluster analysis of LTFUs among PLHIV based on six patient level variables. The horizontal axis shows the distance between each cluster using the Ward method, in which 6 clusters were identified with an optimal number of over 200 to 3,000 PLHIVs in each. In Figure 4b, the cluster plot indicates the distribution of the 6 LTFU clusters by color. Cluster 1 PLHIVs are colored red, cluster 2 PLHIVs are brown, cluster 3 is green, cluster 4 is turquoise, cluster 5 is blue, and cluster 6 is pink. Among the 11,589 LTFUs included in the cluster analysis, 3,596 (31.0%) were grouped in cluster 1, 2,363 (20.4%) in cluster 2, 2,228 (19.2%) in cluster 3, 1,435 (12.4%) in cluster 4, 1,725 (14.9%) in cluster 5 and 242 (2.1%) in cluster 6. Table 1 summarises the cluster analysis of LTFUs and the different aggregated behavior or risk profile in each cluster. Cluster 1 consists of female PLHIVs who in the North-West region were

reported as LTFU, were the youngest on average (35.9 years) and were on ART for 28.7 months. This group got an ARV refill for 2 months and did not have a reported viral load test result. Cluster 2 consisted of male LTFUs in the south-south with a recorded LTFU event, and this category was older on average (44.8 years) compared to clusters 1 (35.9 years), 3 (36.9 years) and 6 (39.9 years). They were on ART for 35.3 months, got just one month of ARV refill, and had no reported viral load test in their medical records. Cluster 3, consisting of female LTFUs, was on ART for 52.3 months in the south-south region, obtained 2 months of ARV refill, and had a reported viral load test result. Cluster 4 consists of male LTFUs in the north-west and, in age (44.5 years) and period on ART (52.3 months), was identical to clusters 2 and 3 respectively. Cluster 4 got 2 months of ARV refill, as in cluster 3, and had a reported viral load test result. Cluster 5 was the oldest on average (49.2 years) compared to the other clusters, composed of female LTFUs in the north-west, and was on ART for 72.6 months. They got an ARV refill for 2 months but did not have a documented viral load test result. Cluster 6 consisted of females in the north-east with a recorded LTFU event. For a period of 60.4 months, this group was on ART and was the only group to obtain 6 months of ARV refill. They have a documented viral load test result (Annex 3).

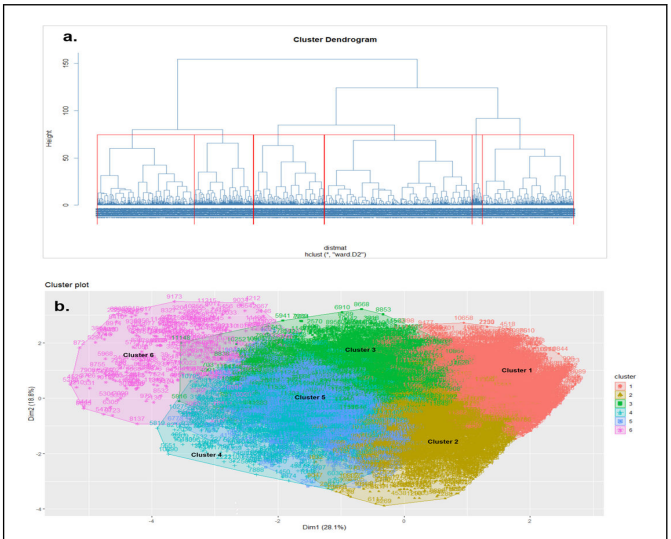

Figure 4: (a): Dendogram showing six clusters identified by Hierarchical clustering algorithm in R (red rectangles define the clusters for a given level of 6 clusters); (b): Cluster plot showing the distribution.

Table 1: Summary of aggregated LTFU profile among PLHIVs from hierarchical clustering.

Cluster	Region	Sex	Age	Duration on ART	Months of ARV refill	Viral load status
1	North-West	Female	35.9	28.7	2	No viral load test
2	South-South	Male	44.8	35.3	1	No viral load test
3	South-South	Female	36.9	52.3	2	Documented viral load test result
4	North-West	Male	44.5	52.3	2	Documented viral load test result
5	North-West	Female	49.2	72.6	2	No viral load test
6	North-East	Female	39.9	60.4	6	Documented viral load test result

DISCUSSION

Several studies have shown that LTFU poses challenges to the successful implementation of ART programs in low resource settings. To gain deeper understanding of the behavior of LTFU patients in the HIV treatment continuum, this study used the unsupervised machine learning algorithm "agglomerative hierarchical clustering" in R to aggregate LTFU profiles of PLHIVs into clusters. In the 12-year program review period, this study revealed that 20.4% of PLHIVs were LTFU indicating that this phenomenon is still a common programmatic challenge as exemplified in previous studies [11]. Our finding implied that as PLHIV age increased from 40-years and above the rate of LTFU decreased. Our finding aligns with a recent study that showed that patients aged above 45-years had lower risk of LTFU as compared to those aged 15-28 years. This finding was consistent with those of studies conducted in Southern Nigeria and Ethiopia [12]. In our study, LTFUs doubled steadily by age among adolescents (15-19 years) and young people (15-29 years), and this could be due to immaturity in analytical thinking, and particular challenges associated with puberty. Fear of stigma and discrimination,

as this younger age group is dependent on others, and independent members of this age group could be more mobile as compared to the older PLHIVs. This idea is also congruent with the qualitative findings indicating that the younger age groups who fear stigmatization are more prone to being LTFU from ART. The finding is different from that of a previous study conducted by Eguzo, et al. [13] which showed younger groups were at a lower risk of LTFU.

The LTFU profile of PLHIVs from hierarchical clustering indicated that the majority (66.7%) of the clusters consisted of female LTFUs. Although this may be attributed to the higher number of females in this study, our findings collaborate with similar research in Uganda and Togo that found that females were more likely to be LTFU than male PLHIVs [14]. The high number of females in our study reflects the actual high proportion of female PLHIVs in our HIV clinics and also reflect the national HIV testing patterns that indicate that a higher proportion of males than females are unaware of their HIV infection (61.9% and 47.8%, respectively). Previous studies indicate that stigma and lack of support, particularly psychosocial/emotional among PLHIV, were prominent reasons for LTFU. A study done in Ethiopia reported that statistically significant gender differences exist in a Health-Related Quality of Life (HRQoL) assessment among PLHIV on ART. The study suggested that high perceived stigma and no psychosocial support outside family members was strongly associated with poor psychological quality of health among female PLHIVs compared to males [15]. Similarly, another study in Vietnam reported that females had significantly lower scores than males on environmental and psychological indicators of HRQoL. Some researchers have suggested that gender differences in HRQoL are due to gender difference in expression of somatic complaints and psychological illness. They suggest that females report poorer quality of life because their illnesses may be taken less seriously, and therefore they receive less empathy and social support than their male counterparts. There is evidence that HRQoL of PLHIV has a significant role in ART retention, treatment adherence, and survival [16]. Based on evidence from these studies, it is possible to suppose that in our study poor psychological quality of health among females due to high perceived stigma and lack of psychosocial support outside family members may reflect reasons for a higher number of female LTFU clusters than males. Further studies are recommended to evaluate gender differences in health-related quality of life and its associated factors among PLHIVs on ART.

Our study showed geographical variability in the distribution of LTFUs in the study states. LTFU was higher (between 500 to over 2,000 PLHIV) in the southern region (Akwa Ibom, Cross River, Edo, and Lagos), in the north-east (Bauchi, Borno and Adamawa) and the North-West (Kano). This geographical variation has been reported in a previous Nigerian study although with a different pattern [17,18]. Our study suggests that the high HIV burden settings of Nigeria reflects the region with documented high LTFUs. Eight states which contribute 80% of Our study showed geographical variability in the distribution of LTFUs in the study states. LTFU was higher (between 500 to over 2,000 PLHIV) in the southern region (Akwa Ibom, Cross River, Edo, and Lagos), in the north-east (Bauchi, Borno and Adamawa) and the North-West (Kano). This geographical variation has been reported in a previous Nigerian study although with a different pattern [17,18]. Our study suggests that the high HIV burden settings of Nigeria reflects the region with documented high LTFUs. Eight states which contribute 80% of the PLHIV burden in the study states (*i.e.*, Akwa Ibom, Lagos, Kano, Borno, Cross River, Edo, Adamawa, and Niger) presented high rates of LTFUs. The GIS overlay analysis revealed that a high proportion of LTFUs were confined to regions with moderate to high household wealth index. This pattern was also like the distribution of high LTFUs in regions with moderate to high maternal educational levels. Limited evidence exists on the association between wealth index and LTFU outcome in the HIV treatment cascade. In a study by Yetnayet, et al. wealth index was found to be positively associated with domains of HRQoL among PLHIV on ART. Other studies support that PLHIV of better income had better physical HRQoL. Another study shows that women on ART who were more educated and residing in urban areas were more likely to have better physical health than women who were less educated and living in rural areas. The high rate of LTFUs recorded in the regions with high wealth index and high maternal educational level in our study may suggest that a sizeable proportion of the PLHIV in our HIV clinics are in the poor wealth index, may have a primary, secondary or no educational status and currently reside in resource-poor settings. We recommend the integration and reporting of select HRQoL metrics/indicators as part of the national routinely collected HIV data to inform LTFU surveillance among PLHIV in care in the HIV treatment continuum.

In this study, the high proportion of LTFUs was reflective of shorter-duration on ART. Female PLHIV classified in cluster 1 presented the shortest duration on ART (8-months) and the greatest proportion of LTFUs (31.0%) compared to the proportion of female LTFUs in cluster 3 (19.2%) and cluster 6 (2.1%) who were on ART for 52 months (4-years) and 60 months (5-years) respectively. Similarly, the proportion of LTFU (20.4%) among males classified in cluster 2 on ART for 35.3 months was greater than the proportion of male LTFU (14,9%) in cluster 5 who were on ART for 72.6 months (6-years). Our findings align with a prospective cohort study conducted in Tanzania which indicated that LTFU was associated with shorter time since ART initiation [19]. Our findings have shown that the rate of LTFU has varied by year of ART initiation. Although LTFU rate was highest in the first twenty-four months of ART initiation, LTFU rate declined steadily over the review period (for example, 19.4% to 2.7% in 10 years). The rapid growth of PLHIV on treatment within the national programs may also be accompanied by poorer patient retention and higher rates of LTFU in the previous years. There was some indication in our

findings to suggest that states with more patient load tended to have higher LTFU rates than other states. Recently, there has been greater attention on reducing LTFU rates to ensure patients are retained in care, maintain adherence and achieve better long-term outcomes. Treatment programmes in Nigeria conduct outreach and tracking for adults receiving ART who have missed clinic visits. Most report phone calls as the method of contact, but other methods include home visits, consulting with pharmacies and checking hospital records. ART adherence support services, such as one-on-one counselling and reminder tools, are also offered at a vast majority of treatment programmes. Hence, increased support services at the site-level such as implementation of client-centered care and Multi-Month Dispensing (MMD) to engage patients in long-term care may have contributed to the decreasing LTFU seen in recent years. All the clusters, except for cluster 2 received MMD.

Our study showed that the viral load test was low, with only half (50.0%) of the clusters (*i.e.,* cluster 3, cluster 4 and cluster 6) having a documented viral load test result. Two out of the three clusters with documented viral load test results were females. There is some indication in our result to suggest that gender-based differences in HIV viral load uptake exists. Our finding collaborated with the results from the 2018 Nigeria HIV/AIDS Indicator and Impact Survey (NAIIS) which indicated a viral load uptake of 69% among female PLHIV compared to the 31% among male PLHIV [20]. We recommend the adoption of Point-of-Care (POC) viral load tests and increasing trained workforce in clinics as approaches to improve viral load test uptake. There were some limitations to our study. Consequently, other important socio-economic and clinical variables particularly, patient residence (urban/rural area), marital status, history of stigma, $CD4^+$ count and WHO clinical stage were not available for analysis. There is the potential for site-level differences in the resources available that can dictate the level of patient care provided, the type of ART and other unmeasurable confounders that could influence the results. Disengagement from the clinic may be influenced by cultural or social factors that vary between the states, such as stigma and discrimination, conflict events and restrictions in movement during COVID-19 lockdowns/curfews.

CONCLUSION

This study demonstrates that aggregating LTFU behavior among patients on ART offers great benefit for LTFU surveillance in the HIV treatment cascade. We examined patient similarities in behavior that was associated with LTFU, this is important to inform targeted HIV program interventions for patient-centered care, to reduce LTFU and promote optimal retention. We have shown that the LTFU rates among PLHIV was highest within two years of commencement of ART and declined over time. We have identified important profiles of patient behavior which may be used to target prompt tracing efforts or inform the design of interventions, such as longer ART refills, connecting those without sufficient social support with treatment supporters, and periodic tracking of gender differences in a HRQoL assessment among PLHIV on ART. Optimization of retention in care must care must be prioritized if we are to improve the long-term outcomes of PLHIV on ART and reach the third of the UNAIDS 95-95-95 targets to achieve epidemic control.

ETHICAL CONSIDERATION

This analysis was conducted with routine data gathered through the PEPFAR/USAID Nigeria HIV/AIDS treatment program. The study is covered by NRHEC approval for program data review and LTFU analysis. This study only analysed anonymized and de-identified data.

DECLARATION OF INTERESTS

We declare no competing interests.

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