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The ART advantage: healthcare utilization for diabetes and hypertension in rural South Africa

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Abstract

Background—The prevalence of diabetes and hypertension has increased in HIV-positive populations but there is limited understanding of the role that ART programs play in the delivery of services for these conditions. The aim of this study is to assess the relationship between ART use and utilization of healthcare services for diabetes and hypertension.

Methods—Health and Aging in Africa: a Longitudinal Study of an INDEPTH Community in South Africa is a cohort of 5,059 adults. The baseline study collects biomarker-based data on HIV, ART, diabetes and hypertension and self-reported data on healthcare utilization. We calculated differences in care utilization for diabetes and hypertension by HIV and ART status and used

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multivariable logistic regressions to estimate the relationship between ART use and utilization of services for these conditions, controlling for age, sex, body mass index (BMI), education and household wealth quintile.

Results—Mean age, BMI, hypertension and diabetes prevalence were lower in the HIV-positive population (all p<0.001). Multivariable logistic regression showed that ART use was significantly associated with greater odds of blood pressure (aOR 1.27 95% CI 1.04–1.55) and blood sugar measurement (aOR 1.26, 95% CI 1.05–1.51), counseling regarding exercise (aOR 1.57, 95% CI 1.11–2.22), awareness of hypertension diagnosis (aOR 1.52, 95% CI 1.12–2.05) and treatment for hypertension (aOR 1.63, 95% CI 1.21–2.19).

Conclusions—HIV-positive patients who use ART are more likely to have received healthcare services for diabetes and hypertension. This apparent ART advantage suggests that ART programs may be a vehicle for strengthening health systems for chronic care.

INTRODUCTION

The establishment and scale-up of HIV antiretroviral treatment (ART) programs in sub-Saharan Africa has been among the most successful global public health efforts in recent years. In recent years ART coverage in eastern and southern Africa has nearly doubled, from 24% in 2010 to 54% in 2015, with over 10 million people living with HIV (PLWHIV) currently on ART in this region.[1] The resulting health benefits have been very significant, including gains in adult life expectancy of more than a decade.[2,3] As PLWHIV age on ART, the prevalence of comorbid non-communicable diseases,[4] such as diabetes and hypertension, have also increased, with recent studies showing a diabetes prevalence of 13.7% in older African adults and hypertension in more than 50% of older adults in southern Africa.[5–7] However, evidence to guide programs and policies for those affected remains limited.[8–12] As such, there is a pressing need for greater research at the intersection of these epidemics, especially in low and middle-income countries that face a dual burden of high HIV prevalence and rising cardiometabolic conditions coupled with weak health system infrastructure.[13]

The role of ART programs and their impact on health system performance in sub-Saharan Africa has been an area of controversy for many years. Some experts have expressed concern that ART programs may exacerbate health inequalities by directing scarce resources to PLWHIV or diverting those resources away from primary health care systems that serve the general adult population to HIV-related programs.[14–16] In contrast, others have argued that ART programs may actually serve as a backbone on which to build stronger health systems by increasing the overall infusion of resources to the system and strengthening both human resources for health and systems for laboratory and clinical medicine that are common to ART programs and other types of healthcare service provision.[14,17] Moreover, the marginal costs of adding these basic diagnostic and treatment services for diabetes and hypertension to existing ART programs is likely to be low, since clinical infrastructure and personnel are already in place. With little data to support or refute these claims, there remains a lack of clarity about the effect of ART programs on health system performance for conditions other than HIV.[5,18–20]

Within a large cohort of adults aged >40 years in Agincourt, South Africa, this study aims to describe (1) differences in utilization of healthcare services for diabetes and hypertension among HIV-positive versus HIV-negative persons and (2) the relationship between ART use and healthcare service utilization for diabetes and hypertension among HIV-positive persons . We hypothesize that the HIV-infected individuals who utilize ART have greater access to diagnosis and care for comorbid diabetes and hypertension as compared to individuals not receiving ART, irrespective of their HIV-infection status. In essence we postulate that ART programs may provide a platform to strengthen health system performance for other chronic conditions.

METHODS

Overview of the HAALSI cohort

The Health and Aging in Africa: A Longitudinal Study of an INDEPTH Community in South Africa (HAALSI) aims to understand population aging in a rapidly transitioning community of rural northeast South Africa. The cohort consists of adults aged 40 and over and is nested within a health and demographic surveillance system (HDSS) covering the Agincourt sub-district adjacent to southern Mozambique.[21] The sub-district is a rural region comprising 31 villages with high rates of migration. The local population is served by six clinics and two health centers along with three district hospitals that are located within 60 km of the study site.

Enrollment in the HAALSI cohort, with participants randomly sampled from the Agincourt HDSS, began in November 2014 and closed in November 2015.[22] Individuals 40 years and older as of July 1, 2014 who had been living in the study site for the 12 months prior were eligible for selection. A total of 6,281 women and men were selected for the main household survey in order to achieve a target sample size of 5,000 people. Those who participated in earlier studies and met the eligibility criteria were selected with 100 percent probability while the remainder of the sample was selected randomly from the 2013 HDSS census, stratifying on sex in order to achieve equal numbers of men and women.[23]

The baseline survey, upon which this analysis is based, included self-reported demographic, health and economic information, questions on self-reported healthcare service utilization for HIV, diabetes and hypertension, as well as anthropometry and laboratory studies. The survey was administered by trained, local fieldworkers who recorded participant responses in a Computer Assisted Personal Interview system. As part of the survey administration, these trained fieldworkers also collected blood through finger prick and prepared dried bloodspots (DBS) from each participant who consented to blood collection. The anthropometry and laboratory data included height, weight, blood pressure, and point-of-care glucose. In addition, the DBS were later tested for HIV antibody and viral load in all consenting participants. The HIV screening and confirmatory enzyme-linked immunosorbent assays used were the Vironostika HIV 1/2 Ag/Ab MicroELISA System (Biomeriuex, France) and the Roche Cobas E411 Combi Ag (USA), respectively. The Viral Load Platform was Biomeriux NucliSens with a lower limit of detection of <100 copies by DBS.

For those participants with a positive HIV antibody test, further testing for exposure to either emtricitabine (FTC) or lamivudine (3TC) was performed via dried blood spot (DBS). Study samples were analysed at the Pharmacokinetic Laboratory at the University of Cape Town in South Africa. A semi-quantitative LC/MS/MS assay with a lower limit of detection of 0.02 μg/ml was validated for the determination of 3TC and FTC from DBS. The method consisted of a protein precipitation, followed by high performance liquid chromatography with MS/MS detection using gradient elution. An AB Sciex API 4000 mass spectrometer at unit resolution in the multiple reaction monitoring (MRM) mode was used to monitor the transition of the protonated precursor ions at m/z 248.0 and 230.2 to the product ions at m/z 129.9 and 112.0 for emtricitabine and lamivudine, respectively. Electro Spray Ionisation (ESI) was used for ion production.[24,25] Samples that fell above the lower limit of detection for either of the antiretroviral drugs tested were classified as positive for ART use. The time from ingestion to reaching this threshold has been estimated at 1.5 days for 3TC.[24] Ethical approval for HAALSI was obtained from the University of the Witwatersrand, the Harvard T.H. Chan School of Public Health, and the Mpumalanga Provincial Research and Ethics Committee.

Defining HIV-infection, ART, and viral suppression

In this study, HIV infection status was defined using the result of the DBS antibody testing, rather than self-reported status. Those participants who tested positive for exposure to either FTC or 3TC were classified as ART users, irrespective of their self-reported HIV or ART status. Thus, ART exposure in this study is defined as a binary variable indicating that either a drug or drugs (FTC or 3TC or both drugs) were present in the DBS sample or no drug was present in the sample. All first and second line antiretroviral regimens in South Africa utilize one of these two drugs as part of a three drug combination. Finally, HIV viral load was measured using DBS viral load testing, allowing for a biological assessment of viral suppression. We define viral suppression based on the DBS results at <100 copies per ml, the lower limit of detection for the assay. We also provide a comparative assessment of the rate of viral suppression when it is defined as <400 copies per ml, the upper limit for routine viral load monitoring per South African guidelines and as <1000 copies per ml, the threshold for defining treatment failure per South African guidelines. We performed all supplementary analyses at each of these viral load thresholds.

Utilization of healthcare services for hypertension and diabetes—Measured height and weight were used to define body mass index (BMI) as well as diagnoses of hypertension and diabetes. Three blood pressure measurements were taken two minutes apart for each respondent, using a standard manual blood pressure cuff. The first measurement was dropped; the second and third measurements were averaged.[26] Hypertension was defined as a mean systolic blood pressure ≥140 mm Hg or diastolic blood pressure ≥90 mm Hg or self-reported use of medication for hypertension prescribed by a doctor, nurse or healthcare worker. Diabetes was defined as a fasting plasma glucose ≥7.0 mmol/L or random plasma glucose ≥11.1 mmol/L measured at the time of interview or self-reported use of medication for diabetes mellitus prescribed by a doctor, nurse or healthcare worker.[27,28] Utilization of care for hypertension and diabetes was assessed using the following variables as reported by each participant: access to diagnosis (ever measurement of blood pressure and ever measurement of blood sugar by a healthcare provider), receiving advice on lifestyle modification (advised by healthcare provider to change diet or exercise), awareness of diagnosis (told about diagnosis of hypertension or told about diagnosis of diabetes by healthcare provider) and access to treatment (self-reported use of medication for blood pressure or self-reported use of medication for blood sugar). The latter two outcomes were only assessed among those who met criteria for a diagnosis of the respective condition.

Analysis—We calculated descriptive demographic and health characteristics stratified into three groups: HIV-negative participants (HIV-negative), HIV-positive participants who were not currently using ART (HIV+/No ART) and HIV-positive participants who were current ART users based on FTC/3TC exposure testing (HIV+/ART users). Individual participants could only be assigned to one of these groups. Means were compared using one-way ANOVA and proportions using chi-squared tests. We then calculated the proportion of participants in the HIV+/ART user group who self-reported utilization of each of the NCD care metrics outlined above and compared this to the proportion of people in the HIV-negative and HIV+/No ART groups who self-reported utilization of these same services.

Next, to test our central hypothesis, we used multivariable logistic regressions to assess the association between ART use and each of the following outcomes in terms of diagnosis and advice on lifestyle modification from a healthcare provider across the cohort: (1) ever receipt of a blood pressure measurement (2) ever receipt of a blood sugar measurement (3) ever receipt of advice to change diet and (4) ever receipt of advice to exercise. We then use logistic regression to assess the association between ART use and each of the following outcomes related to awareness of diagnosis and treatment of diabetes or hypertension among those who met criteria for a diagnosis of either condition: (5) awareness of diabetes diagnosis among diabetics, (6) awareness of hypertension diagnosis among hypertensives, (7) treatment receipt for diabetes among diabetics, (8) treatment receipt for hypertension among hypertensives. All models were adjusted for age, sex, BMI, household wealth index and educational attainment. The household wealth index is the quintile ranking of scores derived from principal components analysis of ownership of household items, livestock and vehicles.

As a sensitivity analysis, we also performed this multivariate regression to examine whether the relationship was preserved in self-reported ART and for the ART users who were also virally suppressed. As described previously, we examined these relationships using three different definitions of viral suppression (<100 copies, <400 copies and <1000 copies).

FINDINGS

HIV infection, ART and viral suppression in Agincourt, South Africa

Figure 1 depicts the HIV-positive population in the HAALSI study stratified by ART use and viral suppression. Among 4,560 participants who underwent DBS testing for HIV antibody, 1,048 (23%) were found to be HIV-positive. As discussed in detail elsewhere, this is a high HIV prevalence given the older age of this cohort.[22] Moreover, 662 (64%) of these HIV-positive participants were also positive for exposure to FTC or 3TC, though only 450 or 68% of the ART users as defined by DBS exposure testing also self-reported ART use. Finally, among the ART users, 479 (72%) were virally suppressed where viral suppression was defined by a viral load of <100 copies, the lower limit of assay detection in this study. When using the alternative viral load threshold of <400 copies, 549 (83%) were suppressed while 594 (90%) were suppressed at a threshold of <1000 copies.

Diabetes and hypertension in the HIV-positive population

The demographic and health data, displayed in Table 1, show that age, BMI and mean systolic blood pressure are all lower among the HIV-positive population, both in those on and off ART, as compared to the HIV-negative population (p<0.001). There is a lower proportion of HIV-positive participants who have comorbid hypertension (HIV-negative: 63.7%, HIV+/No ART: 43.5%, HIV+/ART Users: 38.7%) and diabetes (HIV-negative: 12.0%, HIV+/No ART: 6.3%, HIV+/ART users: 7.8%) when compared to the HIV-negative population though the prevalence of these conditions remains high across all three groups.

Table 1 also describes self-reported utilization of care for hypertension and diabetes in ART users compared to non-ART users in the HAALSI cohort. The percentage of participants who received a blood pressure or blood sugar measurement or counseling from a healthcare provider regarding exercise was greater among ART-users as compared to non-ART users (HIV-negative: 70.0%, 48.7% and 5.5%, HIV+/No ART: 69.2%, 42.1% and 1.3%, HIV +/ART Users: 71.5%, 49.0% and 7.8%), as was awareness of diagnosis and treatment for hypertension (HIV-negative: 65.2% and 56.5%, HIV+/No ART: 59.6% and 49.1%, HIV +/ART Users: 67.6% and 57.8%) and diabetes (HIV-negative: 55.9% and 53.9%, HIV+/No ART: 47.8% and 43.5%, HIV+/ART Users: 56.9% and 54.9%). These differences were only statistically significant for blood sugar measurement and counseling to exercise.

ART and utilization of healthcare services for diabetes and hypertension

Multivariable logistic regression models of diagnosis and preventive counseling for diabetes and hypertension (Table 2) showed greater odds of ever receiving a blood pressure measurement (adjusted odds ratio [aOR] 1.27 95% CI 1.04–1.55), blood sugar measurement (aOR 1.26, 95% CI 1.05–1.51) or counseling regarding exercise (aOR 1.57, 95% CI 1.11–2.22) among HIV+/ART users as compared to those who were HIV-negative, after adjusting for age, sex, BMI, education and household wealth quintile. However, the odds of receiving preventive counseling from a healthcare provider regarding diet (aOR: 1.24, 95% CI: 0.92 – 1.67) among the HIV+/ART users was not statistically significant.

Regression analyses (Table 3) also demonstrated greater odds of being aware of a diagnosis of hypertension among those hypertensive participants who were HIV+/ART users (aOR 1.52, 95% CI 1.12–2.05) as compared to those who were HIV-negative. The HIV+/ART group also had greater odds of receiving treatment for their hypertension and treatment (aOR 1.63, 95% CI 1.21–2.19), again compared to those who were HIV-negative. Relationships of similar magnitude were seen between ART use and awareness of diabetes diagnosis or treatment of diabetes, but these were not statistically significant due to lower prevalence of diabetes diagnosis and treatment. Though not shown in Tables 2 and 3, all of these relationships were equally strong and significant among the sub-group of self-reported ART users and among those who were ART users and virally suppressed (see Supplementary

Appendix). There was no qualitative difference in the results at alternative thresholds of viral suppression.

DISCUSSION

This study offers several key findings regarding the relationship between HIV infection, ART use and utilization of health services for hypertension and diabetes, two major non-communicable diseases of increasing importance in this region. First, in a community with very high HIV, hypertension and diabetes prevalence, ART utilization is associated with utilization of needed hypertension and diabetes care, including greater diagnostic testing and preventive counseling regarding lifestyle modification for diabetes and hypertension as well as treatment among those affected by these comorbid chronic diseases. This rural South African cohort was well-suited to examining these relationships given the high prevalence of HIV and the similarly high rates of both hypertension and diabetes in this group of older adults.

However, due to the cross-sectional nature of this study, it is unknown whether ART use actually precedes the diagnosis and treatment of NCDs or vice versa. The mechanism for the association between these services is unclear but may include better access to or utilization of healthcare services generally, increased exposure to health information resulting in better health literacy and more accurate self-reporting of service utilization, more assertive health-seeking behavior or some combination of these factors. One important factor underlying this finding may be that those on ART are required to present to a clinic each month to obtain medications and thus likely come into contact with the health system much more frequently than HIV-negative or HIV-positive people who are not receiving ART. The frequency of this contact may offer more opportunities to be diagnosed, educated or referred to chronic disease clinical staff for care of other health conditions. The data presented here suggest a potential positive spillover effect from ART utilization to care for other chronic conditions. If true, this may suggest a more central role for ART programs in the delivery of care for NCDs among HIV-positive populations, in particular screening, diagnosis and preventive care for the increasingly large population initiating ART in this context.

Our results found that awareness of a hypertension diagnosis is also greater among those hypertensive participants in the HIV+/ART group. ART users who were also hypertensive were also more likely to self-report receiving treatment for their hypertension. However, similar relationships did not exist for awareness of a diabetes diagnosis or treatment of diabetes, though the small number of people with diabetes in the sample may limit the power to draw definitive conclusions regarding this relationship.

In addition, we found a high prevalence of both diabetes and hypertension in this rural South African community specifically among the population over age 40. Though these conditions have not received nearly the same level of attention as HIV, several recent studies in similar settings in Southern Africa have shown comparable prevalence estimates for both diabetes and hypertension in aging African adults.[5–7] This lends further evidence that the burden of these two cardiovascular risk factors is very important in middle-income countries and that failing to address these chronic diseases could have detrimental effects on the population-level gains in life expectancy and quality of life that have been achieved through ART roll-out.[2,29] However, we also show that HIV-positive participants in this rural South African cohort (HIV+/No ART and HIV+/ART) have a lower prevalence of diabetes and hypertension as compared to the HIV-negative population. The lower prevalence of these conditions is likely multifactorial as PLWHIV are on average younger and have a lower BMI than the HIV-negative participants. In particular, their lower BMI may be in part caused by their HIV disease and would be expected to reduce their risk of diabetes and hypertension, though they remain at heightened risk of other opportunistic infections.[4,30]

However, the fact that the prevalence of diabetes and hypertension remains high in the setting of relatively younger age and lower BMI among PLWHIV may also indicate the potential for an increasing burden of these conditions in the future with the shift toward early ART initiation in HIV disease.[31] In particular, early ART initiation may be expected to promote body weight preservation by averting HIV-associated wasting among infected populations, in contrast to older guidelines that recommended ART initiation at a later stage of immunosuppression. Perhaps paradoxically, this could result in even greater rates of hypertension, diabetes and other non-communicable diseases among the HIV-positive population in the future. As shown in this study, greater counseling on healthy lifestyle habits for HIV-positive people on ART may lead to improvements in diet and increased physical activity, thereby mitigating the effects of earlier ART initiation on NCDs.

While these findings provide important insight regarding the design and delivery of care for diabetes and hypertension among PLWHIV, they may also provide lessons that are relevant to care delivery for these conditions in the HIV negative population. When considering possible overlap between the health systems infrastructure underlying HIV care programs and the health systems structures needed to support growing epidemics of diabetes and hypertension,[32,33] these findings suggest that ART programs may serve as a powerful platform for broader population health improvements via increased programmatic integration.[34] One excellent example of the potential for this integration has been the Academic Model Providing Access to Healthcare (AMPATH) program which provides care to >150,000 adults and children living with HIV/AIDS throughout Western Kenya.[35] This collaboration has been able to provide important insights about cardiometabolic diseases in PLWHIV, including high rates of cardiovascular risk, low levels of knowledge and perceived risk of cardiovascular disease in this population.[35] Another example of this may be the Ideal Clinics Initiative in South Africa, a reform effort which in part involves integrating some aspects of care for HIV with care for common chronic conditions such as diabetes and hypertension.[36] Finally, the expansion of universal health coverage will potentially be advanced by the integration of services for common, key conditions such as HIV, diabetes and hypertension.

This study has several limitations. First, data on utilization of health services for NCDs were self-reported, including the diagnosis and care received for both diabetes and hypertension. Despite this limitation, in the case of diagnosis and preventive counseling for these NCDs, the use of self-reported data can be illuminating because it not only reflects the health services participants have received but also their understanding of both those diagnostic tests and advice. In the case of counseling on lifestyle modification, this is particularly relevant given that this type of advice can seemingly only be used in a meaningful way if the recipient understands and retains the information provided. However, the limitation of self-reported data includes misreporting and the direction of any resulting bias is difficult to predict. A second limitation of this study is the lack of temporal data regarding the date and duration of HIV infection, the time when ART was initiated and the timing during which services were received for diabetes and hypertension. Without this information, it is difficult to assess the directionality of the relationship between ART program participation and receipt of care for NCDs. Finally, there are various definitions of viral suppression that could be acceptable in the South African context; however, the supplementary analyses for this population showed a preserved association between virally suppressed ART users and the outcomes of interest across four commonly used thresholds.

In summary, this analysis supports the findings that the burden of non-communicable diseases is substantial among the HIV-positive population in Agincourt. The HIV-positive population that was receiving ART also reported greater access to diagnosis and preventive counseling for diabetes and hypertension, two major non-communicable diseases in South Africa, as well as awareness of diagnosis and treatment of hypertension. This relationship was not preserved for the awareness of diabetes diagnosis and treatment of diabetes, but small sample sizes may limit the power to show this relationship. The positive spillover effects from ART utilization to preventive care for other chronic conditions could provide a powerful vehicle for broader population health improvements via increased programmatic integration.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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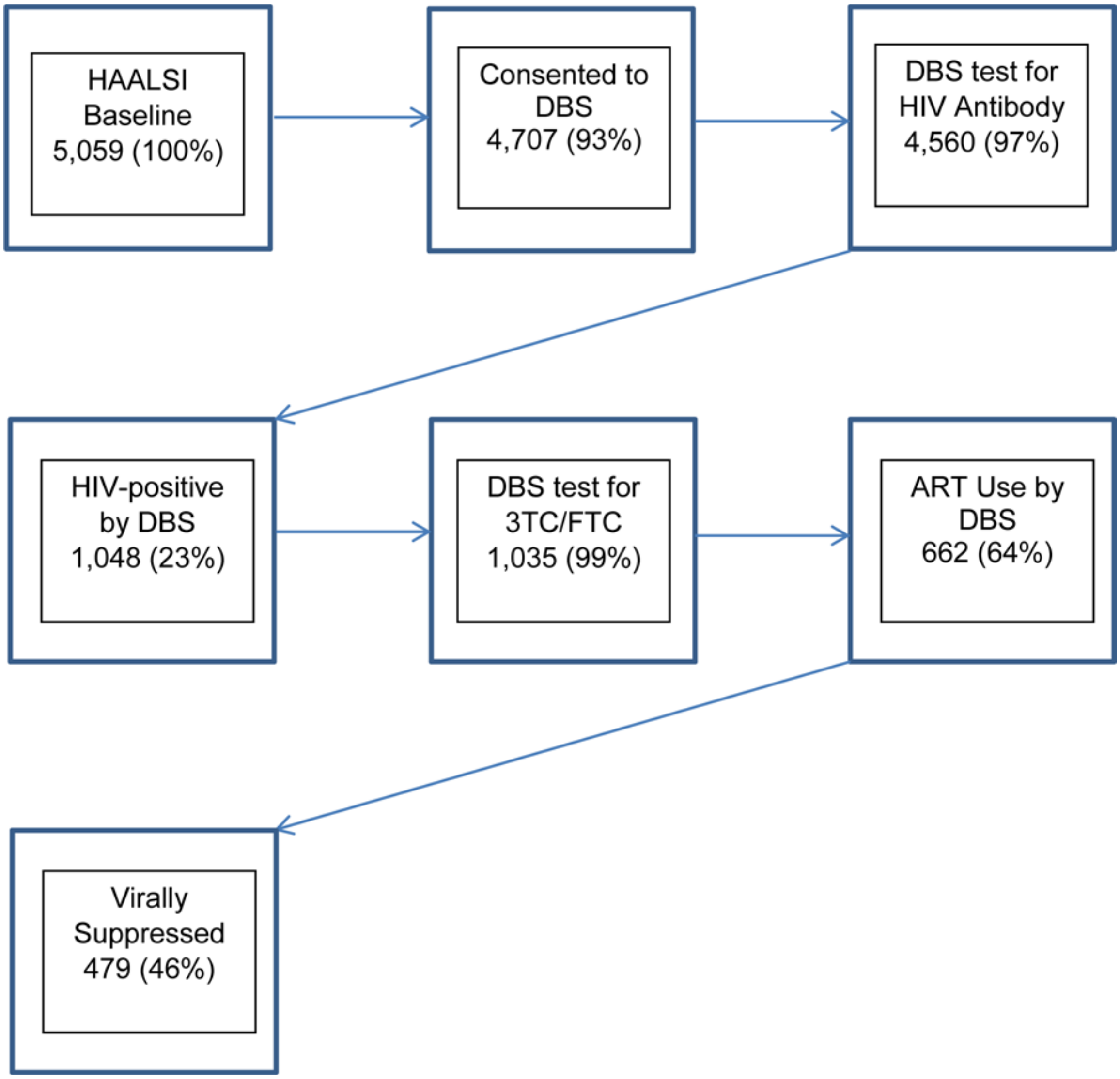

Figure 1.

HIV Infection, ART Use and Viral Suppression in the HAALSI Cohort, Agincourt sub-district, South Africa 2015

Table 1

Demographic characteristics, cardiometabolic risk factors and healthcare utilization by HIV and ART status in the HAALSI Cohort

Indicator	HIV-negative	HIV+/No ART	HIV+/ART	p
Total	3512	373	662	–
Age – Mean	63.6	54.5	55.9	<0.001
Female (%)	54.0	57.3	52.3	0.286
BMI – Mean	27.7	26.8	25.3	<0.001
Diabetic (%)	12.0	6.3	7.8	<0.001
SBP – Mean	140	132	129	<0.001
Hypertensive (%)	63.7	43.5	38.7	<0.001
Ever Blood Pressure	70.0	69.2	71.5	0.692
Ever Blood Sugar	48.7	42.1	49.0	0.049
Told to Change Diet	11.3	6.4	9.7	0.011
Told to Exercise	5.5	1.3	7.8	<0.001
Told Hypertension	65.2	59.6	67.6	0.245
Told Diabetes	55.9	47.8	56.9	0.737
Treated Hypertension	56.5	49.1	57.8	0.159
Treated Diabetes	53.9	43.5	54.9	0.609

Table 2

Multivariate logistic regression results: ART and diabetes and hypertension diagnosis and preventive counseling in Agincourt, South Africa

Covariates	Ever Blood Pressure aOR + 95% CI	Ever Sugar aOR + 95% CI	Advised Change Diet aOR + 95% CI	Told to Exercise aOR + 95% CI
Age	1.02 *** (1.01 – 1.02)	1.02 *** (1.01 – 1.02)	1.02 *** (1.01 – 1.03)	1.00 (0.99 – 1.02)
Female	1.44 *** (1.25 – 1.67)	1.18 ** (1.04 – 1.35)	1.38 *** (1.10 – 1.72)	0.94 (0.71 – 1.26)
Overweight	0.87 * (0.74 – 1.03)	1.35 *** (1.155 – 1.571)	1.18 (0.90 – 1.54)	1.20 (0.84 – 1.71)
Obese	1.03 (0.86 – 1.23)	1.49 *** (1.26 – 1.75)	1.81 *** (1.39 – 2.35)	1.79 *** (1.26 – 2.53)
Education 1–7	1.08 (0.91 – 1.27)	1.25 *** (1.07 – 1.45)	1.39 *** (1.09 – 1.77)	2.23 *** (1.56 – 3.18)
Education 8–11	1.13 (0.88 – 1.45)	1.46 *** (1.16 – 1.84)	0.88 (0.58 – 1.34)	2.90 *** (1.82 – 4.63)
Education 12+	0.75 ** (0.59 – 0.96)	1.25 * (0.99 – 1.58)	0.95 (0.64 – 1.43)	1.95 ** (1.17 – 3.27)
Wealth Quintile 2	1.05 (0.85 – 1.30)	1.05 (0.86 – 1.28)	0.79 (0.56 – 1.13)	0.92 (0.54 – 1.56)
Wealth Quintile 3	1.26 ** (1.02 – 1.57)	1.16 (0.95 – 1.42)	0.93 (0.66 – 1.31)	1.21 (0.739 – 1.99)
Wealth Quintile 4	1.20 (0.96 – 1.49)	1.38 *** (1.12 – 1.69)	1.11 (0.79 – 1.55)	1.39 (0.86 – 2.27)
Wealth Quintile 5	1.47 *** (1.17 – 1.85)	1.53 *** (1.24 – 1.89)	1.51 ** (1.08 – 2.10)	1.62 ** (1.00 – 2.61)
HIV+/No ART	1.11 (0.86 – 1.42)	0.94 (0.74 – 1.18)	0.71 (0.45 – 1.12)	0.26 *** (0.10 – 0.63)
HIV+/ART	1.27 ** (1.04 – 1.55)	1.26 ** (1.05 – 1.51)	1.24 (0.92 – 1.67)	1.57 ** (1.11 – 2.22)
Constant	0.61 ** (0.39 – 0.97)	0.19 *** (0.13 – 0.29)	0.02 *** (0.01 – 0.03)	0.02 *** (0.01 – 0.05)
Observations	4,134	4,134	4,134	4,132

95% CI in parentheses

*** p<0.01,

** p<0.05,

* p<0.1

Table 3

Multivariate logistic regression results: ART and diabetes and hypertension awareness and care in Agincourt, South Africa

Covariates	Told Hypertension aOR + 95% CI	Told Diabetes aOR + 95% CI	Treated Hypertension aOR + 95% CI	Treated Diabetes aOR + 95% CI
Age	1.03*** (1.02 – 1.04)	1.01 (0.99 – 1.03)	1.04*** (1.030 – 1.05)	1.01 (0.99 – 1.03)
Female	1.69*** (1.41 – 2.03)	0.99 (0.65 – 1.53)	1.77*** (1.48 – 2.12)	0.98 (0.64 – 1.50)
Overweight	1.58*** (1.27 – 1.97)	1.06 (0.61 – 1.82)	1.63*** (1.32 – 2.03)	1.09 (0.63 – 1.87)
Obese	2.22*** (1.77 – 2.79)	1.04 (0.61 – 1.77)	2.28*** (1.83 – 2.84)	1.13 (0.67 – 1.92)
Education 1–7	1.22* (0.97 – 1.52)	1.11 (0.70 – 1.75)	1.11 (0.90 – 1.36)	1.08 (0.69 – 1.71)
Education 8–11	0.81 (0.59 – 1.13)	0.96 (0.44 – 2.09)	0.80 (0.58 – 1.09)	0.95 (0.44 – 2.06)
Education 12+	0.95 (0.67 – 1.33)	1.67 (0.75 – 3.75)	0.82 (0.58 – 1.14)	1.66 (0.74 – 3.69)
Wealth Quintile 2	0.97 (0.74 – 1.29)	0.89 (0.42 – 1.89)	0.99 (0.75 – 1.31)	0.915 (0.43 – 1.94)
Wealth Quintile 3	1.38** (1.04 – 1.84)	1.13 (0.54 – 2.37)	1.27* (0.96 – 1.69)	1.11 (0.53 – 2.33)
Wealth Quintile 4	1.48*** (1.11 – 1.96)	1.15 (0.56 – 2.37)	1.47*** (1.11 – 1.94)	1.11 (0.54 – 2.29)
Wealth Quintile 5	1.80*** (1.34 – 2.42)	1.54 (0.73 – 3.23)	1.79*** (1.34 – 2.39)	1.52 (0.72 – 3.19)
HIV+/No ART	1.16 (0.80 – 1.66)	0.98 (0.39 – 2.51)	1.09 (0.76 – 1.55)	0.89 (0.35 – 2.28)
HIV+/ART	1.52*** (1.12 – 2.05)	1.33 (0.69 – 2.56)	1.63*** (1.21 – 2.19)	1.35 (0.71 – 2.60)
Constant	0.09*** (0.05 – 0.19)	0.38 (0.09 – 1.66)	0.04*** (0.02 – 0.08)	0.33 (0.08 – 1.44)
Observations	2,387	428	2,388	427

95% CI in parentheses

*** p<0.01,

** p<0.05,

* p<0.1