Prevalence and Risk Factors for Diabetes Mellitus among newly-diagnosed HIV-infected South African Adults

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Abstract

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Background: Non-communicable diseases and their risk factors, including diabetes mellitus, have been increasing in HIV-endemic resource-limited settings. We sought to determine the prevalence and risk factors for diabetes in HIV-infected South African adults.

Methods: We conducted a cross-sectional study of newly diagnosed HIV-infected adults in a poor urban township in KwaZulu-Natal, South Africa. We used indicators for demographic, socioeconomic, and substance use prior to HIV testing. We defined diabetes as having a hemoglobin A1c (HbA1c) ≥6.5% or in the absence of this test, a random blood glucose (RBG) ≥11.1 mmol/L, and prediabetes was defined as HbA1c 5.7-6.4% or RBG 7.8-11.1 mmol/L. We used logistic regression to identify risk factors for prediabetes or diabetes.

Results: Among 1,048 HIV-infected adults, mean age was 33 years, 630 (60.1%) were female, and 253 (24.2%) were obese. The prevalence of diabetes and prediabetes were 2.8% and 7.4%, respectively. In the multivariate model, age 45 years or older (8.50 OR, 95% CI: 3.27-22.07), BMI greater than 30 kg/m^2 (23.60 OR, 95% CI: 11.41-48.85), female sex (2.20 OR, 95% CI: 1.39-3.48), greater than 5 kilometers from a clinic (1.98 OR, 95% CI: 1.11-3.55), hypertension (2.64 OR, 95% CI:1.55-4.49), CD4 cell counts >350 (1.97 OR, 95% CI:1.06-3.67) and cigarettes use (0.34 OR, 95% CI: 0.15-0.76) were associated with a higher odds of diabetes or prediabetes. None of the 1,048 participants who had either pre-diabetes or diabetes were aware of their diagnosis or reported receiving diabetic treatment.

Conclusions: The prevalence of prediabetes or diabetes was over 10% among newly diagnosed HIV-infected adults in South Africa, and none of these adults were aware of their condition or receiving therapy. Screening may target those who are obese, live farther away from a clinic, older age, have hypertension, have higher CD4 counts and females, while treatment for diabetes needs to be expanded among all HIV-infected adults.

Keywords: HIV/AIDS; diabetes; non-communicable diseases; screening; obesity; South Africa.

Background:

Many countries in sub-Saharan Africa, including South Africa, are experiencing a double burden of disease with high HIV infection rates and high rates of non-communicable diseases.[1] One prominent risk factor for non-communicable diseases is diabetes mellitus, a metabolic disorder characterized by chronic hyperglycemia.[2] The rate of diabetes has steadily risen since the 1980s. Currently, approximately 8.5% of the world's adult population are diabetic, and 1.5 million people died each year from diabetes-related complications.[3] Screening for diabetes is important among HIV-infected adults, since they have a higher AIDS-related mortality rate and all-cause mortality compared to HIV-infected adults without diabetes.[4]

Those with diabetes are more likely to suffer from cardiovascular disease and myocardial infarction.[5] Diabetes has resulted in a higher risk for the development of renal disease and neuropathy.[5] Diabetes also increases the risk of active tuberculosis disease, and approximately 15% of all TB cases in Africa may be attributed to type 2 diabetes.[6,7] In Sub-Saharan Africa, risk factors for the increasing prevalence of diabetes among HIV-negative adults have included obesity, nutrition changes, smoking, alcohol use, socioeconomic factors, ageing and tuberculosis.[8] The prevalence of type 2 diabetes in South Africa is estimated to be 3.9% to 8.8% as reported in a systematic review of three studies, and prevalence tends to be higher in urban areas compared rural areas.[9]

Since there is limited data on diabetes screening at HIV diagnosis in South Africa, we sought to determine the prevalence and risk factors for diabetes and pre-diabetes at the time of HIV diagnosis among adults in a poor urban township of South Africa.

Methods

Study design and participants

We conducted a cross-sectional study of participants from the outpatient department of the iThembalabantu People's Hope Clinic (IPHC) in the Umlazi township of Durban from September 2013 to November 2016. The IPHC tests approximately 2,000-3,000 adults for HIV each month, and provides free clinic- and community-based HIV care and treatment for over 10,000 HIV-infected patients. Eligible participants were 18 years of age or older, presented to the clinic for voluntary HIV testing, and not previously known to be HIV-infected. Pregnant women were excluded. All participants provided a written informed consent to participate and the study was approved by the institutional review board of the University of Washington in Seattle (IRB #49563) and Medical Research Ethics Committee of the University of KwaZulu-Natal in Durban (Protocol #BF052/13).

Clinical Assessments and Testing

A research assistant collected demographic, socioeconomic, food security information from an electronic survey before HIV testing. Those who tested positive for HIV were tested for diabetes by a research nurse. Body weight was measured to the nearest 0.5 kg with the participant in light clothing and using a standardized scale. Height was measured to the nearest 0.5 cm using a standiometer with participants wearing no shoes to calculate body mass index (BMI). A research nurse measured resting seated blood pressure by a standardized blood pressure machine. The research nurse assessed TB-related symptoms and obtained a nebulized sputum samples for tuberculosis culture or GeneXpert MTB/RIF assay. All HIV-infected

participants had a CD4+ T-cell count, which was performed at the National Health Laboratory Service lab at Prince Myshenyi Hospital using FACS Calibur System (BD, San Jose, CA). All participants received routine medical care, including CD4 count testing and initiation of ART, according to current South African guidelines.[10]

Primary Outcome Definitions

Participants were classified as having diabetes, pre-diabetes or no diabetes, using standardized definitions by the World Health Organization. Diabetes is defined as a hemoglobin A1c (HbA1c) test of ≥6.5% and pre-diabetes was defined as HbA1c of 5.7-6.4%.[3] In the absence of an HbA1c result, diabetes was considered present if a random blood glucose (RBG) was ≥11.1 mmol/L and pre-diabetes was 7.8-11.1 mmol/L.[3] Those who were classified as not having diabetes had HbA1c levels less than or equal to 5.6% or in the absence of an HbA1c test, they must have a random blood glucose less than 7.8 mmol/L.[3]

Risk Factors and Definitions

Hypertension was defined as a systolic blood pressure of 140 and above or diastolic blood pressure of 90 and above. Pre-hypertension was defined as a systolic blood pressure from 120-139 or diastolic blood pressure from 80-89.[11] We used the defined categories of hypertension from the Seventh Joint National Committee (JNC 7), which are supported by current WHO and CDC hypertension guidelines. Normal blood pressure was defined as systolic (SBP)/diastolic (DBP) <120/80 mmHg; prehypertension was defined as SBP 120-139 mmHg or DBP 80-89 mmHg; stage 1 hypertension was defined as SBP 140-159 mmHg or DBP 90-99

mmHg; and stage 2 hypertension was defined as SBP ≥160 mmHg or DBP ≥100 mmHg. Herein, unless defined, we use "hypertension" as a participant having either stage 1 or stage 2 hypertension.

BMI was calculated as kg/m^2 and was categorized by standard WHO definitions with underweight as a BMI score below 18.5, overweight between 25 and 29.9 and obese over 30.[12] Access to food was determined by a survey using the Household Food Insecurity Access Scale (HFIAS). The HFIAS consists of nine questions about perceptions and behavior responses about their food vulnerability. Participants answered these questions as "rarely", "sometimes" or "often" which were calculated and categorized into "food secure access", "mildly food insecure access", "moderately food insecure access" and "severely food insecure access". Categories were then collapsed into food secure and any level of food insecure.[13]

Statistical Analyses

We described demographic, socioeconomic, and clinical parameters among categories of diabetes, pre-diabetes or no diabetes. We calculated proportions of risk factor categories separated by outcome and a chi-square test was performed by separately comparing pre-diabetes to no diabetes and diabetes to no diabetes. We used a one-way ANOVA test to compare diabetes across all three CD4 count categories with CD4 counts of less than 200 as the referent category. For the risk factor assessment, we combined diabetes with prediabetes among the HIV-infected cohort. We conducted the univariate analysis by calculating odds ratios for each independent variable and performed a Wald test for each variable. In the multivariate analysis, we adjusted for upstream variables: age, sex and education. The results were reported as odds ratios (ORs)

with 95% confidence intervals (CIs), associated two-tailed p-values at the alpha 0.05 level and used Stata 14 (College Station, USA).

Results

We enrolled 1,684 participants, and excluded 636 who did not have either a HbA1c or RBC. Among the remaining 1,048 participants, average age was 33.27 (SD ± 9.12) years (Table 1). Females represented 60.1% of the study participants. Participants were mostly educated with 44.5% having at least a high school education and most were unemployed (56.4%). Incomes were mainly lower with 82.8% of them less than 2,000 ZAR/month, or approximately 150 USD. Most of the participants were food secure (87.3%) and lived within 5 kilometers from the clinic (90.8%). Participants were mostly healthy with BMIs of 18.5-24.9 making up the largest proportion (45.4%) and normal blood pressure was the greatest proportion (41.6%). Only 5.6% of participants had tuberculosis. Most participants did not suffer from substance abuse as 76.3% never used cigarettes and 61.3% never used alcohol.

Prevalence of Diabetes

The prevalence of diabetes was 2.6% (95% CI: 1.7%-3.7%) in the cohort and 7.4% (95% CI: 5.8%-9.1%) had prediabetes (Table 2). The mean HbA1c for participants is 5.98% (SD ± 1.1%) for all participants and a mean random blood glucose of 93.99 mmol/L (SD ± 32.8). Amongst participants who had a CD4 count ≥350 cells/mm^3, 4.7% had diabetes. Amongst those who had a CD4 count between 200 and 350 cells/mm^3, 1.2% of them had diabetes. Amongst those with a CD4 count <200 cells/mm^3, 0.5% have diabetes. For those with CD4 counts ≥ 350 cells/mm^3, the mean HbA1c was 6.05 mmol/L (SD ± 1.3) and a mean random blood glucose of

103.2 mmol/L (SD ± 40.0). For those with CD4 counts between 200 and 350 cells/mm^3, the mean HbA1c was 5.8 mmol/L (SD ± 0.5) and a mean random blood glucose of 97.4 mmol/L (SD ± 21.7). For those with CD4 count <200 cells/mm^3, the mean HbA1c was 5.6 mmol/L (SD ± 0.5) and the mean random blood glucose of 101.3 mmol/L (SD ± 19.0). When comparing mean RBG and HbA1c within categories of CD4 counts, there was no significant difference.

Risk factors for diabetes among HIV-infected.

People with diabetes or pre-diabetes tended to be of older age, female, live farther than 5 kilometers from a clinic, have higher or lower BMI than normal, hypertension, have higher CD4 counts, and have never used cigarettes or alcohol (Table 3).

People over 45 years of age were most likely to have diabetes or prediabetes (Table 4) with an OR of 6.68 (95% CI: 2.62-16.99). Males were less likely to have diabetes or prediabetes with an OR of 0.55 (95% CI: 0.35-0.86). People living > 5 kilometers were more likely to have diabetes or prediabetes with an OR of 2.16 (95% CI: 1.22-3.82). Education, employment, income and food security were not found to differ significantly between those with diabetes or prediabetes and those without.

Among clinical indicators for diabetes, tuberculosis was not found to be significantly different between those with diabetes and prediabetes compared to without either. Patients considered to be underweight (BMI <18.5) were more likely to have diabetes or prediabetes with an OR of 3.01 (95% CI: 1.03-8.84). Obese people had the highest odds of diabetes or prediabetes with an OR of 18.84 (95% CI: 10.03-35.38). Those with hypertension were more likely to have diabetes or prediabetes with an OR of 3.01 (95% CI: 1.81-4.99). Participants with CD4 count > 350 were more likely to have diabetes or prediabetes with an OR of 1.89 (95% CI: 1.03-3.46).

Among indicators of substance abuse, the ORs of cigarettes use in the last month and alcohol use in the last month were 0.29 (95% CI: 0.14-0.60) and 0.54 (95% CI: 0.33-0.88), respectively.

In the multivariate analysis, older age, female sex, living more than 5 kilometers from a clinic, obese people, hypertension, CD4 counts of >350 cells/mm^3 and no cigarette use were associated with having diabetes or prediabetes (Table 4). People aged ≥45 years had 8.50 higher odds of developing diabetes or prediabetes compared to adults <25 years old (95% CI: 3.27-22.07). Females were 2.20 times more likely to have diabetes or prediabetes, on average, compared to females (95% CI: 1.16-2.84). Participants living greater than 5 kilometers from a clinic were 98% more likely to have prediabetes or diabetes than participants <5 kilometers (95% CI: 1.11-3.55). Obese participants had an odds 23.60 times greater to have diabetes or prediabetes, on average, compared to somebody of normal BMI (95% CI: 11.41-48.85). Participants with hypertension were 2.64 times more likely, on average, to have diabetes or prediabetes, compared to those without hypertension (95% CI: 1.55-4.49). Participants with a CD4 count >350 cells/mm^3 were 97% more likely to have prediabetes or diabetes (95% CI: 1.06-3.67). Using cigarettes in the last month was 66% less likely to have prediabetes or diabetes (95% CI: 0.15-0.76). The adjusted odds ratios for participants with underweight BMI and no alcohol use were not found to be significant.

Discussion

In this cohort of newly-diagnosed HIV-infected individuals in Durban, South Africa, we found that the risk factors that were significantly associated with having diabetes or prediabetes were people who were 45 years of age or older, female sex, living more than 5 kilometers from a clinic, obese individuals of a BMI over 30, hypertension, and CD4 counts greater than 350

cells/mm^3 and no cigarette use. We found that underweight BMI and never using alcohol were associated with diabetes and prediabetes in the univariate analysis but when controlling for education, sex and age were not associated. Screening for diabetes is possible at HIV testing, and can be targeted to certain risk groups.

The prevalence of diabetes was on the lower range compared to previous studies on HIV-negative populations in South Africa.[9] This was probably due to the study population was younger compared to the general population. Similar to prior studies older age was associated with greater risk of diabetes or prediabetes.[8] However, we found female sex to be associated, contrary to other studies. This is probably due to our study population had more obese women than men. In addition, clinical indicators such as obesity based on BMI were associated with higher diabetes and prediabetes.[8] In a review paper of HIV-negative individuals, nutrition and socioeconomic factors were contributors to a higher risk of diabetes in Sub-Saharan Africa.[8] Lack of education, low income, unemployment and food insecurity were not found to be associated. Our study found that smokers were less likely to have diabetes or prediabetes which is counter to what most studies have shown but we believe this only to be because the classification of smokers was by use of cigarettes in the previous month and not a prolonged exposure.[14] There has been one other study shown to have a protective effect for current smokers on risk of diabetes amongst HIV-positive individuals.[15] Prior research shows that very low food security is associated with a 67% lower odds of glycemic control in PWLHIV.[16] In a sub-analysis of food security and only diabetes, there appears to be some evidence that people with severe food insecurity have a higher odds of diabetes but our study may not have the statistical power to detect a significant difference. People who lived farther from the clinic were more likely to have prediabetes or diabetes. This is probably an indicator of access to healthcare. This

analysis was one of the only studies to assess risk factors for diabetes among HIV-infected individuals in Sub-Saharan Africa compared to other studies conducted in developed countries.[15,16,17]

Prior studies have shown that diabetes and tuberculosis may be associated, but the causal relationship has been uncertain.[5,6] Our study showed no association between tuberculosis and diabetes or prediabetes but could be contributed to lack of temporality in our study design. In our study, hypertension was associated with a greater odds of diabetes or prediabetes in the multivariate analysis. While hypertension is not considered a cause of diabetes, it is a common comorbidity.[19] CD4 counts greater than 350 was found to be associated with diabetes or prediabetes in our multivariate analysis. In previous studies, one did find a greater risk for diabetes amongst CD4 counts greater than 500 in the univariate analysis but not in the multivariate analysis.17 Other studies have found no association.[18,20] There is a theory that hyperglycemia enhances CD4 cell counts in HIV-uninfected.[21] Future studies should explore whether CD4 cell counts affect diabetes.

Our study utilized a large sample size in order to detect differences in risk factors, but had several limitations. Our study lacked complete data on HbA1c, a measure that is better in detecting diabetes than RBG. In a sub-analysis we compared risk factor characteristics between HbA1c and RBG. There were not substantial differences between the two measures except for BMI where over 90% of people with diabetes or prediabetes based on HbA1c were considered to have a BMI over 30. Our study had incomplete data on HIV viral load or antiretroviral therapy since our study consisted of treatment naïve individuals. HIV drug treatments can contribute to adverse metabolic complications and we were unable to assess (Hardigan 2014).

In conclusion, participants who were obese, living greater than 5 kilometers from the clinic, CD4 cell counts greater than 350 or older females were most likely to have diabetes or prediabetes at HIV diagnoses. They were not aware of their HIV status or receiving treatment prior to entering the study. Our study shows that the risk factors for diabetes in a cohort of HIV- individuals do not substantially differ from those without HIV. Future prospective studies are needed to evaluate whether HIV-specific clinical indicators are risk factors of diabetes, especially whether CD4 counts contribute to a higher risk of diabetes.

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Conflict of Interest Statement

We declare that we have no conflicts of interest.

References

1. Young F, Critchley JA, et al. A review of co-morbidity between infectious and chronic disease in Sub-Saharan Africa: TB and diabetes mellitus, HIV and metabolic syndrome, and the impact of globalization. *Global Health.* 2009 Sep 14;5:9.
2. WHO. About Diabetes. 2014. https://web.archive.org/web/20140427013458/http://www.who.int/diabetes/action_online/basics/en/index1.html
3. WHO. HbA1c in the diagnosis of type 2 diabetes.2016. http://www.who.int/diabetes/publications/sys_rev_hba1c_web.pdf
4. Smith et al. Factors associated with specific causes of death amongst HIV-positive individuals in the D:A:D study. *AIDS*. 2010; 24: 1537-1548.
5. Hardigan C, Kattakuzhy S. Diabetes mellitus type II and abnormal glucose metabolism in the setting of HIV. *Endocrinology Metabolic Clin North Am.* 2014 Sept;43(3):685-696.
6. Jeon CY, Murray MB. Diabetes mellitus increases the risk of active tuberculosis: a systematic review of 13 observational studies. *Plos Medicine.* 2008 July;5(7):e152.
7. Ronacher K, Joosten SA, et al. Acquired immunodeficiencies and tuberculosis: focus on HIV/AIDS and diabetes mellitus. *Immunological Reviews.* 2015; 264: 121-137.
8. Tuei VC, Maiyoh GK, Ha C. Type 2 diabetes mellitus and obesity in sub-Saharan Africa. *Diabetes/Metabolism Research and Reviews.* 2010;26:433-445.
9. Hall V, Thomsen RW, et al. Diabetes in Sub Saharan Africa 1999-2022: Epidemiology and public health implications. A systematic review. *BMC Public Health*. 2011; 11: 564.
10. Republic of South Africa Department of Health. The South African antiretroviral treatment guidelines. 2013.

11. WHO, International Society of Hypertension Writing Group. 2003 World Health Organization (WHO)/International Society of Hypertension (ISH) statement on management of hypertension. *Journal of Hypertension*. 2003;21(11):1983-1992.
12. WHO. Global Database on Body Mass Index. 2004. http://apps.who.int/bmi/index.jsp?introPage=intro_3.html
13. Coates, Jennifer, Anne Swindale and Paula Bilinsky. Household Food Insecurity Access Scale (HFIAS) for Measurement of Household Food Access: Indicator Guide (v. 3). Washington, D.C.: Food and Nutrition Technical Assistance Project, Academy for Educational Development, August 2007.
14. Pan A, Wang Y, Talaei M, et al. Relation of active, passive, and quitting smoking with incident diabetes: a meta-analysis and systematic review. *Lancet Diabetes Endocrinology.* 2015 Dec;3(12):958-967.
15. De Wit S, Sabin CA, Weber R, et al. Incidence and risk factors for new-onset diabetes in HIV-infected patients. *Diabetes Care.* 2008;31:1224-1229.
16. Palar K, Frongillo EA, Wilson T, et al. Food insecurity is associated with poor diabetes control in the women's Interagency HIV Study. Poster presented at the CROI conference, Seattle, WA. 2017 Feb.
17. Butt AA, McGinnis K, Rodriguez-Barradas MC, et al. HIV infection and risk of diabetes mellitus. *AIDS.* 2009;23(10):1227-1234.
18. Ledergerber B, Furrer H, Rickenbach M, et al. Factors associated with the incidence of type 2 diabetes mellitus in HIV-infected participants in the Swiss HIV cohort study. *Clinical Infectious Diseases*. 2007;45:111-119.

19. Dobesh PP. Managing hypertension in patients with type 2 diabetes mellitus. *American Journal of Health-System Pharmacy*. 2006 Jun;63(12):1140-9.

20. Moyo D, Tanthuma G, Cary MS, et al. Cohort study of diabetes in HIV-infected adults evaluating the effect of diabetes mellitus on immune reconstitution. *Diabetes Research and Clinical Practice.* 2014 March;103(3):e34-e36.

21. Giubilato S, Liuzzo G, Brugaletta S, et al. Expansion of $CD4^{+}CD28^{null}$ T-lymphocytes in diabetic patients: exploring new pathogenic mechanisms increased cardiovascular risk in diabetes mellitus. *European Heart Journall*. 2011;32:1214-1226.

Table 1: Description of Cohort

	Female (n=630)	**Male (n=418)**	**Total Cohort (n=1,048)**
Demographics	**n(%)**	**n(%)**	**n (%)**
Age (years)			
18-24	136 (21.7%)	32 (7.7%)	168 (16.1%)
25-34	308 (49.1%)	207 (49.5%)	515 (49.3%)
35-44	122 (19.5%)	124 (29.7%)	246 (23.5%)
45+	61 (9.7%)	55 (13.2%)	116 (11.1%)
Race			
Zulu	475 (93.9%)	340 (92.4%)	815 (93.3%)
Xhosa	24 (4.7%)	9 (2.5%)	33 (3.8%)
Other South African	7 (1.4%)	16 (4.3%)	23 (2.7%)
Other Nationality	0 (0%)	3 (0.8%)	3 (0.3%)
Socioeconomic			
Education			
None	126 (20.0%)	98 (23.4%)	224 (21.4%)
Primary school or some high school	218 (34.6%)	140 (33.5%)	358 (34.2%)
High school graduate or higher	286 (45.4%)	18 (43.1%)	466 (44.5%)
Employment			
Unemployed	402 (63.8%)	189 (45.2%)	591 (56.4%)
<20 hours/week	200 (31.8%)	198 (47.4%)	398 (38.0%)
>20 hours/week	28 (4.4%)	31 (7.4%)	59 (5.6%)
Income			
<2,000 ZAR/month	543 (86.5%)	320 (77.3%)	863 (82.8%)
>2,000 ZAR/month	85 (13.5%)	94 (22.7%)	179 (17.2%)
Food Insecurity			
Food secure	456 (86.8%)	368 (88.0%)	914 (87.3%)
Food insecure (mild, moderate, severe)	83 (13.2%)	50 (12.0%)	133 (12.7%)
Distance from Clinic			
<5 Kilometers	569 (90.6%)	381 (91.2%)	950 (90.8%)

≥5 Kilometers	59 (9.4%)	37 (8.9%)	96 (9.2%)
Clinical			
BMI			
<18.5	23 (3.7%)	46 (11.0%)	69 (6.6%)
18.5-24.9	213 (33.9%)	262 (62.7%)	475 (45.4%)
25-29.9	174 (27.7%)	76 (18.2%)	250 (23.9%)
30+	219 (34.8%)	34 (8.1%)	253 (24.2%)
Hypertension			
Normal (<120 SBP & <80 DBP)	272 (43.3%)	163 (39.0%)	435 (41.6%)
Prehypertension (120-139 SBP or 80-89 DBP)	228 (36.3%)	138 (33.0%)	366 (35.0%)
Hypertension (140+ SBP or 90+ DBP)	128 (20.4%)	117 (28.0%)	245 (23.4%)
Tuberculosis			
Negative	598 (94.9%)	391 (93.5%)	989 (94.4%)
Positive	32 (5.1%)	27 (6.5%)	59 (5.6%)
Substance Abuse			
Cigarette Use			
Never Used	582 (92.5%)	216 (51.8%)	798 (76.3%)
Used, not in last month	11 (1.8%)	16 (3.8%)	27 (2.6%)
Used in last month	36 (5.7%)	185 (44.4%)	221 (21.1%)
Alcohol Use			
Never Used	467 (74.2%)	174 (41.8%)	641 (61.3%)
Used, but not in last month	38 (6.0%)	34 (8.2%)	72 (6.9%)
Used in last month	124 (19.7%)	208 (50.0%)	332 (31.8%)

Table 2: Mean glucose, hemoglobin A1c and prevalence of diabetes among HIV-infected by CD4.

Variable	Total N(%)	CD4 >350 N(%)	CD4 200-350 N(%)	CD4 ≤200 N(%)
Diabetes	27 (2.6%)	14 (4.7%)	2 (1.2%)	1 (0.5%)
Prediabetes	77 (2.6%)	28 (9.3%)	9 (5.4%)	15 (7.4%)
No Diabetes	944 (90.1%)	259 (86.1%)	155 (93.4%)	186 (92.1%)
	Mean ± SD	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**
Hemoglobin A1c	5.98 ± 1.1	6.05 ± 1.3	5.8 ± 0.5	5.6 ± 0.5
Random Blood Glucose	94.0 ± 32.8	103.2 ± 40.0	97.4 ± 21.7	101.3 ± 19.0

Table 3: Descriptive statistics for the entire cohort of diabetes, prediabetes and no diabetes assessed by random blood glucose and HbA1c.

	No Diabetes (n=944)	**Prediabetes (n=77)**	**p-value**	**Diabetes (n=27)**	**p-value**
Demographics					
Age (years)					
18-24	162 (17.2%)	6 (7.8%)	**0.003**	0 (0%)	**0.02**
25-34	468 (49.7%)	35 (45.5%)		12 (44.4%)	
35-44	218 (23.2%)	19 (24.7%)		9 (33.3%)	
45+	93 (9.9%)	17 (22.1%)		6 (22.2%)	
Sex					
Male	389 (41.2%)	25 (32.5%)	0.133	4 (14.8%)	**0.006**
Female	555 (58.8%)	52 (67.5%)		23 (85.2%)	
Socioeconomic					
Education					
None	195 (20.7%)	20 (26.0%)	0.423	9 (33.3%)	0.469
Primary school or some high school	327 (34.6%)	24 (31.2%)		7 (25.9%)	
High school graduate or higher	422 (44.7%)	33 (42.9%)		11 (40.7%)	
Employment					
No	532 (56.4%)	47 (61.0%)	0.062	12 (44.4%)	0.461
<20 hours/week	363 (38.5%)	22 (28.6%)		13 (48.2%)	
>20 hours/week	49 (5.2%)	8 (10.4%)		2 (7.4%)	
Income					
<2,000 ZAR/month	777 (82.8%)	63 (82.9%)	0.974	23 (85.2%)	0.741
>2,000 ZAR/month	162 (17.3%)	13 (17.1%)		4 (14.8%)	
Food Insecurity					
Food secure	823 (87.3%)	69 (89.6%)	0.552	22 (81.5%)	0.376
Food insecure (mild, moderate, severe)	120 (12.7%)	8 (10.4%)		5 (18.5%)	
Distance from Clinic					
< 5 kilometers	864 (91.6%)	65 (85.5%)	0.072	21 (77.8%)	**0.012**
≥5 kilometers	79 (8.4%)	11 (14.5%)		6 (22.2%)	

Clinical					
BMI					
<18.5	64 (6.8%)	4 (5.2%)	<**0.001**	1 (3.7%)	<**0.001**
18.5-24.9	463 (49.1%)	11 (14.3%)		1 (3.7%)	
25-29.9	246 (26.1%)	3 (3.9%)		1 (3.7%)	
30+	170 (18.0%)	59 (76.6%)		24 (88.9%)	
Hypertension					
Normal	407 (43.2%)	23 (29.9%)	**0.013**	5 (18.5%)	<**0.001**
Prehypertension	332 (35.2%)	27 (35.1%)		7 (25.9%)	
Hypertension	203 (21.6%)	27 (35.1%)		15 (55.6%)	
Tuberculosis					
Negative	890 (94.3%)	74 (96.1%)	0.503	25 (92.6%)	0.711
Positive	54 (5.7%)	3 (3.9%)		2 (7.4%)	
CD4 Count					
>350 cells/mm^3	259 (43.2%)	28 (53.9%)	0.262	14 (82.4%)	**0.005**
201-350 cells/mm^3	155 (25.8%)	9 (17.3%)		2 (11.8%)	
≤200 cells/mm^3	186 (31.0%)	15 (28.9%)		1 (5.9%)	
Substance Abuse					
Cigarette Use					
Never Used	706 (74.9%)	67 (88.2%)	**0.024**	25 (92.6%)	0.065
Used, but not in last month	24 (2.6%)	2 (2.6%)		1 (3.7%)	
Used in last month	213 (22.5%)	7 (9.2%)		1 (3.7%)	
Alcohol Use					
Never Used	566 (60.2%)	51 (66.2%)	0.561	24 (88.9%)	**0.005**
Used, but not in last month	65 (6.9%)	5 (6.5%)		2 (7.4%)	
Used in last month	310 (32.9%)	21 (27.3%)		1 (3.7%)	

Table 4: Odds ratios for the association between baseline characteristics and diabetes or prediabetes in the entire cohort, using random blood glucose and hemoglobin A1c to classify diabetes (N=1,048)

	# diabetic / total at risk	Unadjusted OR (95% CI)	p-value	Adjusted† OR (95% CI)	p-value
Demographics					
Age (years)					
18-24	6/168 (3.6%)	ref	-	ref	-
25-34	47/515 (9.1%)	2.71 (1.14-6.46)	**0.024**	**3.12 (1.30-7.48)**	**0.011**
35-44	28/246 (11.4%)	3.47 (1.40-8.57)	**0.007**	**4.24 (1.68-10.69)**	**0.002**
45+	23/116 (19.8%)	6.68 (2.62-16.99)	**<0.001**	**8.50 (3.27-22.07)**	**<0.001**
Sex					
Male	29/418 (6.9%)	ref	-	ref	-
Female	75/630 (11.9%)	1.81 (1.16-2.84)	**0.009**	**2.20 (1.39-3.48)**	**0.001**
Socioeconomic					
Education					
High school graduate or higher	44/466 (9.4%)	ref	-	ref	-
Primary school or some high school	31/358 (8.7%)	0.91 (0.56-1.47)	0.699	0.75 (0.45-1.23)	0.256
None	29/224 (13.0%)	1.43 (0.86-2.35)	0.163	1.16 (0.69-1.96)	0.573
Employment					
Unemployed	59/591 (10.0%)	ref	-	-	-
<20 hours/week	35/398 (8.8%)	0.87 (0.56-1.35)	0.532	0.85 (0.54-1.34)	0.481
>20 hours/week	10/59 (17.0%)	1.84 (0.89-3.82)	0.102	1.94 (0.90-4.19)	0.091
Income					
>2,000 ZAR/month	17/179 (9.5%)	ref	-	-	-
<2,000 ZAR/month	86/863 (10.0%)	0.95 (0.55-1.64)	0.849	1.08 (0.61-1.94	0.789
Food Security					
Food Secure	91/914 (10.0%)	ref	-	-	-
Food Insecure (mild, mod, severe)	13/133 (9.8%)	0.97 (0.53-1.81)	0.948	0.97 (0.52-1.83)	0.934
Distance from Clinic					
<5 Kilometers	86/950 (9.1%)	ref	-	-	-

≥5 Kilometers	17/96 (17.7%)	2.16 (1.22-3.82)	**0.008**	**1.98 (1.11-3.55)**	**0.022**
Clinical					
BMI					
<18.5	5/69 (7.3%)	3.01 (1.03-8.84)	**0.044**	2.87 (0.97-8.49)	0.057
18.5-24.9	12/475 (2.5%)	ref	-	ref	-
25.0-29.9	4/250 (1.6%)	0.63 (0.20-1.97)	0.424	0.68 (0.21-2.16)	0.511
30+	83/253 (32.8%)	18.84 (10.03-35.38)	**<0.001**	**23.60 (11.41-48.85)**	**<0.001**
Hypertension					
Normal	28/435 (6.4%)	ref	-	-	-
Prehypertension	34/366 (9.3%)	1.49 (0.88-2.51)	0.134	1.39 (0.82-2.36)	0.226
Hypertension	42/245 (17.1%)	3.01 (1.81-4.99)	**<0.001**	**2.64 (1.55-4.49)**	**0.001**
Tuberculosis					
Negative	99/989 (10.0%)	ref	-	-	-
Positive	5/59 (8.5%)	0.83 (0.33-2.13)	0.702	0.73 (0.28-1.89)	0.515
CD4 Count					
≤200 cells/mm^3	16/202 (7.9%)	ref	-	-	-
201-350 cells/mm^3	11/166 (6.6%)	0.83 (0.37-1.83)	0.636	0.83 (0.37-1.86)	0.644
>350 cells/mm^3	42/301 (14.0%)	1.89 (1.03-3.46)	**0.040**	**1.97 (1.06-3.67)**	**0.033**
Substance Abuse					
Cigarettes Use					
Never Used	92/798 (11.5%)	ref	-	ref	-
Used, but not in last month	3/27 (11.1%)	0.96 (0.28-3.25)	0.947	1.19 (0.34-4.19)	0.792
Used in last month	8/221 (3.6%)	0.29 (0.14-0.60)	**0.001**	**0.34 (0.15-0.76)**	**0.008**
Alcohol Use					
Never used	75/641 (11.7%)	ref	-	-	-
Used, but not in last month	7/72 (9.7%)	0.81 (0.36-1.84)	0.618	0.91 (0.39-2.11)	0.830
Used in last month	22/332 (6.6%)	0.54 (0.33-0.88)	**0.013**	0.69 (0.40-1.17)	0.166

†Adjusted for age, sex and education.