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Patient retention from HIV diagnosis through one year on antiretroviral therapy at a primary healthcare clinic in Johannesburg, South Africa

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Abstract

Objective—To compare patient retention at three stages of pre-antiretroviral (ART) care and two stages of post-ART care to identify when greatest attrition occurs.

Design—An observational cohort study.

Methods—We reviewed files of all adult, non-pregnant individuals testing HIV-positive January 1 – June 30, 2010, at a primary health clinic in Johannesburg, South Africa (N=842). We classified retention in pre-ART stage 1 (HIV diagnosis to CD4 results notification in 3 months), pre-ART stage 2 (initially ineligible for ART with repeat CD4 test 1 year of prior CD4), pre-ART stage 3 (initiating ART 3 months after first eligible CD4 result), as well as at 0–6 and 6–12 months post-ART.

Results—Retention among all patients during pre-ART stage 1 was 69.8% (95%CI 66.7–72.9%). For patients initially ART-ineligible (n=221), 57.4% (95%CI 49.5–65.0%) returned for a repeat CD4 during pre-ART stage 2. Among those ART-eligible (n=589), 73.5% (95%CI 69.0–77.6%) were retained during pre-ART stage 3. Retention increased with time on ART, from 80.2% (95%CI 75.3–84.5%) at 6 months to 95.3% (95%CI 91.7–97.6%) between 6–12 months. Cumulative retention from diagnosis to 12 months on ART was 36.9% (95%CI 33.0–41.1%) for

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those ART-eligible and 43.0% (95%CI 36.4–49.8%) from diagnosis to repeat CD4 testing within one year among those ART-ineligible.

Conclusions—Patient attrition in the first year following HIV diagnosis was greatest prior to ART initiation: over 25% at each of three pre-ART stages. As countries expand HIV testing and ART programs, success will depend on linkage to care, especially prior to ART eligibility and initiation.

Keywords

HIV/AIDS; antiretroviral therapy (ART); retention; attrition; linkage to care; South Africa

Introduction

South Africa's national antiretroviral therapy (ART) program is currently the largest in the world, with over 1.7 million adults and children enrolled in the first seven years.^{1,2} Rapid scale-up has put tremendous pressure on the limited resources of the public health sector. Despite the fact that 300,000 patients enroll in the South African ART program each year,³ an estimated 250,000 people died of AIDS in 2010⁴ and only 52% of those currently ART-eligible are receiving treatment.²

An enormous challenge to South Africa's attempts to expand the impact of its program is attrition from HIV care. Uninterrupted retention for HIV patients is critical as patients who stop treatment are at increased risk of drug resistance, morbidity and mortality.^{5,6} Several studies have documented rates of retention on ART in resource-limited settings,^{7–11} and have demonstrated that during the first year on HIV treatment patients are at high risk for attrition (i.e., programmatic loss and mortality).^{9,12,13} More recent work has documented high rates of attrition among patients not yet on ART from the time of testing positive to completion of CD4 staging,^{14,15} from completing staging to repeat CD4 testing for ART eligibility,^{16,17} and from ART eligibility to ART initiation.^{16,18,19}

While these studies highlight a problem with attrition from HIV care, three major limitations impede conclusions about the extent of the problem. First, progression through the consecutive stages of HIV care (e.g., testing positive, CD4 staging, ART initiation) are typically studied in isolation among distinct cohorts which prevents a measure of overall program attrition from the time of testing positive through long-term ART. To our knowledge, only one study has examined retention through pre-ART and post-ART stages among patients in Southern Africa. Using data from the first year of the public ART program (2004–2005) in Mozambique, Micek et al. reported data from separate HIV testing and treatment facilities and found retention was lowest at the period of enrollment at the ART sites (56.5%) and for timely ART initiation among ART-eligible (31.3%), but did not report cumulative retention through all stages or describe retention among patients ineligible for ART.²⁰ Second, operational definitions of patient retention differ greatly between studies, limiting comparability. Recommendations for standardized definitions for pre-ART care have recently been proposed,²¹ allowing for estimates that can be compared across programs and countries. Third, most national HIV programs do not report retention indicators during pre-ART care, so we currently have no way of quantifying the magnitude of loss to initiation at the country level.

To address the limited longitudinal measures of attrition from HIV care across multiple stages of care, we set out to measure attrition through five stages of early HIV care at a single site in a cohort of patients testing positive using the newly recommended definitions.

Methods

Study setting

Witkoppen Health and Welfare Centre (“Witkoppen”) is a high-volume (8,500 patient visits per month) primary healthcare clinic in Johannesburg, South Africa, operated by a non-governmental organization receiving public and private financial support. Witkoppen provides HIV/AIDS services, integrated TB/HIV care, pre/post-natal care, chronic care, mental health services and social welfare assistance to a primarily low-income population residing in densely-populated peri-urban formal and informal settlements in northern Johannesburg.

Pre-ART care at Witkoppen begins at the time of testing HIV positive using two simultaneous rapid dried blood spot tests, with results available in about 20 minutes. Blood for CD4 testing is drawn at the clinic on the same day a patient receives a positive HIV result and is sent to an off-site National Health Laboratory Services (NHLS) facility. Patients are scheduled to return for CD4 results 2–4 weeks after testing positive. At this second visit, ART-eligible patients attend a first adherence counseling session and are examined by a clinician. Blood is collected for additional baseline tests, and they are scheduled to return 2–4 weeks later for a second adherence counseling session and ART initiation. Patients initially ineligible for ART receive counseling about their CD4 result, are examined by a clinician, and are scheduled to return for a follow-up CD4 test within six months. Patients—both pre-ART and on-ART—who miss scheduled appointments are to be phoned by clinic staff for rebooking, and if untraceable, to be referred for community outreach tracing.

ART is initiated on-site by doctors and qualified nurses. Patients at Witkoppen are generally treated according to the South African National Treatment Guidelines,²² with an important exception. In 2010, Witkoppen began initiating all HIV-positive patients with a CD4 count 350 cells/mm^3 , a year before South Africa adopted this policy nationwide.²³

Study design

We conducted an observational cohort study through retrospective clinical record review of all non-pregnant adult individuals at Witkoppen testing HIV-positive for the first time between 01 January–30 June 2010 (N=969). Starting with a roster of eligible patients sourced from the clinic’s monthly HIV testing statistics, we excluded patients whose paper files could not be located after three separate attempts using the clinic number provided and were unlisted in TherapyEdge-HIV™, the electronic clinic HIV patient database (N=125), suggesting an invalid clinic ID number or erroneous inclusion on the list of eligible patients. We also excluded two patients who transferred facilities immediately after testing HIV-positive. For the 842 patients included in the analysis, we reviewed clinic files after a minimum of 12 months (median 16.5 months, IQR 14.8–18.1) from the time of testing HIV-positive or at least 12 months post-initiation for those who were initially eligible for ART. Data were collected using Microsoft Excel 2010 (Microsoft Corp., Redmond, WA).

Approval for this study was granted by the Human Research Ethics Committee of the University of the Witwatersrand and the Institutional Review Board of the University of North Carolina at Chapel Hill.

Definition of study variables

Retention was defined as remaining alive and in care at Witkoppen and was determined using clinic visit dates. Attrition refers to both loss to follow-up (no clinic attendance 3 months after last scheduled visit) and death but does not include transfers. Patients who

transfer are removed from the analysis at the start of the stage in which they transferred. Missed visits among patients who returned to care and treatment interruptions do not contribute to our definition of retention. We defined three stages of pre-ART care²⁴ using standardized definitions²¹ for retention in each stage as defined in Table 1. For pre-ART stage 1, we report the proportion of patients who complete CD4 staging within three months after testing HIV-positive. For pre-ART stage 2, we report the proportion of patients not eligible for ART who received a second CD4 test within one year after the first CD4 staging. Patients eligible for ART at the time of HIV diagnosis skip pre-ART stage 2 and move directly to pre-ART stage 3, where we report the proportion of patients initiating ART within three months after being determined ART-eligible. Eight patients (0.9%) reported initiating ART at other facilities without transferring out and returned to Witkoppen, so the date initiated elsewhere was used. We report post-ART retention at six and 12 months after ART initiation. Retention within a stage is dependent on successfully completing the prior stage. Cumulative retention analyses exclude patients who transferred during the stages reported (n=59).

We defined initial CD4 count as the value at the time of testing HIV-positive. ART-eligibility at the time of testing HIV-positive was confirmed during the file review and is generally defined as a CD4 count ≥ 350 cells/mm³; however 23 patients with CD4 values 200–350 were considered ineligible for ART due to clinician non-compliance with the clinic's ART guidelines and three patients with CD4 > 350 were considered eligible at clinician discretion. TB treatment was defined as initiating TB treatment within one year of testing HIV-positive. For patients with an available South African ID number (33.9% of patients lost to follow-up) mortality was confirmed using the National Population Register of the South African Department of Home Affairs.²⁵

Statistical analysis

Patient characteristics at the time of testing HIV-positive were summarized using counts and proportions for categorical variables and medians and interquartile ranges (IQRs) for continuous variables. We report retention at the three stages of pre-ART care and two ART time points as counts and proportions with 95% confidence intervals (95%CI). We identified predictors of any pre-ART or post-ART attrition by estimating adjusted risk ratios (aRR) and 95%CI obtained by log-binomial regression analysis.

Results

Characteristics of the 842 eligible patients are summarized in Table 2. Overall, 55.1% were female. Patients were a median (IQR) of 34 years (28–40) and had a median (IQR) initial CD4 count of 211.5 (92–350) cells/mm³. Nearly half (41.5%) were born outside South Africa, mostly in Zimbabwe (75.9% of foreign-born), and 72.6% tested HIV-positive on their first visit to Witkoppen. Initial CD4 values were not available for 32 patients (3.8%) due to the patient leaving prior to CD4 testing (n=25) or missing lab results (n=7) and never returning for repeat testing. Of the remainder, 589 (72.7%) were ART-eligible when testing HIV-positive. Nearly 11% of patients initiated TB treatment within a year of HIV testing.

Patient retention by stage

Retention through each of stage of pre- and post-ART care is shown in Figure 1, while Figure 2 shows cumulative continuous retention through all stages of early HIV care. Among patients newly-diagnosed with HIV, the greatest attrition occurred in pre-ART care, with over 25% attrition at each of the three pre-ART stages (Figure 1) among those remaining in care at the beginning of each stage. Overall retention in pre-ART stage 1 was 69.8% (95%CI 66.7%–72.9%) and included 32 subjects with no CD4 count, none of whom

completed the stage. When limited to those with a CD4 count, retention was somewhat higher for those ineligible for ART than those eligible when testing HIV positive (76.5% vs. 71.1%, respectively). The lowest proportion retained was in pre-ART stage 2 among those ART-ineligible, with only 57.4% (95% CI 49.5–65.0%) of those who returned for their initial CD4 results returning for a repeat CD4 test within one year. Median (IQR) CD4 value at repeat testing among those previously ineligible for ART was 424 cells/mm³ (337–570) with 32.6% ART-eligible at their second CD4 staging. Retention after ART initiation was higher than the pre-ART stages at 80.2% (95% CI 75.3–84.5%) between 0–6 months and 95.3% (95% CI 91.7–97.6%) between 6–12 months.

The cumulative proportion of patients who were ART-eligible when testing HIV-positive who remained in care through 12 months on ART was only 36.9% (95% CI 33.0–41.1%), and among those ART-ineligible, 43.0% (95% CI 36.4–49.8%) were retained within one year of initial CD4 staging (Figure 2). While attrition at each stage is substantial, overall attrition steadies over time. Among those completing a stage (or retained for pre-ART stage 2), the median (IQR) time to completing stage 1 (testing to completing staging) was 16 days (9–28), stage 2 (completing staging until a repeat CD4 count) was 162 days (138–186), and stage 3 (ART eligibility to ART initiation) was 23 days (12–36), suggesting most patients who complete a stage do so within the defined time periods.

During the study period, 48 (5.7%, 95% CI 4.3–7.4%) patients died, however when we limit this to the 38.8% (n=327) of the sample with a valid South Africa ID, mortality doubles to 11.9% (95% CI 8.7–15.8%). Initial CD4 results are available for 46 (95.8%) of the deceased patients; of these, 87.0% were eligible for ART. Patients who died had a lower median initial CD4 count (105 cells/mm³, IQR 49–169) than those who did not (225 cells/mm³, IQR 101–354), but did not differ from the overall cohort in terms of age, sex or TB treatment. Among ART-eligible patients, 2.5% (95% CI 1.5–4.1%) of patients in pre-ART stage 1 and 3.9% (95% CI 2.4–6.2%) of patients in pre-ART stage 3 died. Following ART initiation, 2.4% (95% CI 1.1–4.8%) of patients died with less than six months on treatment and 1.0% (95% CI 0.2–3.1%) with more than six months on ART. Among patients who were ART-ineligible, none died during pre-ART stage 1 and 2.7% (95% CI 1.1–5.6%) of patients in pre-ART stage 2 died. Overall, 77.5% of ART-eligible patients who died did not initiate ART.

Predictors of pre-ART and post-ART attrition

Younger age (18–29 years) was associated with increased attrition in the pre-ART stages (aRR 1.56, 95% CI 1.21, 2.00), and possibly after ART initiation (aRR 1.27, 95% CI 0.76, 2.13), compared to age 30–39 (Table 3). An initial CD4 <50 cells/mm³ predicted increased attrition before (aRR 1.51, 95% CI 1.08, 2.12) and after ART initiation (aRR 2.30, 95% CI 1.15, 4.63), compared to an initial CD4 200–350 cells/mm³. Male sex was associated with increased likelihood of attrition before ART (aRR 1.47, 95% CI 1.16, 1.87), but not after ART initiation (aRR 0.76, 95% CI 0.45, 1.28). Patients born outside of South Africa tended to fail to complete 12 months on ART (aRR 1.48, 95% CI 0.92, 2.40) compared to their South African counterparts. TB treatment was strongly associated with decreased attrition in the pre-ART stage (aRR 0.04, 95% CI 0.01, 0.27), but not following ART initiation (aRR 1.42, 95% CI 0.79, 2.53).

Discussion

Retention in HIV care from the time of testing positive through lifelong ART treatment is critical for getting patients onto treatment promptly and for preventing morbidity and mortality associated with disease progression. This study, one of the first to follow a consistent cohort of newly-diagnosed HIV-positive patients over a year through the various stages of pre-ART and early ART care, allowed us to summarize attrition throughout early

HIV care. Our findings paint a stark picture—the proportion of patients ART-eligible when testing positive retained continuously in care through one year on ART was under 40%. This suggests that the majority of patients in our study continued to be at high risk of HIV-associated death and opportunistic infections despite knowing their HIV-positive status.

This finding is consistent with a previous review of sub-Saharan African studies that estimated overall retention in pre-ART care to be 33%.²⁴ One critical problem however with summarizing previous studies' results is a lack of consistent definitions of retention and time periods over which retention was measured. Thus while many studies have previously documented high pre-ART^{14–18} and on-ART attrition^{7–11} at specific stages in care, our finding of substantial patient loss throughout the stages of early HIV care is one of the only studies to document this in a single cohort of ART-eligible and ineligible patients using standardized definitions.²¹ Studies that only investigate retention in disjointed cohorts are also unable to comment on the timing of attrition. We found that the pre-ART periods are a time of considerable loss, with over one-quarter of patients still in care lost at each stage.

Our results also document the challenge of retention among patients ineligible for ART at the time of testing positive for HIV. Given that South Africa guidelines call for repeat CD4 testing every six months,²² the pre-ART stage 2 definition used gives patients ample time to return. Despite this, we found only 57.4% (95% CI 49.5–65.0%) of ART-ineligible individuals completed a repeat CD4 count within one year. This is true despite the fact that pre-ART services were available at the same clinic where the patient completed HIV testing and CD4 staging and did not require visiting a separate location. While low, our retention results are higher than other recent studies from South Africa which have shown retention for patients not yet eligible for ART to be between 36.0% and 46.3%,^{16,17} and consistent with a meta-analysis result of 54.2% among ART-ineligible patients in sub-Saharan Africa.²⁶

The majority of patients in our study were ART-eligible when testing positive for HIV under the site's threshold of a CD4 count ≥ 350 cells/mm³. Among these eligible patients, for whom moving from HIV diagnosis to CD4 staging to ART initiation can be completed within two to eight weeks, attrition was greatest in pre-ART care. In just these few first weeks, patient attrition was 28.9% (95% CI 25.3–32.6%) from testing to CD4 staging and 26.5% (95% CI 22.4–31.0%) from ART eligibility to ART initiation. For those who initiated treatment, attrition 0–12 months after ART initiation remained high overall at 25.0% (95% CI 20.1–30.4%), but most attrition occurred during 0–6 months on ART (19.8%, 95% CI 15.5–24.7%) and stabilized between 6–12 months on ART (4.7%, 95% CI 2.4–8.3%). This finding suggests that if patients have the motivation and support to complete the early milestones of CD4 staging and ART initiation, they are likely to remain in care. Given the substantial proportion (28.9%) of ART-eligible patients who did not return for their second clinic visit to receive CD4 results, the challenge is to retain patients within the very first weeks of HIV care: from diagnosis through CD4 staging and ART initiation. Recognition of this challenge has encouraged new efforts to retain these patients, including offering point-of-care CD4 technology and same-day ART initiation.^{27–29}

We identified several important predictors of patient attrition within the first year of HIV care (Table 3). Differing directions of estimates for predictors of pre-ART or post-ART attrition indicate that there may be different drivers of retention within each group at these unique stages that require specific, targeted interventions. For example, males had greater attrition in the pre-ART stages, but no gender difference was observed post-ART. Overall, our findings are consistent with other studies noting poorer retention among males^{9,11,16,18,19} and younger patients^{9,11,16} and highlight the need for interventions targeted to these specific groups, such as improved male involvement approaches, youth-

friendly services, mobile technology and others. Patients on TB treatment had much less likelihood of attrition during pre-ART stages, which differs from the results of an ART-eligible Durban cohort where newly-diagnosed TB patients experienced 76% greater attrition than TB-free patients.³⁰ Our finding likely is due to regular follow-up at the clinic during TB treatment and active tracing of those who default TB treatment. After ART initiation, patients in our study were as likely, or possibly more likely, to drop out of care as those not on TB treatment, highlighting the importance of communicating the need for regular ART care beyond the TB treatment period. Being born outside of South Africa was associated with a nearly 50% increased likelihood of attrition following ART initiation, similar to Bygrave, et al.,³¹ but in contrast to better retention in care among self-identified foreigners in South Africa found by McCarthy, et al.³² Witkoppen has a very high proportion of patients born outside of South Africa, which is becoming increasingly common in Johannesburg public-sector clinics, if not throughout the country.^{28,33} In addition to migration among immigrant patients, clinics should evaluate the potential for short- or long-term migration away from the clinic among immigrant and South African patients, and facilitate links to care and provide sufficient drug supply.

Mortality in our study was low at 5.7%. Even though we used the South Africa Department of Home Affairs National Population Register to verify deaths, which has been shown to be 80% complete for adults with valid ID numbers,³⁴ this estimate of overall mortality likely is underestimated as nearly half of our cohort was not South African and when we limited our mortality estimate to only those with a valid South African ID, mortality doubled. It is difficult to compare our mortality to findings of other studies since most focus only on either pre-ART or post-ART mortality. Among patients who died who were eligible for ART, we found that the majority of deaths occurred prior to ART initiation, further emphasizing the importance of linkage to care during the critical pre-ART period and the need to fast-track patients with severe immunosuppression.

Our results should be interpreted in light of their limitations. First, the generalizability of our results may be limited given that our data represent only one facility. Retention may have been higher than in most settings given the integration of HIV testing and care on-site. Previous studies suggest that moving from facility to facility for CD4 testing, ART initiation, etc., may encourage attrition.^{20,35} Second, retention may be underestimated as some patients considered lost in our analysis may have continued care and initiated treatment elsewhere. We only know of the intention to continue care elsewhere among patients who requested a transfer, a common limitation of studies investigating patient retention. Third, we defined attrition based on visit dates, which does not consider missed visits or treatment interruptions, which may overestimate the true amount of patient engagement in care. Finally, due to high patient drop-out throughout the study period, our sample size was reduced by the post-ART stages, limiting the precision of our regression analysis estimates for this period. Strengths of our study include a comprehensive dataset that allows for retention estimates from the point of testing HIV-positive through ART retention with few missing data. The study was conducted under routine clinical conditions and represents patient retention within a real-world scenario at one clinic.

Our findings help to explicate the problem of attrition from HIV programs throughout the continuum of early HIV care. In our study, patient attrition was highest during the pre-ART period, but our findings suggest that once patients initiate ART, they are more likely to be retained. These findings support the need for retention interventions that target patient loss from the very first visit when a patient learns their HIV-positive diagnosis.

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Figure 1. Study profile of completion of key stages of early HIV care among 842 newly diagnosed HIV-positive patients at an HIV treatment program in South Africa
 Stage completion is dependent on completing the prior stage in the time period specified. Patients eligible for ART per CD4 value at the time of HIV testing skip Pre-ART Stage 2 and move directly to Pre-ART Stage 3.
 *12 month ART retention data not available by the end of data collection.

Eligible for ART per CD4 at time of testing HIV-positive (n=544) **Ineligible for ART per CD4 at time of testing HIV-positive (n=207)**

Error bars indicate 95% confidence intervals on the proportions.

Stage completion is dependent on completing the prior stage in the time period specified.

*Patients eligible for ART at the time of HIV testing skip pre-ART stage 2 and proceed directly to pre-ART stage 3.

Patients who transferred during the stages shown were excluded from this analysis (n=59).

Figure 2. Cumulative patient retention from HIV diagnosis through one year on ART for 544 HIV-positive patients eligible for ART, and one year after initial CD4 staging for 207 HIV-positive patients ineligible for ART

Error bars indicate 95% confidence intervals on the proportions.

Stage completion is dependent on completing the prior stage in the time period specified.

*Patients eligible for ART at the time of HIV testing skip pre-ART stage 2 and proceed directly to pre-ART stage 3.

Patients who transferred during the stages shown were excluded from this analysis (n=59).

Table 1

Definitions of stages of early HIV care.

Stage	Key event	Definition of stage	Definition of retention
Pre-ART stage 1	CD4 staging	Start: testing HIV positive End: Completing CD4 staging, including results notification	Completing CD4 staging within 3 months of HIV diagnosis
Pre-ART stage 2	<i>If ineligible for ART</i> Repeat CD4 testing	<i>If ineligible for ART</i> Start: Results notification of first CD4 test after HIV testing End: Patient eligible for ART per repeat CD4 result	<i>If ineligible for ART</i> Completing a repeat CD4 test within 12 months of first CD4 staging date
Pre-ART stage 3	ART initiation	Start: Results notification of ART-eligible CD4 result End: ART initiation	Initiating ART within 3 months of ART-eligible CD4 result
Post-ART retention: 0–6 months	6 months ART retention	Start: ART initiation End: 6 months on ART	Continuing in care for 6 months following ART initiation
Post-ART retention: 6–12 months	12 months ART retention	Start: 6 months on ART End: 12 months on ART	Continuing in care for 12 months following 6 months on ART

Pre-ART stage definitions per Fox, Larson and Rosen, 2012.²¹

Table 2

Characteristics of the study participants (N=842).

Sex, <i>n</i> (%)	
Female	464 (55.1)
Male	378 (44.9)
Age at HIV testing, <i>median (IQR)</i>	34 (28–40)
Age at HIV testing, <i>n</i> (%)	
18–29 years	254 (30.2)
30–39 years	352 (41.8)
40 years and older	236 (28.0)
First CD4 value (cells/mm ³), <i>median (IQR)</i>	211.5 (92–350)
First CD4 value, <i>n</i> (%)	
<50 cells/mm ³	102 (12.1)
50–199 cells/mm ³	282 (33.5)
200–350 cells/mm ³	225 (26.7)
>350 cells/mm ³	201 (23.9)
Missing	32 (3.8)
Nationality, <i>n</i> (%)	
Born in South Africa	468 (55.6)
Born outside of South Africa	349 (41.5)
Missing	25 (3.0)
Employment status, <i>n</i> (%)	
Employed	435 (51.7)
Not employed	386 (45.8)
Missing	21 (2.5)
HIV-positive at first clinic visit, <i>n</i> (%)	
Yes	611 (72.6)
No	229 (27.2)
Missing	2 (0.2)
TB treatment [*] , <i>n</i> (%)	
Yes	92 (10.9)
No	750 (89.1)

IQR, interquartile range

* Initiated TB treatment within one year from the time of testing HIV-positive.

Table 3

Multivariate analysis of factors associated with patient attrition prior to ART and within the first 12 months after ART initiation among newly-diagnosed HIV-positive patients at an HIV treatment program in South Africa.

	Any pre-ART stage (n=842)			Any post-ART stage (n=288)*		
	n (%)	Crude RR (95% CI)	Adjusted RR (95% CI)	n (%)	Crude RR (95% CI)	Adjusted RR (95% CI)
Age at HIV testing						
18–29 years	96 (37.8)	1.57 (1.26, 1.94)	1.56 (1.21, 2.00)	18 (27.3)	1.55 (0.95, 2.52)	1.27 (0.76, 2.13)
30–39 years	94 (26.7)	1	1	27 (20.0)	1	1
40 years and older	48 (20.3)	0.65 (0.49, 0.86)	0.74 (0.52, 1.04)	12 (13.8)	0.62 (0.34, 1.11)	0.68 (0.36, 1.30)
First CD4 value						
<50 cells/mm ³	32 (31.4)	1.28 (0.93, 1.75)	1.51 (1.08, 2.12)	13 (28.9)	1.60 (0.94, 2.71)	2.30 (1.15, 4.63)
50–199 cells/mm ³	69 (24.5)	0.94 (0.73, 1.21)	1.10 (0.82, 1.48)	31 (21.4)	1.18 (0.74, 1.88)	1.48 (0.81, 2.73)
200–350 cells/mm ³	58 (25.8)	1	1	11 (11.6)	1	1
>350 cells/mm ³	47 (23.4)	0.90 (0.67, 1.19)	0.90 (0.65, 1.26)	NA [‡]	NA [‡]	NA [‡]
Sex						
Female	116 (25.0)	1	1	37 (21.3)	1	1
Male	122 (32.3)	1.29 (1.04, 1.60)	1.47 (1.16, 1.87)	20 (17.5)	0.83 (0.51, 1.35)	0.76 (0.45, 1.28)
Nationality						
Born in South Africa	119 (25.4)	1	1	25 (16.3)	1	1
Born outside of South Africa	115 (33.0)	1.30 (1.04, 1.61)	1.11 (0.88, 1.40)	31 (25.6)	1.57 (0.98, 2.51)	1.48 (0.92, 2.40)
Employed						
Yes	119 (27.4)	1	1	29 (18.5)	1	1
No	113 (29.3)	1.07 (0.86, 1.33)	1.07 (0.84, 1.36)	27 (22.1)	1.20 (0.75, 1.91)	1.13 (0.70, 1.81)
HIV-positive at first clinic visit						
Yes	185 (30.3)	1.31 (1.00, 1.71)	1.16 (0.86, 1.55)	43 (21.1)	1.33 (0.76, 2.34)	1.13 (0.64, 1.99)
No	53 (23.1)	1	1	13 (15.9)	1	1
TB treatment [‡]						
Yes	1 (1.1)	0.03 (0.00, 0.24)	0.04 (0.01, 0.27)	14 (25.5)	1.38 (0.81, 2.34)	1.42 (0.79, 2.53)
No	237 (31.6)	1	1	43 (18.5)	1	1

RR, relative risk; CI, confidence interval; n (%) show proportion not retained in each category

Model is adjusted for all variables listed. Patients who transferred out of the clinic are removed from the analysis according to date of transfer.

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* Post-ART model includes only patients who were initially eligible for ART and completed pre-ART stage 1 and pre-ART stage 3.

[†] Patients with CD4 values >350 are ineligible for ART.

[‡] Initiated TB treatment within one year from the time of testing HIV-positive.