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Decreased sexual risk behavior in the era of HAART among HIV-infected urban and rural South Africans attending primary care clinics

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Abstract

Objective—In light of increasing access to highly active antiretroviral treatment (HAART) in sub-Saharan Africa, we conducted a longitudinal study to assess the impact of HAART on sexual risk behaviors among HIV-infected South Africans in urban and rural primary care clinics.

Design—Prospective observational cohort study.

Methods—We conducted a cohort study at rural and urban primary care HIV clinics in South Africa consisting of 1544 men and 4719 women enrolled from 2003–2010, representing 19703 clinic visits. The primary outcomes were being sexually active, unprotected sex, and >1 sex partner and were evaluated at six monthly intervals. Generalized estimated equations assessed the impact of HAART on sexual risk behaviors.

Results—Among 6263 HIV-infected men and women, over a third (37.2%) initiated HAART during study follow-up. In comparison to pre-HAART follow-up, visits while receiving HAART were associated with a decrease in those reporting being sexually active (AOR: 0.86 [95% CI: 0.78–0.95]). Unprotected sex and having >1 sex partner were reduced at visits following HAART initiation compared to pre-HAART visits (AOR: 0.40 [95% CI: 0.34–0.46] and AOR: 0.20 [95% CI: 0.14–0.29], respectively).

Conclusions—Sexual risk behavior significantly decreased following HAART initiation among HIV-infected South African men and women in primary care programs. The further expansion of antiretroviral treatment programs could enhance HIV prevention efforts in Africa.

Keywords

South Africa; HAART; antiretroviral therapy; sexual behavior; HIV transmission; AIDS; HIV

Author contributions: KKV, NM, and GdB with assistance from ML designed the study and wrote the manuscript. KKV with EM and EWT did the analyses. LM, NT, NM, MM and PP provided patient care and oversaw data collection. PP and GEG provided oversight on analysis and manuscript writing.

CONFLICTS OF INTEREST

The authors have no conflicts of interest.

INTRODUCTION

Increasing access to highly active antiretroviral therapy (HAART) has extended life and reduced morbidity and mortality among HIV-infected individuals [1, 2]. However, as HAART improves physical health, HIV-infected individuals may be more likely to engage in unsafe sex (i.e. risk compensation or behavioral disinhibition) [3–6]. On the other hand, increased access to clinical care via HIV prevention counseling and receiving HAART may encourage positive changes in sexual risk behavior. As HAART becomes more readily available in resource-limited settings, the relationship between treatment and sexual behavior also becomes more important [7, 8]. A key component of the recently proposed HIV prevention strategy of “Universal Test and Treat,” in which everyone diagnosed with HIV infection is promptly initiated on HAART to decrease HIV transmission by reducing population viral load, partially depends on sexual risk behavior not increasing once individuals are on HAART [9, 10].

South Africa has an adult HIV prevalence of 18.1% and has the largest HIV epidemic in the world with 5.7 million HIV-infected individuals [11]. Since 2005, a growing number of HIV-infected South Africans have gained access to HAART so that by 2007, a third of South Africans in need of treatment were receiving HAART [12]. In South Africa, the high prevalence of HIV is likely fueled by a range of high risk sexual behaviors, including inconsistent condom use, early age at sexual debut, and multiple sex partners [13–17].

Secondary prevention efforts that aim to decrease the risk of HIV transmission from already infected individuals through behavioral and biomedical interventions have yet to be widely implemented in southern Africa [7, 18]. There is some evidence that HAART may not be associated with an increase in sexual risk taking behavior in sub-Saharan Africa [19], although much of this data has included limited patient follow-up, was cross-sectional, or was conducted exclusively among high risk groups [19–26]. With increasing efforts to expand treatment access and secondary prevention in the region, quantifying and comparing potential shifts in sexual behaviors over time among populations of HAART initiators remains an urgent priority.

We examine the relationship between HAART status and being sexually active, having unprotected sex, and having >1 sex partner before and after HAART initiation, overall and stratified by gender, among an operational cohort of South African men and women enrolled in urban and rural primary care programs.

METHODS

Setting and participants

Between June 2003 and January 2010, HIV-infected patients were recruited to participate in an operational cohort study at HIV primary care and support clinics in urban and rural South Africa. Eligible participants were ≥ 18 years, HIV-infected, and had given written informed consent. The urban clinic was at the Perinatal HIV Research Unit (PHRU) at Chris Hani Baragwanath Hospital in Soweto, and the rural at Tintswalo Hospital in Mpumalanga Province. Participants were either self-referred for HIV care, or were referred from mother-to-child transmission prevention programs, hospital wards, or HIV counseling and testing programs.

Clinical care, delivered primarily by nurses with physician oversight, included the following HIV-related clinical services: symptom screening for sexually transmitted infections (STIs) and tuberculosis (TB) [27], prophylactic treatment for opportunistic infections (OIs),

treatment for STIs and HIV-related OIs, annual cervical smears[28], and female family planning methods. Clinical and research study personnel underwent training sessions that involved rehearsing the survey questions, training in non-judgmental survey delivery, and instruction in prevention counseling. Since 2004 at PHRU and 2005 at Tintswalo, participants were referred for or offered HAART when they were diagnosed with WHO stage 4 disease, or when their CD4 cell counts fell below 200 cells/ul per South African guidelines [29, 30]. Patients were enrolled in care prior to treatment initiation and gave written informed consent prior to data being collected. At the time of HAART initiation, all patients were offered adherence counseling. All care was provided free of charge. The Ethics Committee at the University of the Witwatersrand approved this study.

Data collection

At baseline, participants were interviewed using a standardized questionnaire that collected demographic, socio-economic, behavioral, and health history information. Participants were interviewed using a similar instrument at data collection visits scheduled 4–7 months apart, but could visit the clinic at any time for care. Laboratory data included CD4 cell count at baseline and every 6 months. For the current study, we assessed socio-demographic variables: age, employment, urban or rural residential status, marital status, number of people living in household, and current contraception status (for women); and behavioral variables: sexual activity, alcohol use, needing assistance in completing daily activities (as a measure of general health status), and disclosure of HIV status. At baseline and study follow-up, participants were asked about their sexual behaviors, including whether or not they had a regular partner, whether they had a casual sex partner, and the frequency of condom use with both regular and casual partners (if they had one). Recall for these questions was the 6 months since the last clinic visit. Condom use for each partner type was collected using categorical variables, and consistent condom use was defined as self-report of always using a condom with a sex partner. These measures of sexual behavior have been employed in this setting [31].

Statistical analyses

We assessed three measures of self-reported sexual behavior as outcomes in the current study: 1) being sexually active; 2) having unprotected sex with a regular and/or casual partner; and 3) having >1 sex partner. Since not all participants reported a regular or casual sex partner, we first examined factors associated with being sexually active. The outcomes of having unprotected sex and having >1 sex partner were analyzed only among those who reported being sexually active. We restricted our analyses to CD4 cell counts taken within 90 days of a study visit. Data was analyzed according to an intent-to-treat analysis, where once participants were initiated on HAART, they were considered HAART-experienced at all subsequent clinic visits. To assess the effect of HAART initiation on potential changes in sexual risk behavior, we compared sexual behavior during pre-HAART visits to behavior reported after HAART initiation. After introducing HAART status—the primary predictor variable—into the models, each covariate was introduced into the three models to assess potential confounding based either on a change of at least 10% of the non-log transformed beta coefficient of independent risk factors, or *a priori* confounders based on a review of earlier studies. The three sexual behavior outcomes were assessed as time-varying outcomes. CD4 cell count and HAART status were adjusted for as time-varying covariates. The baseline status of all other socio-demographic and behavioral covariates were also adjusted for in the models. We controlled for time-dependent changes in risk behavior by adjusting for years since enrollment in care via calendar year category (2002–2004, 2004–2006, and 2006–2009) [24]. We employed generalized estimating equations (GEE) with a logit link and exchangeable correlation structure to assess the impact of HAART on sexual risk behavior utilizing PROC GENMOD in SAS [32]. To further examine within-participant

variation (i.e. treatment effect) while still controlling for stable participant characteristics, we also employed fixed effects regression methods utilizing PROC LOGISTIC in SAS [33]; however this analysis was broadly similar to the GEE analysis and is therefore not presented here. We examined three multivariable models of sexual behavior using GEE, namely being sexually active (Model I), unprotected sex (Model II), and having >1 sex partner (Model III). In a sensitivity analysis these three outcomes were re-examined by restricting analyses to those participants who initiated HAART during follow-up. We also assessed the impact of CD4 cell count on sexual behavior through examining clinic visits for which CD4 cell count data was available. All analyses used STATA (STATA CORP, version 10.0, College Station, TX) and SAS (SAS Institute, version 9.2, Cary, NC) software.

RESULTS

Characteristics of participants

Between 2003 to 2009, there were a total of 6263 participants, of whom 4719 (75.3%) were women, accounting for a total of 19703 clinic visits (4479 for men and 15224 for women). During the study period, 2332 participants (37.2 %) initiated HAART, of whom 71.7% were women. Table 1 presents the characteristics of all 6263 participants, stratified by gender and treatment status. The median age at study enrollment was 33.8 years (IQR: 29.1–40.0) and the median CD4 cell count at study enrolment was 253 cells/ul (IQR: 110–440). The urban cohort was larger (65.3%), and most participants were unemployed (76.4%) and never married (53.8%). At baseline, most (87.3%) had disclosed their HIV status, and 33.2% reported alcohol use. About a third enrolled into care between 2002–2004, 2005–2006, and 2006–2009, respectively. The mean number of study visits was 3.22 (SD 2.45) per person, with a mean number of 2.64 (SD 1.59) post-HAART visits and 2.59 (SD 2.15) pre-HAART visits per person. At study enrollment, compared to those who did not initiate HAART, participants who did start HAART during the study were less likely: to be women (71.7% vs. 77.5%; $p<0.0001$), to be urban residents (42.6% vs. 78.7%; $p<0.0001$), to be employed (18.3% vs. 26.8%, $p<0.0001$), and to be never married (48.6% vs. 56.9%; $p<0.0001$), and were more likely to be older (age>40 years: 32.6% vs. 20.5%; $p<0.0001$).

Sexual behavior and HAART

Table 2 presents the frequency of being sexually active (Model I), reporting unprotected sex (Model II), and having >1 sex partner (Model III) at visits before and after HAART initiation. Out of a total of 9568 pre-HAART and 3496 post-HAART visits, participants were more likely to be sexually active before HAART compared to after HAART initiation (70.7% vs. 56.6%; $p<0.0001$). By partner type, participants with: both a primary and casual partner, a primary partner only, and a casual partner only, reported a higher frequency of being sexually active before HAART initiation compared to after HAART initiation ($p<0.0001$). Both men and women were more likely to report being sexually active before HAART initiation ($p<0.0001$). In regards to unprotected sex, of 13064 visits at which sexual activity was reported, participants reported unprotected sex at 1968 pre-HAART (20.6%) visits compared to 346 post-HAART (9.9%) visits ($p<0.0001$). By partner type, participants with both a primary and casual partner and only a primary partner reported a higher frequency of unprotected sex before HAART initiation than after HAART initiation ($p<0.05$). Both men and women reported unprotected sex at a higher frequency before HAART initiation ($p<0.0001$). Of 600 visits during which having >1 sex partner was reported, participants reported having >1 sex partner at 542 pre-HAART (5.7%) visits compared to 58 post-HAART (1.7%) visits ($p<0.0001$), a difference that held across genders. We also examined these three sexual behavior outcomes only among the subset of participants who initiated HAART who contributed a total of 9032 visits. Similar to the analyses above, participants reported a higher frequency of being sexually active, engaging

in unprotected sex, and having >1 sex partner at pre-HAART visits compared to post-HAART visits ($p<0.0001$).

Adjusted analyses of HAART and being sexually active (Model I) overall and stratified by gender

Overall, the likelihood of being sexually active decreased after HAART initiation (AOR: 0.86 [95% CI: 0.78–0.95]; $p=0.0036$), and this decrease was greater for women (AOR: 0.40 [95% CI: 0.35–0.46]; $p<0.0001$) than for men (AOR: 0.90 [95% CI: 0.74–1.08]; $p=0.2745$) (See Table 3). Other independent predictors of decreased sexual activity included female gender (AOR: 0.76 [95% CI: 0.66–0.87]; $p=0.0001$), older age (AOR >40 years: 0.31 [95% CI: 0.27–0.36]; $p<0.0001$), and needing assistance with daily activities (AOR: 0.59 [95% CI: 0.50–0.71]; $p<0.0001$); and of increased sexual activity included urban residence (AOR: 1.97 [95% CI: 1.71–2.26]; $p<0.0001$) and married/living together (AOR: 4.42 [95% CI: 3.85–5.08]; $p<0.0001$). Though not significant predictors overall, unemployment for men and alcohol use, injectable hormone- and pill-based contraception, and enrollment in care since 2006 for women were significantly associated with being sexually active.

Adjusted analyses of HAART and unprotected sex (Model II) overall and stratified by gender

Overall unprotected sex decreased after HAART initiation (AOR: 0.40 [95% CI: 0.34–0.46]; $p<0.0001$), and this decrease was greater for men (AOR: 0.33 [95% CI: 0.24–0.44]; $p<0.0001$) than for women (AOR: 0.71 [95% CI: 0.59–0.86]; $p=0.0005$) (See Table 4). Overall other independent predictors of increased unprotected sex were: female gender (AOR: 1.63 [95% CI: 1.37–1.95]; $p<0.0001$), married/living together (AOR: 1.27 [95% CI: 1.10–1.46]; $p=0.0010$), STI symptoms (AOR: 1.35 [95% CI: 1.20–1.53]; $p<0.0001$), and older age (AOR for >40 years: 1.25 [95% CI: 1.03–1.53]; $p=0.0229$); and of decreased unprotected sex were: urban residence (AOR: 0.71 [95% CI: 0.58–0.85]; $p=0.0004$) and enrollment in care since 2006 (AOR: 0.71 [95% CI: 0.59–0.85]; $p=0.0003$). Though not significant predictors overall, needing assistance with daily activities for men and unemployment, hormone-based contraception, and disclosure of HIV status for women were significantly associated with unprotected sex.

Adjusted analyses of HAART and having >1 sex partner (Model III) overall and stratified by gender

Overall the likelihood of having >1 sex partner decreased after HAART initiation (AOR: 0.20 [95% CI: 0.14–0.29]; $p<0.0001$), and this decrease was greater for women (AOR: 0.09 [95% CI: 0.05–0.17]; $p<0.0001$) than for men (AOR: 0.35 [95% CI: 0.23–0.53]; $p<0.0001$) (See Table 5). Other independent predictors associated with a decreased odds of having >1 sex partner were female gender (0.45 [95% CI: 0.36–0.56]; $p<0.0001$), married/living together (AOR: 0.41–0.67]; $p<0.0001$), and enrollment in care since 2005 (AOR for 2005–2006: 0.20 [95% CI: 0.15–0.27]; $p<0.0001$ and AOR for 2006–2009: 0.19 [95% CI: 0.13–0.29]; $p<0.001$). Though not significant predictors overall, urban residential status and disclosure of HIV status for men and older age (AOR for >40 years) for women were significantly associated with having >1 sex partner.

Sensitivity analyses

Restricting analyses to the subset of 2307 participants who initiated HAART during follow-up time did not alter the overall association between HAART and being sexually active (AOR: 0.87 [95% CI: 0.77–0.98]; $p=0.0238$), unprotected sex (AOR: 0.43 [95% CI: 0.36–0.52]; $p<0.0001$), and having >1 sex partner (AOR: 0.17 [95% CI: 0.12–0.24]; $p<0.0001$). Additionally, to examine the impact of behavior change following HAART initiation that

was independent of CD4 cell count, we examined the three behavioral outcomes adjusting for CD4 cell count in the 5704 visits with CD4 cell counts, (65.2% were pre-HAART and 34.8% were post-HAART); outcomes were consistent with the earlier analyses for the association between HAART and being sexually active (AOR: 0.78 [95% CI: 0.67–0.93]; $p=0.0047$), unprotected sex (AOR: 0.32 [95% CI: 0.23–0.44]; $p<0.0001$), and having >1 sex partner (AOR: 0.25 [95% CI: 0.13–0.50]; $p<0.0001$). We also assessed effect modification by strata of CD4 cell count based on cut-offs that have been considered for treatment initiation (<200 cells/ul, 200–350 cells/ul, vs. >500 cells/ul) and these stratum-specific AORs were not significantly different from each other, suggesting that sexual risk behavior did not differ by CD4 cell count strata.

DISCUSSION

In this population of HIV-infected South African men and women enrolled in urban and rural primary care programs, we documented a strong and sustained reduction in sexual risk behaviors following HAART initiation. Among both men and women in these two cohorts, we observed reductions in those reporting sexual activity, unprotected sex, and >1 sex partner, suggesting that HAART in this population is not associated with risk compensation. Furthermore, these findings were independent of CD4 cell count. To our knowledge, this is one of the first studies to report on sexual risk among a longitudinal HIV-infected cohort spanning nearly a decade of observation before and after HAART initiation in a resource-limited setting. These findings add to our understanding of how HAART could further assist in reducing the secondary transmission of HIV.

There has been a paucity of longitudinal data examining the relationship between initiating HAART and sexual risk among HIV-infected Africans. Our findings from a large clinic-based sample of men and women provide greater generalizability than earlier studies from the region. Recent data from HIV-infected female sex workers in Kenya found that unprotected sex but not the number of sex partners decreased following HAART initiation [24]. Also, recent national survey data from Cameroon showed that HAART was associated with consistent condom use [25, 26]. South African and Kenyan cohorts with 12 months of HAART follow-up have also documented a decrease in the frequency of unprotected sex [34, 35]. A clinic-based cohort from Uganda found that while sexual activity increased following HAART, condom use increased and the number of sex partners decreased [36]. An earlier Ugandan cohort with up to 6 months of HAART also documented reductions in risky sexual behavior [23]. Recent cross-sectional studies from African settings have also suggested that HAART was not associated with increased sexual risk behaviors [20–22, 37]. In contrast, a study from Cote d'Ivoire found that unprotected sex significantly increased during the first 6 months of treatment [38]. Differing results in these settings highlight the complexity of measuring the association between HAART and sexual behavior and variations in study populations and treatment program characteristics. As HAART continues to be rolled-out in resource-limited settings and an increasing number of individuals are on treatment for an extended period of time, further quantitative and qualitative research should examine whether initial decreases in sexual risk behavior are sustained and reasons for this. While epidemiological studies can examine whether individuals on treatment engage in sexual risk behaviors, qualitative and biological data is needed to understand specific reasons for reductions in sexual risk behaviors. We unfortunately have no evidence for reasons for our findings however, apart from counseling prior to HAART initiation, other reasons may include treatment optimism and metabolic effects of HAART.

Sexual activity was reported at two-thirds of study visits overall, and decreased following HAART initiation. Data from Uganda and Cote d'Ivoire have also found that a substantial number of patients on HAART do not engage in sexual activity [21, 39]. In the current

study, despite the finding that HAART was not associated with an increase in unprotected sex, many participants still engaged in unprotected intercourse and hence the potential risk for HIV transmission persists. Earlier data from South Africa has documented high levels of unprotected sex (i.e. 30–50%) among HIV-infected individuals [40]. It is important that HIV clinical care programs continue to emphasize consistent condom use even after initiating therapy.

Overall urban residents were less likely to report unprotected sex or multiple sex partners. It is possible that urban residents have greater access to prevention messages. Participants who had disclosed their HIV status were less likely to engage in sexual risk behaviors. HIV disclosure was very high in this population (>80%) at clinic enrollment, and may suggest that many patients could negotiate condom use and discuss sensitive issues such as sex and relationships with their partners [35]. These findings are similar to an earlier cross-sectional analysis we undertook prior to the wider roll-out of HAART [31]. Additionally, unprotected sex was more frequent among couples who were married or living together, which is in accordance with earlier data from Africa [23]. Data from Uganda among discordant couples showed that HAART was associated with reduced HIV transmission risk and sexual risk behavior decreased following enrollment [41]. Due to the fact that HIV discordance is common within African couples, couples-based prevention in care settings remains important [39, 42, 43].

The current study included only patients enrolled in primary care programs in which they received ongoing counseling and prevention messages, and hence patients may have been less likely to report risky sexual behaviors. However, study staff received training to ask questions in a non-judgmental manner to minimize social desirability. Also, due to the comprehensive care and prevention package, it is not possible to disentangle the relative effects of prevention activities, counseling, and condom provision from the effects of providing HAART. It is possible that the documented reductions in sexual risk behavior may have occurred due to the comprehensive nature of care as opposed to HAART alone. While the current open cohort spanned an eight year period, participants had 2–3 visits after initiating HAART, and further longitudinal follow-up will be needed to examine longer-term sexual risk behaviors on HAART. Additional variables that are important determinants of sexual risk behavior that we were unable to assess include: desire for children, involvement in commercial sex, drug use, and primary partner HIV status. The current study used a 6 month recall period for sexual risk behaviors, but a shorter period may have been warranted to assess specific sexual behaviors such as condom use. We are unable to comment on reasons for losses to follow-up as this information was not systematically collected, which could have biased these findings. While the current study utilized both GEE and fixed effects models, bias induced by missing data during follow-up could have occurred [44]. Though patients who did not initiate HAART varied on socio-demographic characteristics, we adjusted for these variables in our multivariable analysis and also conducted further sensitivity analyses excluding patients who did not initiate HAART. To elucidate the impact of HAART on within participant sexual behavior, we also conducted further analyses using fixed effects modeling, and those findings were consistent with the analyses presented here.

Strengths of the current study include prospective data collection before and after HAART initiation. Participants received the same clinic-based HIV prevention and counseling services before and after HAART initiation, reducing potential information bias. A large sample size allowed us to examine a range of confounding variables in our models. We also assessed sexual behavior using a variety of relevant outcome measures, which demonstrated consistent changes toward lower levels of risk taking. Earlier studies in this region have often had short study follow-up or limited generalizability due to being conducted among

high-risk sub-populations. The current study can be generalized to HIV-infected patients receiving primary care in both urban and rural settings in sub-Saharan Africa where HAART is increasingly available.

To develop effective secondary prevention interventions in African settings in the era of expanding access to treatment, a broad evidence base about patterns of sexual risk behaviors among HIV-infected individuals before and after initiating HAART is necessary. The current study documents consistent behavioral risk reduction following HAART, and provides evidence for the use of HAART as a means of HIV prevention. The public health benefits through the use of HAART for prevention depends not only on the number of individuals treated, but also that treated individuals do not massively increase sexual risk taking behaviors [45, 46]. More interventions are needed to promptly initiate HIV-infected individuals on treatment in resource-limited settings, and to consider providing HAART to individuals who currently do not meet treatment guidelines as they may be at considerable risk for transmitting HIV. Integrating access to prompt treatment with appropriate counseling and prevention programs could reduce HIV transmission in the hyperendemic settings of southern Africa.

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References

1. Palella F, Delaney KM, Moorman AC, Loveless MO, Fuhrer J, Satten GA, Aschman DJ, Holmberg SD. Declining morbidity and mortality among patients with advanced human immunodeficiency virus infection. HIV Outpatient Study Investigators. *New England Journal of Medicine*. 1998; 338:853–860. [PubMed: 9516219]
2. Kumarasamy N, Solomon S, Chaguturu SK, Cecelia AJ, Vallabhaneni S, Flanigan TP, Mayer KH. The changing natural history of HIV disease: before and after the introduction of generic antiretroviral therapy in southern India. *Clinical Infectious Disease*. 2005; 41:1525–1528.
3. Dukers N, Goudsmit J, de Wit JB, Prins M, Weverling GJ, Coutinho RA. Sexual risk behaviour relates to the virological and immunological improvements during highly active antiretroviral therapy in HIV-1 infection. *AIDS*. 2001; 15:369–378. [PubMed: 11273217]
4. Kelly J, Otto-Salaj LL, Sikkema KJ, Pinkerton SD, Bloom FR. Implications of HIV treatment advances for behavioral research on AIDS: protease inhibitors and new challenges in HIV secondary prevention. *Health Psychology*. 1998; 17:310–319. [PubMed: 9697940]
5. Stolte I, Dukers NH, Geskus RB, Coutinho RA, de Wit JB. Homosexual men change to risky sex when perceiving less threat of HIV/AIDS since availability of highly active antiretroviral therapy: a longitudinal study. *AIDS*. 2004; 18:303–309. [PubMed: 15075549]
6. Ostrow D, Fox KJ, Chmiel JS, Silvestre A, Visscher BR, Vanable PA, Jacobson LP, Strathdee SA. Attitudes towards highly active antiretroviral therapy are associated with sexual risk taking among HIV-infected and uninfected homosexual men. *AIDS*. 2002; 16:775–780. [PubMed: 11964534]
7. Fisher J, Smith L. Secondary prevention of HIV infection: the current state of prevention for positives. *Current opinion in HIV and AIDS*. 2009; 4:279–287. [PubMed: 19532065]
8. Salomon J, Hogan DR, Stover J, Stanecki KA, Walker N, Ghys PD, Schwartländer B. Integrating HIV prevention and treatment: from slogans to impact. *PLoS Medicine*. 2005; 2:e16. [PubMed: 15647780]

9. Granich R, Gilks CF, Dye C, De Cock KM, Williams BG. Universal voluntary HIV testing with immediate antiretroviral therapy as a strategy for elimination of HIV transmission: a mathematical model. *Lancet*. 2008; 373:48–57. [PubMed: 19038438]
10. Dodd P, Garnett GP, Hallett TB. Examining the promise of HIV elimination by ‘test and treat’ in hyperendemic settings. *AIDS*. 2010; 24:729–735. [PubMed: 20154580]
11. United Nations. 2008 update on the global AIDS epidemic. 2008.
12. UNAIDS. South Africa - progress towards universal access. 2008.
13. Pettifor A, Kleinschmidt I, Levin J, Rees HV, MacPhail C, Madikizela-Hlongwa L, Vermaak K, Napier G, Stevens W, Padian NS. A community-based study to examine the effect of a youth HIV prevention intervention on young people aged 15–24 in South Africa: results of the baseline survey. *Tropical Medicine and International Health*. 2005; 10:971–980. [PubMed: 16185231]
14. Eaton L, Flisher AJ, Aarø LE. Unsafe sexual behaviour in South African youth. *Social Science and Medicine*. 2003; 56:149–165. [PubMed: 12435558]
15. Pettifor A, Rees HV, Kleinschmidt I, Steffenson AE, MacPhail C, Hlongwa-Madikizela L, Vermaak K, Padian NS. Young people’s sexual health in South Africa: HIV prevalence and sexual behaviors from a nationally representative household survey. *AIDS*. 2005; 19:1525–1534. [PubMed: 16135907]
16. Human Sciences Research Council. A Turning Tide Among Teenagers?. Cape Town, South Africa: HSRC Press; 2008. South African National HIV Prevalence, Incidence, Behavior, and Communication Survey, 2008.
17. Hargreaves J, Bonell CP, Morison LA, Kim JC, Phetla G, Porter JD, Watts C, Pronyk PM. Explaining continued high HIV prevalence in South Africa: socioeconomic factors, HIV incidence and sexual behaviour change among a rural cohort, 2001–2004. *AIDS*. 2007; 21:S39–S48. [PubMed: 18040163]
18. Janssen RS, Holtgrave DR, Valdiserri RO, Shepherd M, Gayle HD, De Cock KM. The serostatus approach to fighting the HIV epidemic: prevention strategies for infected individuals. *American Journal of Public Health*. 2001; 19:1019–1024. [PubMed: 11441723]
19. Kennedy C, O’Reilly K, Medley A, Sweat M. The impact of HIV treatment on risk behaviour in developing countries: a systematic review. *AIDS Care*. 2007; 19:707–720. [PubMed: 17573590]
20. Sarna A, Luchters SM, Geibel S, Kaai S, Munyao P, Shikely KS, Mandaliya K, van Dam J, Temmerman M. Sexual risk behaviour and HAART: a comparative study of HIV-infected persons on HAART and on preventive therapy in Kenya. *International Journal of STD & AIDS*. 2008; 19:85–89. [PubMed: 18334059]
21. Moatti J, Prudhomme J, Traore DC, Juillet-Amari A, Akribi HA, Msellati P. Côte d’Ivoire HIV Drug Access Initiative Socio-Behavioural Evaluation Group. Access to antiretroviral treatment and sexual behaviours of HIV-infected patients aware of their serostatus in Côte d’Ivoire. *AIDS*. 2003; 17:S69–S77. [PubMed: 14565612]
22. Bateganya M, Colfax G, Shafer LA, Kityo C, Mugenyi P, Serwadda D, Mayanja H, Bangsberg D. Antiretroviral therapy and sexual behavior: a comparative study between antiretroviral-naïve and -experienced patients at an urban HIV/AIDS care and research center in Kampala, Uganda. *AIDS Patient Care and STDs*. 2005; 19:760–768. [PubMed: 16283836]
23. Bunnell R, Ekwaru JP, Solberg P, Wamai N, Bikaako-Kajura W, Were W, Coutinho A, Liechty C, Madraa E, Rutherford G, Mermin J. Changes in sexual behavior and risk of HIV transmission after antiretroviral therapy and prevention interventions in rural Uganda. *AIDS*. 2006; 20:85–92. [PubMed: 16327323]
24. McClelland R, Graham SM, Richardson BA, Peshu N, Masese LN, Wanje GH, Mandaliya KN, Kurth AE, Jaoko W, Ndinya-Achola JO. Treatment with antiretroviral therapy is not associated with increased sexual risk behavior in Kenyan female sex workers. *AIDS*. 2010:24.
25. Marcellin F, Bonono CR, Blache J, Carrieri MP, Spire B, Koulla-Shiro S. EVAL Study Group. Higher risk of unsafe sex and impaired quality of life among patients not receiving antiretroviral therapy in Cameroon: results from the EVAL survey (ANRS 12–116). *AIDS*. 2010; 24:S17–25. [PubMed: 20023436]
26. Dia A, Marcellin F, Bonono R-C, Boyer S, Bouhnik A-D, Protopopescu C, Koulla-Shiro S, Carrieri MP, Abe C, Spire B. the EVAL Study Group. Prevalence of unsafe sex with one’s steady

- partner either HIV-negative or of unknown HIV status and associated determinants in Cameroon (EVAL ANRS12–16 survey). *Sexually Transmitted Infections*. 2010; 86:148–154. [PubMed: 19837727]
27. Golub J, Pronyk P, Mohapi L, Thsabangu N, Moshabela M, Struthers H, Gray GE, McIntyre JA, Chaisson RE, Martinson NA. Isoniazid preventive therapy, HAART and tuberculosis risk in HIV-infected adults in South Africa: a prospective cohort. *AIDS*. 2009; 23:631–636. [PubMed: 19525621]
 28. Omar, TSS.; Tshabangu, N.; Golub, J.; Hanrahan, C.; Gray, G.; Struthers, H.; McIntyre, J.; Mohapi, L.; Martinson, N. Progression and Regression of Pre-malignant Cervical Lesions in HIV-infected Women from Soweto: A Prospective Cohort. 17th Conference on Retroviruses and Opportunistic Infections; San Francisco. 2010.
 29. South African Clinicians Society guidelines: antiretroviral therapy in adults. *South African Journal of HIV Medicine*. 2008; 29:18–31.
 30. World Health Organization. Towards universal access: Scaling up priority HIV/AIDS interventions in the health sector. 2008.
 31. Lurie M, Pronyk P, de Moor E, Heyer A, de Bruyn G, Struthers H, McIntyre J, Gray G, Marinda E, Klipstein-Grobusch K, Martinson N. Sexual behavior and reproductive health among HIV-infected patients in urban and rural South Africa. *Journal of Acquired Immune Deficiency Syndrome*. 2008; 47:484–493.
 32. Allison, P. Logistic regression using the SAS system: Theory and application. Cary, NC: SAS Institute; 1999.
 33. Allison, P. Fixed Effects Regression Methods for Longitudinal Data Using SAS. Cary, NC: SAS Institute Inc; 2005.
 34. Luchters S, Sarna A, Geibel S, Chersich MF, Munyao P, Kaai S, Mandaliya KN, Shikely KS, Rutenberg N, Temmerman M. Safer sexual behaviors after 12 months of antiretroviral treatment in Mombasa, Kenya: a prospective cohort. *AIDS Patient Care and STDs*. 2008; 22:587–594. [PubMed: 18601582]
 35. Eisele T, Mathews C, Chopra M, Lurie MN, Brown L, Dewing S, Kendall C. Changes in risk behavior among HIV-positive patients during their first year of antiretroviral therapy in Cape Town South Africa. *AIDS and Behavior*. 2008; 13:1097–1105. [PubMed: 18846418]
 36. Wanyama, J.; Kasibante, D.; Kayiira, P.; Wandera, B.; Kambugu, A. Sexual Behavior of HIV+ Persons before and after 1 Year of ART at the Infectious Diseases Clinic, Kampala, Uganda. 17th Conference on Retroviruses and Opportunistic Infections; San Francisco. 2010.
 37. Kaida A, Gray G, Bastos FI, Andia I, Maier M, McIntyre J, Grinsztejn B, Strathdee SA, Bangsberg DR, Hogg R. The relationship between HAART use and sexual activity among HIV-positive women of reproductive age in Brazil, South Africa, and Uganda. *AIDS Care*. 2008; 20:21–25. [PubMed: 18278611]
 38. Diabaté S, Alary M, Koffi CK. Short-term increase in unsafe sexual behaviour after initiation of HAART in Côte d'Ivoire. *AIDS*. 2008; 22:154–156. [PubMed: 18090406]
 39. Lurie M, Williams BG, Zuma K, Mkaya-Mwamburi D, Garnett GP, Sweat MD, Gittelsohn J, Karim SS. Who infects whom? HIV-1 concordance and discordance among migrant and non-migrant couples in South Africa. *AIDS*. 2003; 17:2245–2252. [PubMed: 14523282]
 40. Eisele T, Mathews C, Chopra M, Brown L, Silvestre E, Daries V, Kendall C. High levels of risk behavior among people living with HIV Initiating and waiting to start antiretroviral therapy in Cape Town South Africa. *AIDS and Behavior*. 2008; 12:570–577. [PubMed: 17636372]
 41. Reynolds, S.; Makumbi, F.; Kagaayi, J.; Nakigozi, G.; Galiwongo, R.; Quinn, T.; Wawer, M.; Gray, R.; Serwadda, D. ART Reduced the Rate of Sexual Transmission of HIV among HIV-discordant Couples in Rural Rakai, Uganda. 16th Conference on Retroviruses and Opportunistic Infections; Monreal. 2009.
 42. Carpenter L, Kamali A, Ruberantwari A, Malamba SS, Whitworth JA. Rates of HIV-1 transmission within marriage in rural Uganda in relation to the HIV sero-status of the partners. *AIDS*. 1999; 13:1083–1089. [PubMed: 10397539]

43. Allen S, Meinzen-Derr J, Kautzman M, Zulu I, Trask S, Fideli U, Musonda R, Kasolo F, Gao F, Haworth A. Sexual behavior of HIV discordant couples after HIV counseling and testing. *AIDS*. 2003; 17:733–740. [PubMed: 12646797]
44. Protopopescu C, Raffi F, Roux P, Reynes J, Dellamonica P, Spire B, Leport C, Carrieri M-P. ANRS CO8 (APROCO-COPILOTE) Study Group. Factors associated with non-adherence to long-term highly active antiretroviral therapy: a 10 year follow-up analysis with correction for the bias induced by missing data. *Journal of antimicrobial chemotherapy*. 2009; 64:599–606. [PubMed: 19602563]
45. Mayer K, Venkatesh KK. Antiretroviral Therapy for HIV Prevention: Current status and future prospects. *American Journal of Public Health*. 2010 In press.
46. Burns D, Dieffenbach CW, Vermund SH. Rethinking HIV-1 Prevention. *Clinical Infectious Disease*. 2010 In press.

Table 1

Baseline socio-demographic, clinical, and behavioral characteristics of HIV-infected South African participants overall, stratified by gender and HAART status

	All, % (N=6263)	Men, % (N=1544)	Women, % (N=4719)	Initiated HAART, % (N=2332)
Gender				
Men	24.7	--	--	28.3
Women	75.3			71.7
Age, (years)				
<30	29.4	15.5	34.0	22.8
30–40	45.5	47.3	44.9	44.6
>40	25.0	37.1	21.1	32.6
Residential status				
Urban	65.3	57.7	67.7	57.4
Rural	34.7	42.3	32.3	42.6
Employment				
Employed	23.6	31.9	20.8	18.3
Unemployed, wants to work	52.8	38.3	57.6	47.1
Unemployed, does not want to work	23.7	29.8	21.7	34.7
Marital status				
Never married	53.8	38.6	58.7	48.6
Married or living together	29.4	44.6	24.4	27.6
Divorced/separated/widowed	16.8	16.8	16.9	23.8
Number of individuals in household				
2 or less	15.9	26.3	12.5	13.4
3–5	48.1	43.9	49.5	47.4
> 5	36.0	29.8	38.0	39.2
Needs assistance with daily activities				
No	89.9	92.4	89.1	84.8
Yes	10.1	7.6	10.9	15.2
Contraception status				
None	--	--	92.2	--
Injectable hormone			6.6	
Pill			1.2	
Alcohol use				
No	66.8	34.4	77.3	69.6
Yes	33.2	65.6	22.7	30.4
Disclosed HIV status				

	All, % (N=6263)	Men, % (N=1544)	Women, % (N=4719)	Initiated HAART, % (N=2332)
No	12.7	14.0	12.3	11.7
Yes	87.3	86.0	87.7	88.3
Current STI symptoms				
No	80.6	88.7	78.0	77.4
Yes	19.4	11.3	22.0	22.6
CD4 cell count at enrollment, (cells/ul)				
<200	41.7	36.0	43.6	45.4
200–350	22.7	24.6	22.1	22.6
>350	35.5	39.5	34.3	32.0
Year enrolled into care				
2002–2004	36.3	33.8	37.1	32.2
2005–2006	32.9	33.3	32.7	30.9
2006–2009	30.9	32.9	30.2	36.9

Table 2

Frequency of being sexually active (Model I), unprotected sex (Model II), and having >1 sex partner (Model III) at clinic visits stratified by HAART status

N (%) Reporting being sexually active at visit (Model I)				
Category	Total # of visits	Pre-HAART 13,528 visits	Post-HAART 6175 visits	p-value **
Total	19703	9568/13528 (70.7)	3496/6175 (56.6)	<0.0001
By partner type				
Both primary and casual	19703	542/13528 (4.0)	58/6175 (0.9)	<0.0001
Primary only	19703	8914/13528 (65.9)	3422/6175 (55.4)	<0.0001
Casual only	19703	112/13528 (0.8)	16/6175 (0.3)	<0.0001
No partner	19703	3960/13528 (29.3)	2679/6175 (43.4)	<0.0001
By gender				
Men	4479	2140/2847 (75.2)	1086/1632 (66.5)	<0.0001
Women	15224	7428/10681 (69.5)	2410/4543 (53.0)	<0.0001
N (%) Reporting having unprotected sex at visit *-Model II				
Category	Total # of visits	Pre-HAART 9568 visits	Post-HAART 3496 visits	p-value **
Total	13064	1968/9568 (20.6)	346/3496 (9.9)	<0.0001
By partner type				
Both primary and casual	600	213/542 (39.3)	15/58 (25.9)	0.045
Primary only	12336	1720/8914 (19.3)	328/3422 (9.6)	<0.0001
Casual only	128	35/112 (31.3)	3/16 (18.8)	0.306
By gender				
Men	3226	359/2140 (16.8)	68/1086 (6.3)	<0.0001
Women	9839	1609/7428 (21.7)	278/2410 (11.5)	<0.0001
N (%) Reporting >1 sex partner at visit *-Model III				
Category	Total # of visits	Pre-HAART 9568 visits	Post-HAART 3496 visits	p-value **
Total	13064	542/9568 (5.7)	58/3496 (1.7)	<0.0001
By gender				
Men	3226	201/2140 (9.4)	43/1086 (4.0)	<0.0001
Women	9838	341/7428 (4.6)	15/2410 (0.6)	<0.0001
N (%) restricted to those participants who initiated HAART				
Being sexually active	9032	1832/2857 (64.1)	3496/6175 (56.6)	<0.0001
Unprotected sex *	5328	392/1832 (21.4)	346/3496 (9.9)	<0.0001
>1 sex partner *	5328	175/1832 (9.6)	58/3496 (1.7)	<0.0001

* Analyzed at 13064 of 19703 visits at which sexual activity was reported.

** The chi-square p-value compare each row category before HAART initiation to after HAART initiation.

Table 3

Predictors of being sexually active (Model I) overall and stratified by gender (N=19703 visits)

	All (N=19703 visits)	Men (N=4479 visits)	Women (N=15224 visits)
	AOR* (95% CI); p-value	AOR (95% CI); p-value	AOR (95% CI); p-value
HAART status			
No	1.00	1.00	1.00
Yes	0.86 (0.78–0.95); 0.0036	0.90 (0.74–1.08); 0.2745	0.40 (0.35–0.46); <0.0001
Gender			
Men	1.00	--	--
Women	0.76 (0.66–0.87); 0.0001		
Age, (years)			
<30	1.00	1.00	1.00
30–40	0.71 (0.63–0.80); <0.0001	0.83 (0.59–1.16); 0.2965	0.78 (0.68–0.90); 0.0006
>40	0.31 (0.27–0.36); <0.0001	0.51 (0.35–0.74); 0.0004	0.37 (0.31–0.45); <0.0001
Residential status			
Rural	1.00	1.00	1.00
Urban	1.97 (1.71–2.26); <0.0001	2.74 (2.03–3.71); <0.0001	0.72 (0.60–0.86); 0.0004
Employment			
Employed	1.00	1.00	1.00
Unemployed, wants to work	0.77 (0.68–0.87); <0.0001	0.56 (0.43–0.74); <0.0001	1.04 (0.88–1.21); 0.6261
Unemployed, does not want to work	0.57 (0.48–0.68); <0.0001	0.45 (0.32–0.62); <0.0001	0.96 (0.76–1.20); 0.7385
Marital status			
Never married	1.000	1.00	1.00
Married or living together	4.42 (3.85–5.08); <0.0001	5.78 (4.34–7.71); <0.0001	3.24 (2.69–3.90); <0.0001
Divorced/separated/widowed	0.63 (0.54–0.73); <0.0001	0.70 (0.50–0.98); 0.0413	0.65 (0.55–0.77); <0.0001
Needs assistance with daily activities			
No	1.00	1.00	1.00
Yes	0.59 (0.50–0.71); <0.0001	0.61 (0.39–0.94); 0.0249	0.72 (0.59–0.89); 0.0031
Contraception status			
None	--	--	1.00
Injectable hormone			1.56 (1.27–1.92); <0.0001
Pill			2.66 (1.70–4.15); <0.0001
Alcohol use			
No	1.00	1.00	1.00
Yes	1.25 (1.11–1.41); 0.0002	1.05 (0.84–1.32); 0.6301	1.36 (1.16–1.60); 0.0001
Year enrolled into care			
2002–2004	1.00	1.00	1.00

	All (N=19703 visits)	Men (N=4479 visits)	Women (N=15224 visits)
	AOR* (95% CI); p-value	AOR (95% CI); p-value	AOR (95% CI); p-value
2005–2006	1.12 (0.99–1.26); 0.0550	0.90 (0.69–1.17); 0.4575	0.98 (0.84–0.87); 0.8434
2006–2009	0.97 (0.86–1.11); 0.7436	0.81 (0.61–1.07); 0.1451	0.84 (0.71–0.98); 0.0296

* AOR, adjusted odds ratio

Table 4

Predictors of unprotected sex (Model II) overall and stratified by gender (N=13064 visits)*

	All (N=13064 visits)	Men (N=3226 visits)	Women (N=9838 visits)
	AOR** (95% CI); p-value	AOR (95% CI); p-value	AOR (95% CI); p-value
HAART status			
No	1.00	1.00	1.00
Yes	0.40 (0.34–0.46); <0.0001	0.33 (0.24–0.44); p<0.0001	0.71 (0.59–0.86); 0.0005
Gender			
Men	1.00	--	--
Women	1.63 (1.37–1.95); <0.0001		
Age, (years)			
<30	1.00	1.00	1.00
30–40	0.88 (0.76–0.98); 0.0898	0.61 (0.40–0.92); 0.0191	0.83 (0.71–0.98); 0.0335
>40	1.25 (1.03–1.53); 0.0229	0.93 (0.60–1.45); 0.7692	1.06 (0.83–1.34); 0.6135
Residential status			
Rural	1.00	1.00	1.00
Urban	0.71 (0.58–0.85); 0.0004	0.59 (0.40–0.89); 0.0118	1.71 (1.34–2.17); <0.0001
Employment			
Employed	1.00	1.00	1.00
Unemployed, wants to work	1.22 (1.04–1.43); 0.0106	1.01 (0.72–1.42); 0.9356	1.27 (1.05–1.54); 0.0135
Unemployed, does not want to work	1.66 (1.32–2.08); <0.0001	1.33 (0.85–2.07); 0.2026	1.58 (1.19–2.10); 0.0014
Marital status			
Never married	1.00	1.00	1.00
Married or living together	1.27 (1.10–1.46); 0.0010	1.47 (1.04–2.08); 0.0276	1.25 (1.06–1.48); 0.0079
Divorced/separated/widowed	1.20 (0.95–1.50); 0.1138	1.58 (0.93–2.65); 0.0842	1.08 (0.82–1.42); 0.5562
Needs assistance with daily activities			
No	1.00	1.00	1.00
Yes	1.38 (1.06–1.81); 0.0166	1.74 (0.95–3.19); 0.0692	1.12 (0.82–1.53); 0.4537
Contraception status			
None	--	--	1.00
Injectable hormone			0.47 (0.35–0.62); <0.0001
Pill			0.67 (0.38–1.19); 0.1813
Alcohol use			
No	1.00	1.00	1.00
Yes	1.12 (0.97–1.30); 0.1045	1.05 (0.18–1.76); 0.3336	1.08 (0.91–1.29); 0.3409
Disclosed HIV status			
No	1.00	1.00	1.00

	All (N=13064 visits)	Men (N=3226 visits)	Women (N=9838 visits)
	AOR ** (95% CI); p-value	AOR (95% CI); p-value	AOR (95% CI); p-value
Yes	0.69 (0.57–0.84); 0.0002	0.74 (0.48–1.12); 0.1602	0.73 (0.58–0.92); 0.0089
STI symptoms			
No	1.00	1.00	1.00
Yes	1.35 (1.20–1.53); <0.0001	1.55 (1.10–2.17); 0.0111	1.34 (1.15–1.56); 0.0002
Year enrolled into care			
2002–2004	1.00	1.00	1.00
2005–2006	1.05 (0.91–1.21); 0.4340	0.96 (0.69–1.33); 0.8251	1.59 (1.33–1.89); <0.0001
2006–2009	0.71 (0.59–0.85); 0.0003	0.58 (0.38–0.88); 0.0109	1.14 (0.92–1.41); 0.02024

* Analyzed at 13064 of 19703 visits at which sexual activity was reported.

** AOR, adjusted odds ratio

Table 5

Predictors of >1 sex partner (Model III) overall and stratified by gender (N=13064 visits)

	All (N=13064 visits)	Men (N=3226 visits)	Women (N=9838 visits)
	AOR** (95% CI); p-value	AOR (95% CI); p-value	AOR (95% CI); p-value
HAART status			
No	1.00	1.00	1.00
Yes	0.20 (0.14–0.29); <0.0001	0.35 (0.23–0.53); <0.0001	0.09 (0.05–0.17); <0.0001
Gender			
Men	1.00	--	--
Women	0.45 (0.36–0.56); <0.0001		
Age, (years)			
<30	1.00	1.00	1.00
30–40	0.96 (0.76–1.21); 0.7355	0.77 (0.50–1.18); 0.2393	1.00 (0.76–1.32); 0.9539
>40	1.58 (1.17–2.13); 0.0023	0.88 (0.54–1.43); 0.6201	2.29 (1.61–3.25); <0.0001
Residential status			
Rural	1.00	1.00	1.00
Urban	0.73 (0.56–0.96); 0.0277	0.64 (0.42–0.97); 0.0366	0.80 (0.56–1.13); 0.2177
Marital status			
Never married	1.00	1.00	1.00
Married or living together	0.53 (0.41–0.67); <0.0001	0.47 (0.32–0.67); <0.0001	0.56 (0.41–0.77); 0.0004
Divorced/separated/widowed	0.88 (0.63–1.22); 0.4639	0.57 (0.32–1.00); 0.0505	1.12 (0.76–1.65); 0.5482
Disclosed HIV status			
No	1.00	1.00	1.00
Yes	0.82 (0.62–1.08); 0.1733	0.62 (0.41–0.96); 0.0338	0.86 (0.60–1.23); 0.4361
STI symptoms			
No	1.00	1.00	1.00
Yes	1.16 (0.94–1.44); 0.1510	1.40 (0.92–2.13); 0.1152	1.09 (0.84–1.41); 0.5028
Year enrolled into care			
2002–2004	1.00	1.00	1.00
2005–2006	0.20 (0.15–0.27); <0.0001	0.49 (0.32–0.73); 0.0006	0.10 (0.07–0.16); <0.0001
2006–2009	0.19 (0.13–0.29); <0.0001	0.51 (0.32–0.82); 0.0056	0.06 (0.03–0.14); <0.0001

* Analyzed at 13064 of 19703 visits at which sexual activity was reported.

** AOR, adjusted odds ratio