HHS Public Access

Author manuscript

AIDS Behav. Author manuscript; available in PMC 2022 October 01.

Published in final edited form as:

AIDS Behav. 2021 October ; 25(10): 3047–3056. doi:10.1007/s10461-021-03258-0.

A prospective study of depressive symptoms, condomless sex, and HIV viral load in HIV-positive female sex workers in Kenya

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Abstract

The relationships between depressive symptoms, viral suppression, and condomless sex were examined in a prospective cohort study of 369 HIV-positive Kenyan female sex workers. Participants were screened for depressive symptoms at baseline and every six months until

Authors' Contributions

Study design (R. Scott McClelland, Barbra A. Richardson, Walter Jaoko), analysis of data (Lei Wang, Barbra A. Richardson), drafting of article (Molly A. Rosenthal, R. Scott McClelland), critical revision of article (all authors), and final approval of submitted version (all authors).

Declarations

Conflict of Interest

RSM has received honorarium for consulting for Lupin Pharmaceuticals and research funding, paid to the University of Washington, from Hologic Corporation.

Ethical Approval

The ethics committees fo Kenyatta National Hospital/University of Nairobi and the University of Washington approved this study. All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Consent to Participate

All participants provided written informed consent.

completion of the study (up to 66 months). HIV viral load (VL) was measured every six months and prostate specific antigen (PSA) testing in vaginal secretions was performed quarterly. Mild or greater depressive symptoms were found in 100 (27.1%) women and were associated with increased risk of detectable VL (aRR 1.41, 95%CI 0.97–2.07, p-value=0.07), but were not associated with detectable PSA. The co-occurrence of PSA detection and detectable VL at the same visit suggests the potential for HIV transmission but was uncommon (2.4% of visits). The prevalence of depressive symptoms and the association with detectable VL suggests the need for screening and treatment of depression for comprehensive HIV care in this population.

Keywords

HIV; HIV-positive female sex workers; depression; depressive symptoms; transmission risk

Introduction

Depressive symptoms are common in HIV-positive individuals in both high and low-resource settings (1). A meta-analysis of 66 studies in sub-Saharan Africa found that the prevalence of depressive symptoms in HIV-positive individuals ranged from 14% to 32% (2). The presence of depressive symptoms has been associated with lower rates of antiretroviral (ART) adherence (3–5), detectable viral load (VL) (6,7), and an increased risk of disease progression independent of ART adherence or detectable VL (8,9) in HIV-positive individuals globally. HIV-positive female sex workers (FSWs) are a population that may be particularly prone to depression due to gender-based violence and internalized stigma associated with HIV and sex work (10,11). A meta-analysis of depression in FSWs in low- and middle-income countries found a pooled prevalence of 41.8% (12). In Kenya, a recent study found that the prevalence of depressive symptoms among FSWs was 33.9%, with a quarter of the women noted to be HIV-positive (13). Despite this, there remains a gap in knowledge about the relationship between depressive symptoms, ART adherence, and viral suppression in HIV-positive FSWs.

It is not clear if depressive symptoms lead to risky sexual behavior (14). A study of 624 HIV-positive men and women in the US found that 15% had symptoms of major depressive disorder, which was associated with an increased rate of condomless sex and sexually transmitted infections (STIs) within 12 months (OR 1.5, CI 0.8–2.7) (15). A meta-analysis of FSWs with unknown HIV status found a pooled prevalence of depression of 62.5% and an association between depression, condomless sex, and STIs (16). While the meta-analysis included data from low- and middle-income countries, there were no studies from sub-Saharan Africa. If depressive symptoms contribute to riskier sex in HIV-positive FSWs, this could contribute substantially to HIV transmission, with FSWs contributing an estimated 10% of new HIV infections globally (17–19).”

This prospective cohort study of HIV-positive FSWs in Mombasa, Kenya tested the hypothesis that depressive symptoms are associated with detectable viral load and condomless sex measured using detection of prostate specific antigen (PSA) in vaginal secretions while carefully evaluating the effect of multiple potential confounding factors.

Methods

Population/Procedures

This longitudinal analysis included data from women enrolled in a cohort study that evaluated the relationship between reproductive life course events and HIV transmission risk behaviors in Mombasa, Kenya (20). Participants were aged 18 years or older, laboratory-confirmed HIV-positive, and eligible for ART. Eligibility for ART and the drugs used in the standard first- and second-line regimens were determined using Kenyan national guidelines (21). All participants reported currently exchanging sex for cash or in-kind payment when they enrolled in the cohort.

At enrollment, a study nurse completed a structured face-to-face interview in either Kiswahili or English to obtain data on health, demographics, sexual risk behaviors, and exposure to violence. Every six months, a study nurse completed a face-to-face interview to perform a Patient Health Questionnaire-9 (PHQ-9) and a blood draw for plasma HIV VL. A study clinician conducted a quarterly physical examination including a speculum-assisted pelvic examination for collection of genital swabs for testing of sexually transmitted infections (STIs) and detection of PSA. Participants returned monthly for clinical and behavioral data collection and medication refills. Women received free outpatient care at the research clinic, including risk reduction education, violence counseling and referral, ART according to Kenyan National Guidelines, and STI screening and treatment. At each visit, participants were compensated 250 Kenyan shillings (about $2.50) for travel expenses. The ethics committees of Kenyatta National Hospital/University of Nairobi and the University of Washington approved this study. All participants provided written informed consent.

Measures

The primary exposure was the presence of mild or greater depressive symptoms in the past six months, measured using PHQ-9. Symptoms were scored as 0–4 [minimal], 5–9 [mild], and 10 or higher [moderate to severe] (22). Due to the small number of participants who reported moderate to severe depressive symptoms, these categories were combined with the mild depressive symptoms category for the primary analyses. This tool was chosen because it has been validated in a similar population of HIV-positive individuals in sub-Saharan Africa (23,24).

To understand the relationships between depressive symptoms, adherence, and viral suppression, these analyses evaluated late ART refill, self-rated ART adherence, and viral suppression. Detectable plasma viral load, the primary outcome, was measured at six-month intervals and defined as HIV RNA ≥180 copies per milliliter (c/ml) using the Hologic/Gen-Probe second-generation assay (Aptima; Hologic, San Diego, CA). This cut-point was higher than the lower limit of linear quantitation for this assay (<30 c/ml) because some 100 ml samples had to be diluted 6-fold to a final volume of 600 ml before testing (25). Secondary outcomes included late ART refill and self-rated ART adherence. Late refill, defined as >48 hours late for a scheduled refill based on pharmacy refill data (26), is a strong predictor of detectable plasma viral load, genotypic antiretroviral resistance, and genital HIV shedding (a marker for infectivity) in this population (26,27). Adherence in the past 30 days

was also evaluated using a validated single-item self-rating scale (28). Participants were asked to "rate your adherence in the last month," using the response categories "very poor, poor, fair, good, very good, and excellent." A binary outcome of "very good or excellent" versus less than "very good" was used. This cutoff corresponded to <80% adherence in a prior validation study (28).

Prostate specific antigen in vaginal secretions, a biomarker of semen exposure within the past 24–48 hours, was evaluated at quarterly examinations (ABACard; West Hills, CA, USA) (29,30). Self-reported sexual behaviors were measured monthly as secondary outcomes. Any condomless sex in the past week and abstinence during the past week were evaluated at all visits. In the subset of visits where women were not abstinent in the past week, the total number of sexual partners, total sex acts, and the proportion with 100% condom use were evaluated. The number of sexual partners was dichotomized into ≤1 or >1, and the number of sex acts was dichotomized into ≤2 or >2. The presence of any STIs at quarterly follow-up visits was also analyzed as a secondary outcome. This was defined as presence of *Chlamydia trachomatis, Neisseria gonorrhoeae*, or *Trichomonas vaginalis* by nucleic acid amplification-based detection (Aptima; Hologic, San Diego, CA).

Sexual transmission of HIV is possible when condomless sex occurs while an HIV-positive person has a detectable plasma viral load (31). In this study, events representing HIV transmission potential were defined by the presence of a detectable plasma viral load and detectable PSA in vaginal secretions at the same visit.

Covariate data were collected at different intervals, depending on the measure. Socio-demographic characteristics included age (linear continuous variable; at enrollment); marital status (ever married; annually); years in sex work (<5, 5–9, ≥10; at enrollment); highest education level (<8 years versus 8 or more; at enrollment); workplace (bar, nightclub, home/other; at enrollment); and partnership status (no partners, casual, and/or regular; quarterly). Casual partners were defined as partners with whom women may have sex once or a few times and regular partners were defined as a partner with whom they have sex regularly. Reproductive characteristics included use of modern contraceptives (none/condoms only, hormonal contraceptive pills, hormonal injections, intrauterine device, tubal ligation, hysterectomy; monthly) and laboratory confirmed pregnancy with urine beta-hCG (Plasmatec Laboratory Products, Dorset, UK; quarterly). Women were asked about any casual partners in the last three months (quarterly). In addition, they were asked about exposure to intimate partner violence (IPV) committed by their primary partner, as well as violence by men other than their primary partner, during the past year (annually). The presence of IPV was determined using a 13-question adaptation of the WHO survey on violence against women (20). Alcohol use was measured using the alcohol use disorder identification tool (AUDIT; annually) (32). AUDIT scores were categorized as non-drinkers [0], non-hazardous alcohol use [1–6], hazardous alcohol use [7–15], harmful alcohol use or alcohol dependency [≥16] (32). Disclosure of HIV status was assessed by asking whether women had ever shared their results with someone, and if so, whom (six-monthly). Time on ART was a time-updated measure based on time since the first date of ART use according to pharmacy records for women who initiated ART at the research clinic, or by self-report at enrollment for women who had initiated ART elsewhere.

Age was included as an a priori confounding factor in the multivariate models based on prior studies (33–35). Additional covariates were considered for inclusion in multivariate models if they were plausible confounding factors based on prior research and causal diagrams (20,36–40). For the outcome of detectable VL, variables considered as potential confounders included alcohol use, having a current regular partner, recent sexual or physical violence by someone other than the index partner, and HIV disclosure status. For the outcome of detectable PSA, variables considered as potential confounders included alcohol use, having a current regular partner, recent IPV, and recent sexual or physical violence by someone other than the primary partner. Manual forward selection was performed, entering variables in order of decreasing effect size with respect to the primary outcome (viral load or PSA detection). None of the covariates changed the primary effect estimates by ≥10%, so they were not retained in the final adjusted models (41).

Statistical Analysis

Women contributed visits to this analysis from October 2012 until loss to follow-up or administrative censoring at the end of the study (April 2018). The PHQ-9 was collected every six months and exposure status (presence or absence of depressive symptoms) was carried forward until the next measurement of the PHQ-9. Other covariate values collected less than monthly were also carried forward until the next assessment.

The primary analyses tested the hypotheses that depressive symptoms in the past six months were associated with increased risk of detectable plasma viral load and, separately, with higher risk of detectable PSA in vaginal secretions. An additional analysis explored whether depressive symptoms were associated with a higher risk of HIV transmission potential events where both viral load and PSA were detected at the same visit.

Because each woman contributed multiple measurements of outcomes to the analysis, log-binomial generalized estimating equation models (GEE) were used to estimate the relative risks (RR) and 95% confidence intervals (CI) (42). All models used independence working correlation structure and robust standard errors. Wald test statistics were used and reported as χ^2 (degrees of freedom). Sensitivity analyses were performed to investigate whether the associations between depressive symptoms, VL, and PSA differed between women who remained in follow-up compared to those who were lost to follow-up, which was defined as not returning for a visit for >6 months (43). An additional sensitivity analysis was performed to understand the effect of using the forward effect window with PHQ-9 scores, restricting the analysis to only visits at which the PHQ-9 was collected. Missing data for outcomes were <10%, and for all exposure and covariates data <1%, so we performed complete case analysis for all regression models. Analyses were conducted in STATA Version 13.0.

Results

Between October 2012 and April 2018, 369 women contributed 11,462 monthly visits. Analyses based on monthly visits included 1,101.4 person-years of follow-up time and the median duration of follow up was 35.5 (IQR 16.1, 62.2) months. During this time, women attended a median of 25 (IQR 9, 48) follow-up visits. Baseline characteristics are presented in Table 1. Participants' median age was 40 years (IQR 34, 44), and they reported first

engaging in sex work a median of 10 years (IQR 6, 15) prior to enrollment. Participants median time on ART at the time of study initiation was 1.9 (IQR 0.2, 5.1) years. Mild or greater depressive symptoms in the past two weeks were reported by 100 (27.1%) women. Plasma HIV VL was detectable for 47 (18.2%) women, while PSA was detected in vaginal specimens of 61 (17.3%) women. In the past week, condomless intercourse was reported by 39 (10.6%) women. Of 209 women who reported any sexual intercourse in the past week, 100% condom use was reported by 170 (81.3%) women, >1 sex partner by 108 (51.7%) women, and >2 sexual encounters by 82 (39.2%) women.

Depressive symptoms, plasma viral load, and ART adherence

Overall, 351 women contributed 1,965 six-monthly visits to the viral load analysis, and 369 women contributed 11,462 monthly visits to the adherence analyses. Depressive symptoms were associated with lower self-reported adherence. Women reported less than “very good” adherence at 29/1,146 (2.5%) visits when mild or greater depressive symptoms were present compared to 94/10,316 (0.9%) visits with minimal depressive symptoms (RR 2.78, 95%CI 1.73–4.47, χ^2=17.75 (1), p-value=0.02) (Table 2). The effect was attenuated slightly when adjusted for age (aRR 2.37, 95%CI 1.47–3.81, χ^2=12.53 (1), p=<0.01). Late refills were identified at 150/808 (18.6%) visits with mild or greater depressive symptoms versus 1,703/8,494 (20.1%) visits with minimal depressive symptoms (RR 0.93, 95%CI 0.76–1.13, χ^2=0.59 (1), p=0.44). The association was similar when adjusted for age (aRR 0.89, 95%CI 0.73–1.09, χ^2=0.59 (1), p=0.28). Detectable HIV viral load occurred at 41/186 (22.0%) visits with mild or greater depressive symptoms compared to 254/1,779 (14.3%) visits with minimal depressive symptoms (RR 1.54, 95%CI 1.06–2.24, χ^2=5.17 (1), p=0.02). The association was similar when adjusted for age (aRR 1.41, 95%CI 0.97–2.07, χ^2=3.24 (1), p=0.07).

To assess the effect of loss to follow-up on the results, a sensitivity analysis was conducted excluding visits that took place after any initial period of loss to follow-up, defined as a gap of >6 months between visits. Loss to follow-up was observed in 21 of 369 participants (5.7%) prior to the study end date. These participants contributed 1,168 of 11,462 visits (10.2%). In analyses excluding data after any episode of loss to follow-up, the association between depressive symptoms and self-rated adherence less than “very good” was only slightly attenuated in the unadjusted (RR 2.36, 95%CI 1.30–4.31, χ^2=7.85 (1), p=0.01) and adjusted models (aRR 2.00, 95%CI 1.11–3.61, χ^2=5.30 (1), p=0.02) (Table 3). The association between depressive symptoms and detectable HIV VL was attenuated and no longer statistically significant in either the unadjusted (RR 1.30, 95%CI 0.83–2.03, χ^2=1.30 (1), p=0.25) or adjusted models (aRR 1.18, 95%CI 0.76–1.84, χ^2=0.54 (1), p=0.46).

To examine the effect of using forward effect windows for PHQ-9 data, the analyses were repeated using data restricted to the visits at which the PHQ-9 was collected (Supplemental Table 1). Compared to the primary analysis, this sensitivity analysis demonstrated a larger effect of depressive symptoms on self-reported adherence, while the results were similar for late refill and detectable HIV VL.

Depressive symptoms, semen detection, self-reported sexual behavior, and STIs

Overall, 353 women contributed 3,635 quarterly visits to the analysis of the association between depressive symptoms and condomless sex using the PSA biomarker. Semen detection by PSA was present at 57/380 (15.0%) visits with mild or greater depressive symptoms compared to 515/3,255 (15.8%) visits with minimal depressive symptoms (RR 0.95, 95%CI 0.68–1.32, χ^2=0.10 (1), p=0.75) (Table 2). The association was similar when adjusted for age (aRR 0.86, 95%CI 0.63–1.19, χ^2=0.84 (1), p=0.36).

Among self-reported sexual behaviors, depressive symptoms were not significantly associated with abstinence during the past week (RR 0.96, 95%CI 0.83–1.12, χ^2=0.23 (1), p=0.63). For those reporting sexual activity in the past week, 100% condom use was reported in 404/506 (79.8%) visits with mild or greater depressive symptoms compared to 3,693/4,564 (80.9%) visits with minimal depressive symptoms (RR 0.99, 95%CI 0.91–1.08, χ^2=0.09 (1), p=0.76). More than one sex partner was reported at 263/507 (51.9%) visits with mild or greater depressive symptoms compared to 1,704/4,571 (37.3%) visits with minimal depressive symptoms (RR 1.39, 95%CI 1.14–1.70, χ^2=10.23 (1), p=<0.01). The association was modestly attenuated in analyses adjusted for age (aRR 1.25, 95%CI 1.08–1.67, χ^2=6.45 (1), p=0.01). More than two sexual encounters were reported at 204/507 (40.2%) visits with mild or greater depressive symptoms compared to 1,368/4,571 (29.9%) visits with minimal depressive symptoms (RR 1.34, 95%CI 1.08–1.67, χ^2=7.28 (1), p=<0.01). As with multiple sex partners, the association with more frequent sex was modestly attenuated in analyses adjusted for age (aRR 1.21, 95%CI 0.99–1.47, χ^2=3.49 (1), p=0.06).

In a sensitivity analysis excluding visits that took place after any initial period of loss to follow-up, defined as a gap of >6 months between visits, results were unchanged for semen detection by PSA, STIs, and self-reported sexual behaviors (Table 3). Similarly, results were not meaningfully different in an analysis including only the visits at which PHQ-9 was measured (Supplemental Table 1).

Depressive symptoms and HIV transmission potential

HIV transmission potential was evaluable at 1,797 visits where both viral load and PSA detection were evaluated. Events representing HIV transmission potential were uncommon, occurring at only 44 (2.4%) visits overall. The prevalence of transmission potential was similar at visits with mild or greater depressive symptoms 3/171 (1.8%) compared to visits with minimal depressive symptoms 41/1,626 (2.5%; RR 0.70, 95%CI 0.21–2.34, χ^2=0.34 (1), p=0.56). Results were similar in the final model adjusted for age (aRR 0.61, 95%CI 0.18–1.98, χ^2=0.69 (1), p=0.41).

Post-hoc Calculation of Study Power

Post-hoc power calculations showed that the primary analyses had 80% power to detect relative risks of 1.50, 1.37, and 2.72 for associations between depressive symptoms and detectable VL, detectable PSA, and transmission potential, respectively, using an alpha level of 0.05.

Discussion

In this prospective cohort study of HIV-positive Kenyan female sex workers, mild or greater depressive symptoms were present in about a quarter of women and were associated with lower self-reported ART adherence and with having a detectable plasma viral load. Depressive symptoms were also associated with having more sex partners and more frequent sex, but not with higher rates of condomless sex. Events representing HIV transmission potential, with biological evidence of condomless sex concurrent with a detectable plasma viral load, were rare for participants with and without depressive symptoms. The rare occurrences of transmission potential events and relatively low rate of depressive symptoms are remarkable for a population usually considered to be at high-risk for HIV transmission and mental illness (10,13,19).

The results presented in this paper parallel several studies that have demonstrated an association between depressive symptoms and lower adherence (4,5,7). Fewer studies have explored the relationship between depressive symptoms and virologic failure in women living with HIV in endemic settings. One systematic review of 23 studies of HIV-positive individuals in sub-Saharan Africa showed the likelihood of achieving good adherence was 55% lower among those with depressive symptoms compared to those without (4). A study of 403 HIV-positive individuals in Tanzania found a significant association between depressive symptoms and lower self-reported ART adherence (44). However, there was no evidence of lower viral suppression in those with depressive symptoms. The results of the Tanzanian study could be explained in the context of the greater potency of new ART regimens, which may maintain viral suppression despite imperfect adherence (45). The data presented in the present paper add to the literature by providing a prospective analysis of the relationship between depressive symptoms and detectable HIV viral load in FSWs, a key population to prevent HIV transmission.

Poor adherence to ART can include failure to take individual doses of medication, failure to return for regular refills, or both. In this cohort, a sensitivity analysis excluding follow-up time after any interval during which participants were lost to follow-up for >6 months showed an attenuated association between depressive symptoms and HIV VL suppression. These findings suggest that depressive symptoms could contribute to detectable VL through effects on retention in follow-up.

The absence of an association between depressive symptoms and condomless sex in this population of FSWs differs from the results of most other studies on this topic. A systematic review and meta-analysis of studies examining HIV risk behaviors in FSWs found that higher depression scores were significantly associated with self-reported inconsistent condom use (16). In sub-Saharan Africa, multiple studies in populations including ART-eligible Ugandan adults, Ugandan adults in relationships, and Kenyan FSWs have found a relationship between depressive symptoms and inconsistent condom use (46–49). Interestingly, in this Kenyan cohort, there were associations between depressive symptoms, higher partner numbers, and more frequent sex. These findings highlight the fact that associations between depressive symptoms and sex behaviors are likely to be context-specific and may vary in relation to factors such as women’s access to condoms,

partner attitudes toward condom use, engagement in transactional sex, financial stress driving increased numbers of partners, knowledge of HIV and STI prevention, and severity of depression. Future research should explore the relationship between depression and sex behaviors in different populations and cultural settings to provide a holistic understanding of these relationships.

This study had several strengths. The longitudinal design using time-updated measures helped to highlight the temporal sequence between depressive symptoms, detectable viral load, and biological evidence of semen exposure. Use of the validated PHQ-9 to measure depressive symptoms will facilitate comparison to other studies (23,24). Biomarkers were used to measure the primary outcomes, detectable viral load and detection of PSA in vaginal secretions, avoiding the potential for recall and social desirability biases that are common with self-report of stigmatized behaviors like non-adherence to ART and condomless sex.

This study also had several limitations. First, depressive symptoms are a sensitive topic that may be subject to underreporting because of social desirability bias. It seems likely that underreporting of depression would be unrelated to the study outcomes, both of which were measured with biomarkers. This type of misclassification would most likely cause attenuation of the observed associations. Second, observational data cannot establish the presence of causal associations. Future studies that directly examine whether treatment of depression results in higher levels of viral suppression, fewer sex partners, and less frequent sex in FSWs are needed to provide this level of evidence. Third, this study was unable to distinguish whether a detectable VL was related to poor adherence or antiretroviral resistance, though prior studies in this population of FSWs have found a low incidence of only 3.0 per 100 person-years for emerging resistance in women on ART (50). Fourth, depressive symptoms could have changed during the six-month periods between measurement by PHQ-9 (51,52). Misclassification of depression status during these intervals would most likely represent non-differential misclassification of the exposure, which would tend to bias the effect estimates for associations between depressive symptoms and the outcomes toward a finding of no effect. Notably, in a sensitivity analysis including only visits where PHQ-9 was measured, there was no difference in the primary outcomes. Fifth, this study included a sample of older, urban and peri-urban FSWs engaged in regular care at a research clinic that provides a substantial level of ART adherence support, sexual risk reduction education, and ready access to free condoms. As such, the findings may be most relevant to other populations of FSWs receiving comprehensive HIV treatment and prevention services.

Conclusion

This study adds to the limited body of literature on depressive symptoms, viral load suppression, and sexual behavior in HIV-positive FSWs. The observation that depressive symptoms are associated with lower ART adherence and virologic failure has important implications for the health of individuals, and potentially for secondary HIV transmission related to this key population. Screening and treatment of depressive symptoms should be considered an important component of comprehensive care for HIV-positive FSWs.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgements

We thank all study participants for their involvement in this study and for our research, clinical, laboratory, outreach, and administrative staff for their support.

Funding

This research was supported by a Grant from the National Institute of Child Health and Human Development (RO1 HD072617), and the Center for AIDS Research at the University of Washington (P30 AI27757). RSW was supported by a Grant from the National Institute of Child Health and Human Development (K24 088229).

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Table 1:

Characteristics of 369 study participants at baseline

	N	N (%) or Median (IQR)
Sociodemographic characteristics		
Age, years	369	40 (34, 44)
Ever married	369	281 (76.2)
Primary school or less education (≤8 years)	369	161 (43.6)
Venue of work	369	
Bar/restaurant		223 (60.4)
Nightclub		86 (23.3)
Home/other		60 (16.2)
Number of years in sex work	369	10 (6, 15)
Partnership status in the past 3 months	369	
No partners		104 (28.2)
Casual partners only		82 (22.2)
Regular partners only		107 (29.0)
Casual and regular partners		76 (20.6)
Psychosocial characteristics		
Depressive symptoms by PHQ-9	369	
Minimal (0 to 4)		269 (72.9)
Mild (5 to 9)		69 (18.7)
Moderate/Severe (10 or higher)		31 (8.4)
Alcohol use by AUDIT	369	
Non-drinker		204 (55.3)
Non-hazardous (1 to 6)		98 (26.6)
Hazardous to harmful (7 or higher)		67 (18.2)
Intimate partner violence in last year	369	75 (20.3)
Non-partner violence in last year	369	48 (13.1)
HIV disclosure to primary partner	369	85 (23.0)
Reproductive characteristics		
Contraceptive use	369	
None or condoms only		259 (70.2)
Depo-medroxyprogesterone acetate		51 (13.8)
Progestogen-containing implant		20 (5.4)
Tubal ligation		17 (4.6)
Oral contraceptive pills		8 (2.2)
Intrauterine device		7 (1.9)
Hysterectomy		7 (1.9)
Pregnant	369	6 (1.6)
Post-menopausal	369	64 (17.3)
Fertility desire [1]	362	77 (21.3)

	N	N (%) or Median (IQR)
Fertility intent [2]	362	31 (8.6)
Clinical characteristics		
CD4	369	447 (316, 605)
<50		6 (1.6)
50–199		38 (10.3)
200–349		67 (18.2)
350–499		115 (31.2)
>/=500		143 (38.8)
Time on ART, years	369	1.9 (0.2, 5.1)
Not yet on ART		2 (0.5)
>0 to 1 month		58 (15.7)
>1 to 6 months		78 (21.1)
>6 to 12 months		22 (6.0)
>12 months		209 (56.6)
Biomarkers		
Semen detection by PSA test	352	61 (17.3)
Detectable plasma viral load	258	47 (18.2)
Transmission potential	241	6 (2.5)
Laboratory-confirmed STI	364	36 (9.9)
Self-reported sexual risk behavior in past week		
Condomless sex	369	39 (10.6)
Abstinent	369	159 (43.1)
100% condom use [3]	209	170 (81.3)
>1 sex partners [3]	209	108 (51.7)
>2 sexual encounters [3]	209	82 (39.2)

[1] Fertility desire was assessed by asking, “Do you want to have any/more children?”

[2] Fertility intent was assessed by asking, “Are you trying to become pregnant?”

[3] Analyzed only among women reporting any sexual activity in the past week

Table 2:

Association between depressive symptoms, antiretroviral drug adherence, viral load suppression, and sexual behavior in HIV-positive Kenyan female sex workers

Outcomes	Visits without depressive symptoms *n (%)*	Visits with depressive symptoms *n (%)*	RR (95% CI), χ^2 (1 df)	*p*	aRR[1] (95% CI), χ^2 (1 df)	*p*
Detectable HIV VL (≥ 180 c/ml)	254/1779 (14.3)	41/186 (22.0)	1.54 (1.06, 2.24), 5.17	0.02	1.41 (0.97, 2.07), 3.24	0.07
Self-rated adherence less than very good or excellent	94/10316 (0.9)	29/1146 (2.5)	2.78 (1.73, 4.47), 17.75	<0.01	2.37 (1.47, 3.81), 12.53	<0.01
Late refill (> 48 h)	1703/8494 (20.1)	150/808 (18.6)	0.93 (0.76, 1.13), 0.59	0.44	0.89 (0.73, 1.09), 1.18	0.28
Semen detection by PSA	515/3255 (15.8)	57/380 (15.0)	0.95 (0.68, 1.32), 0.10	0.75	0.86 (0.63, 1.19), 0.84	0.36
Any STI	317/3921 (8.1)	33/416 (7.9)	0.98 (0.62, 1.56), 0.01	0.94	0.85 (0.54, 1.35), 0.47	0.50
Abstinence	4613/9190 (50.2)	477/985 (48.4)	0.96 (0.83, 1.12), 0.23	0.63	1.06 (0.93, 1.21), 0.84	0.36
100% condom use[2]	3693/4564 (80.9)	404/506 (79.8)	0.99 (0.91, 1.08), 0.09	0.76	0.99 (0.91, 1.08), 0.09	0.76
>1 sex partner[2]	1704/4571 (37.3)	263/507 (51.9)	1.39 (1.14, 1.70), 10.23	<0.01	1.25 (1.05, 1.49), 6.45	0.01
>2 sexual encounters[2]	1368/4571 (29.9)	204/507 (40.2)	1.34 (1.08, 1.67), 7.28	<0.01	1.21 (0.99, 1.47), 3.49	0.06
Transmission potential	41/1626 (2.5)	3/171 (1.8)	0.70 (0.21, 2.34), 0.34	0.56	0.61 (0.18, 1.98), 0.69	0.41

[1] Adjusted for age

[2] Restricted to 5078 monthly visits where women reported being sexually active in the past week

Table 3:

Association between depressive symptoms, antiretroviral drug adherence, viral load suppression, and sexual behavior in HIV-positive Kenyan female sex workers excluding visits following any interval of loss to follow-up*

Outcomes	Visits without depressive symptoms *n (%)*	Visits with depressive symptoms *n (%)*	RR (95% CI), χ^2 (1 df)	*p*	aRR[1] (95% CI), χ^2 (1 df)	*p*
Detectable HIV VL (≥ 180 c/ml)	215/1583 (13.6)	28/159 (17.6)	1.30 (0.83, 2.03), 1.30	0.25	1.18 (0.76, 1.84), 0.54	0.46
Self-rated adherence less than very good or excellent	70/9284 (0.8)	18/1010 (1.8)	2.36 (1.30, 4.31), 7.85	0.01	2.00 (1.11, 3.61), 5.30	0.02
Late refill (> 48 h)	1506/7678 (19.6)	120/712 (16.9)	0.86 (0.70, 1.06), 2.01	0.16	0.84 (0.67, 1.04), 2.66	0.10
Semen detection by PSA	465/2954 (15.7)	51/339 (15.0)	0.96 (0.67, 1.36), 0.06	0.80	0.86 (0.61, 1.21), 0.78	0.38
Any STI	269/3500 (7.7)	24/362 (6.6)	0.86 (0.52, 1.44), 0.32	0.57	0.74 (0.45, 1.24), 1.29	0.26
Abstinence	4275/8291 (51.6)	420/879 (47.8)	0.93 (0.79, 1.09), 0.87	0.35	1.02 (0.88, 1.18), 0.09	0.76
100% condom use[2]	3230/4003 (80.7)	370/458 (80.8)	1.00 (0.91, 1.10), 0.01	0.98	1.00 (0.91, 1.10), 0.01	0.95
>1 sex partner[2]	1399/4010 (34.9)	250/459 (54.5)	1.56 (1.26, 1.93), 16.78	<0.01	Did not converge	NA
>2 sexual encounters[2]	1137/4010 (28.4)	191/459 (41.6)	1.47 (1.17, 1.84), 10.86	<0.01	Did not converge	NA
Transmission potential	37/1462 (2.5)	2/150 (1.3)	0.53 (0.12, 2.31), 0.72	0.30	0.45 (0.11, 1.85), 1.23	0.27

*Indicating a gap in visits of >180 days

[1]Adjusted for age

[2]Restricted to 5078 monthly visits where women reported being sexually active in the past week