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Behavioral Responses of Patients in AIDS Treatment Programs: Sexual Behavior in Kenya

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Behavioral Responses of Patients in AIDS Treatment Programs: Sexual Behavior in Kenya*

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Abstract

We estimate changes in sexual behavior for HIV-positive individuals enrolled in an AIDS treatment program using longitudinal household survey data collected in western Kenya. We find that sexual activity is lowest at the time that treatment is initiated and increases significantly in the subsequent six months, consistent with the health improvements that result from ART treatment. More importantly, we find large and significant increases of 10 to 30 percentage points in the reported use of condoms during last sexual intercourse. The increases in condom use appear to be driven primarily by a program effect, applying to all HIV clinic patients regardless of treatment status.

KEYWORDS: HIV/AIDS, Sub-Saharan Africa, antiretroviral treatment, sexual behavior

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1 Introduction

In many sub-Saharan African countries, access to treatment for people with HIV/AIDS is significantly higher today than it was five years ago. Reductions in the price of antiretroviral therapy (ART) - a combination of three medications - coupled with large increases in donor support has resulted in treatment coverage rates of over 30 percent as of December 2007 (World Health Organization 2008). As the number of individuals receiving ART in sub-Saharan Africa grows, evidence has emerged that these medications are as effective in reducing mortality and morbidity among HIV-infected persons in resource-poor settings as in industrialized countries (Hammer et al. 1997; Palella et al. 1998; Coetzee et al. 2004; Wools-Kaloustian et al. 2006). The benefits of treatment have also been shown to extend to the socioeconomic realm - as the health of HIV-infected adults improves, there are large increases in their labor productivity (Larson et al. 2008; Thirumurthy et al. 2008; Habyarimana et al. 2010) and improvements in the well-being of children living in their households (Graff Zivin et al. 2009).

Despite these large benefits from the provision of ART, concerns have been raised that prolonging the life of those infected as well as potential reductions in incentives to engage in safer sexual behavior as a result of treatment availability may further the spread of HIV/AIDS. The evidence on this effect is mixed and generally based on studies in the United States and other developed countries where ART has been available since the mid 1990s. A meta-analytic review of the medical literature concluded that HIV-infected individuals receiving ART generally did not increase their risky behaviors, although infected and uninfected individuals who had reduced concerns about HIV infection as a result of ART availability were associated with higher prevalence of unprotected sex (Crepaz et al. 2004). In contrast, a recent paper by Lakdawalla et al. (2006), which employs an instrumental variables strategy to control for the effect of confounding factors such as health status, finds that the provision of ART leads to a substantial increase in the number of sex partners for HIV+ individuals. As the authors find that unprotected sex also rose in these partnerships, these increases in the number of sex partners due to ART is associated with rising infection risk for uninfected individuals. There is little evidence to date on behavioral responses to treatment in Africa, a setting where HIV prevalence rates are quite high and socio-cultural institutions are rather distinct from those in the US and Europe.[1]

[1] One notable exception is the study by Bunnell et al. (2006), which examines changes in behavior over time among a cohort of treated individuals in rural Uganda. They document

In this paper, we examine the impact of HIV treatment programs on the sexual behavior of HIV-infected individuals in Kenya. The treatment program that we analyze provides, like many other clinics in the region, free HIV care (including ART or HIV prophylaxis) to patients along with basic information on actions that patients can take to prevent further transmission of HIV. Using longitudinal survey data, we examine the impact of enrollment in the treatment program on levels of patients' sexual activity as well as their use of condoms during sexual intercourse by analyzing changes in these outcomes at two different points in time for a cohort of 170 HIV-positive adults. While there are well-known challenges in obtaining accurate and valid data on sexual behavior in any setting (Gersovitz et al. 1998; Wellings et al. 2006), an important advantage of using longitudinal data is that we are able to control for any *time-invariant* inaccuracies in reporting. We are also comforted by the fact that the sexual behavior data used in our study are largely consistent with those obtained by the Demographic and Health Surveys as well as others reported in the literature (Wellings et al. 2006). Our data indicate treated patients' sexual activity increases in response to ART, but also that this increase in sexual activity is accompanied by a large and significant increase in the use of condoms during sexual intercourse.

In order to deepen our understanding of the potential drivers of this behavior, we distinguish between the responses of individuals in the treatment programs who receive ART from those who do not receive it. The latter group are not provided with ART at the point of program enrollment because their health status has not yet deteriorated to the point where they are classified as having AIDS. These patients report little change in their frequency of sexual activity during the study period, but exhibit similar changes in self-reported condom use as the HIV-positive patients who receive ART. Thus, increases in sexual activity are driven by treatment while the increases in self-reported condom use appear to be due to the treatment program rather than treatment itself.

Our results are noteworthy in light of current discussions about the implications of treatment scale-up on HIV incidence rates in sub-Saharan Africa, the region that is most deeply affected by the disease. Recent data from UNAIDS show, for example, that despite the success that many countries have had in scaling-up treatment programs, HIV incidence is trending upwards. The main conclusions about sexual behavior should be viewed with some caution, however, since the primary measure of risky behavior in our data is limited

declining rates of unprotected sex with partners of HIV-negative or unknown status over a period of six months of treatment.

to self-reported sexual activity and condom use. With only the survey data used in this study, it is not possible to verify the veracity of the self-reported sexual behavior data with biomarker data on HIV seroconversion or other sexually transmitted diseases, or even cross-reports of partners. In particular, an important concern is that exposure to treatment programs might increase the likelihood of over-reporting condom use, since the counseling patients receive is likely to focus heavily on encouraging condom use. Other forms or risky behavior, such as the use of sex workers or the prevalence of unfaithfulness for which we do not have measures, could also change as a result of program participation. To the extent that these changes are small, HIV treatment programs such as the one evaluated here should lead to reductions in HIV transmission rates by those enrolled in treatment programs.

The rest of the paper is organized as follows. The next section provides background on HIV/AIDS and ART. In Section 3, we describe the setting of the survey and the treatment program. Section 4 provides an overview of the empirical strategy and Section 5 presents the main results. Section 6 offers some concluding remarks.

2 Background

Once infected by the human immunodeficiency virus (HIV), the ability of individuals to fight infection is eroded since the virus attacks and destroys white blood cells eventually leading to acquired immune deficiency syndrome (AIDS). In sub-Saharan Africa, most HIV transmission among adults occurs predominantly through heterosexual intercourse (UNAIDS 2006). Soon after transmission, infected individuals enter a clinical latent period of many years during which health status declines gradually with few or no symptoms. During this latency period, most HIV-positive individuals are physically capable of performing all normal activities and typically unaware of their status. Over time, however, almost all HIV-infected individuals will experience a weakening of the immune system and progress to developing AIDS. This later stage is usually associated with substantial weight loss (wasting) and a wide range of opportunistic infections. In the absence of treatment with ART, death usually occurs within one year after progression to AIDS (Morgan et al. 2002; Chequer et al. 1992).

HAART has been shown to reduce the likelihood of opportunistic infections and prolong the life of HIV-infected individuals. Treatment is typically initiated when individuals have progressed to AIDS. After only a few months of treatment, patients are generally asymptomatic, have gained weight and have improved functional capacity. Rapid improvements in clinical outcomes after the initiation of treatment have also been documented for the sample of patients we study in this paper (Thirumurthy et al. 2008; Wools-Kaloustian et al. 2006).

In addition to the health improvement and longer life expectancy that results from treatment, studies have also established that ART leads to a reduction in the infectivity of an HIV-positive individuals (Porco et al. 2004; Castilla et al. 2005). The health improvements and extended life coupled with the reduced infectivity of individuals receiving treatment raises several possibilities for the HIV prevention implications of ART. The next section discusses the survey data that we use to examine the impact of ART on treated patients' sexual behavior.

3 Sampling Strategy and Survey Data

The data used in this paper come from a longitudinal household survey we conducted in a rural region of Western Kenya. The survey took place in Kosirai Division, which has an area of 76 square miles and a population of 35,383 individuals living in 6,643 households (Central Bureau of Statistics 1999). Households are scattered across more than 100 villages where crop farming and animal husbandry are the primary economic activities and maize is the major crop.

The largest health care provider in the survey area is the Mosoriot Provincial Rural Health Training Center, a government health center that offers primary care services as well as free medical care (including all relevant medical tests and ART) to HIV-positive patients. This rural HIV clinic, one of the first to be opened in sub-Saharan Africa, has been operated since November 2001 by the USAID-Academic Model Providing Access to Healthcare (AMPATH) Partnership.[2] Following increased funding since late-2003, the AMPATH clinic at Mosoriot has experienced rapid growth and many patients have come to the clinic from outside the catchment area of Kosirai Division. Since 2003, adequate funding has supported free ART to all patients who satisfy the WHO's treatment guidelines.[3]

[2] AMPATH is a joint partnership between the Indiana University School of Medicine, Moi University School of Medicine, and Moi Teaching and Referral Hospital. A description of AMPATH's work in western Kenya can be found in Mamlin et al. (2004). With financial support from USAID, the USAID-AMPATH Partnership was established in 2004.

[3] The threshold of treatment suggested by the WHO is a CD4 count of less than 200/mm3 or if individuals present with a series of opportunistic infections that constitute AIDS. Most

We implemented two rounds of a comprehensive socio-economic survey over the course of one year (between March 2004 and March 2005), with an interval of six months between rounds. The survey sample consists of two distinct groups: the representative census group includes 507 households chosen randomly from a census of households in Kosirai Division without an AMPATH patient in round 1; and the AMPATH group includes 265 households comprised of all AMPATH patient households who resided in Kosirai Division as well as a random sample of patient households from outside the Division. Moreover, within the AMPATH group there is considerable heterogeneity in the timing of treatment initiation among patients. The sample can be divided into three different groups: patients who had initiated ART before round 1, patients who were ART-native in round 1 but initiated ART between round 1 and 2, and patients who did not receive ART throughout the study period because they had not progressed to the late stages of HIV disease when ART was typically initiated. As will be made clear in the next section, our empirical analysis exploits this variation to identify the impact of ART on sexual behavior.

The survey included questions about demographics, health, agriculture, children's nutrition and schooling, and labor supply. We also obtained self-reported information regarding knowledge about HIV/AIDS as well as the respondents' sexual behavior. Sexual behavior data were obtained from the adult respondents, provided they were under the age of 50 years for females or under the age of 60 years for males.[4] Information was collected on sexual activity during several different recall periods (ranging from one week to one year) and self-reported condom use during the last sexual intercourse. Additional details about the survey and study design can be found in Thirumurthy et al. (2008).

In the analysis that follows, we use two variables for measuring the frequency of sexual intercourse. For all respondents who completed the sexual behavior module, we create indicator variables for whether an individual has been sexually active in the past month and past week prior to the time of the survey interview. Protective sexual behavior is captured in a self-reported dichotomous variable that indicates whether a condom was used at the last

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uninfected individuals have a CD4+ T cell count of 800 to 1000 per mm3 of blood.

[4] It is important to note that for many of the AMPATH patients who resided outside Kosirai Division and too far away to be visited at home, we conducted interviews at the clinic in Mosoriot itself. For these patients, all information on the household was obtained from the AMPATH patient and no self-reported data is available from the patients' spouse or other household members.

sexual encounter, a common measure of safe sex that is used by many sexual behavior surveys (Wellings et al. 2006). The condom use question was only administered to respondents that had been sexually active in the previous six months.

Table 1 presents summary statistics for the main outcome variables and demographic characteristics of study participants. For the representative census sample, 77% of the respondents report having sex in the past month and about 10% used a condom the last time they had sex. In addition there are no changes in these outcomes between the two rounds. The AMPATH sample has on average less frequent sex in the last month (30%) although one can observe an increase from 26% to 35% between rounds. Self-reported condom use in the AMPATH sample is higher than in the representative census sample and there is also an increase from round 1 (31%) to round 2 (64%). When comparing the means between the two groups one should keep in mind that the AMPATH sample in a particular round contains people who are at very different stages of treatment and disease progression. The AMPATH sample is more likely to be female and less likely to be in a union (married or co-habitating), but they appear similar in terms of age and educational attainment. In the analysis that follows, restricting the sample according to gender or union status does not significantly change our results.[5] Table 1 also presents summary statistics for the three different groups of patients who comprise the AMPATH sample. The table also shows that in most cases, levels of sexual behavior and self-reported condom use in these three different groups are significantly different from representative census sample. Another interesting pattern in Table 1 is that for the measures of sexual activity (having been sexually active in the past month and the past week), there is a substantial increase for the two groups of ART recipients but not a large increase for the patients who were not on ART throughout the study period. This is consistent with the possibility that improvements in health lead to increases in sexual activity. However, when it comes to self-reported condom use, there is a substantial increase for all three groups of AMPATH patients, including those who were not on ART. It is also worth noting here that the sample size of patients who initiated ART between rounds is quite small compared to the sample sizes of the other groups of adults.

[5]Since greater than 90% of the representative census sample are in a union, there are too few observations in this category to generate comparisons based on a sample restriction based on non-union.

4 Empirical strategy

Our first approach to understanding the relationship between ART and sexual behavior is to estimate linear regressions in which the round 1 and round 2 levels of sexual activity and self-reported activity are estimated separately for each of the four groups of adults in the survey (census sample, patients on ART since before round 1, patients initiating ART between rounds, and patients who never initiated ART during the study period). In this regression, we simply test whether the changes in the sexual behavior outcomes for the three groups of patients are significantly different from the changes reported by adults in the census sample. However, we then estimate regressions with individual fixed effects regressions that better control for individual heterogeneity in baseline levels of sexual activity and self-reported condom use. Specifically we estimate the following individual fixed effects regression:

$$\begin{aligned} outcome_{it} = \beta_0 + \beta_1 ART_{it} + \beta_2 ROUND2_{it} \\ + \beta_3 ART_{it} * ROUND2_{it} + \beta_4 \delta_i + \beta_5 \tau_t + \epsilon_{it}, \end{aligned} \quad (1)$$

where $outcome_{it}$ is one of our indicators of sexual behavior (had sex last month, used a condom at last sexual intercourse, etc.) for individual i at time t (round 1 or round 2), $ROUND2_{it}$ indicates whether the observation at time t is from round 2 of the survey, δ_i is a fixed effect for individual i and τ_t is a set of ten calendar month of interview dummies (with one month omitted from each of the two survey rounds to avoid collinearity).[6] ART_{it} is an indicator of being an ART recipient at the time of the survey round. This regression excludes those individuals in the HIV sample who had not started ART by the end of the last survey round. All regressions also include observations for adult respondents from the representative census sample of households in the survey area. It should be noted that the coefficient β_2 simply represents the effect of the omitted month in round 2. The coefficients of interest are β_1 and β_3, as they indicate the change in sexual behavior over six months for patients who either begin to receive ART between survey rounds ($\beta_1 + \beta_3$) or had already been receiving ART during round 1 (β_3).

This empirical strategy allows us to address a number of econometric concerns. The panel structure of the data allows us to include individual fixed effects, which should account for any unobserved heterogeneity that is constant

[6] These calendar month dummies are included, as evidence on cyclical births in Kenya (Ferguson 2007) raises concerns about a temporal pattern of sexual behavior in our study region.

over time. Importantly, this approach will also control for any time-invariant variation across individuals in the truthfulness of their reported sexual behavior. To the extent that time-varying factors, such as social desirability bias driven by increases in program exposure exist, they are not addressed by our empirical strategy and should be viewed as a limitation of our approach. Data from the representative census sample of households enables us to control for seasonal changes or secular trends in sexual behavior in the study area – the round of interview and month-of-interview indicators control for such effects. Thus, our key identification assumption is that above and beyond the secular changes identified with data from the representative census sample, the group of HIV-positive patients receiving ART do not change their sexual behavior between the two survey rounds due to factors other than the receipt of treatment, which is known to improve the health and extend the life of these patients.

Of course, the provision of treatment is delivered in a package that is bundled with considerable efforts to educate patients about preventing the spread of HIV. Moreover, in our study setting, as is common across sub-Saharan Africa, the initiation of ART often occurs at or near the time that patients have first learned about their HIV status. Both of these factors could drive a change in sexual behavior, independently of an ART effect. To explore this possibility, we proceed by including all the HIV-positive patients in our sample who had not started ART by the time of the second round of data collection. This group of patients is also enrolled in the AMPATH treatment program but their health status had not deteriorated enough to make them clinically eligible for ART. As a result, any changes in their sexual behavior are likely to reflect the combined effect of AMPATH's education and awareness program as well as the effects of learning one's HIV status, but not the direct effects of ART.[7] To the extent that patients are forward looking, these changes may also reflect the impacts associated with the anticipation of receiving ART upon progression to late-stage HIV disease (AIDS). We thus estimate the following regression model with individual fixed effects:

$$\begin{aligned} outcome_{it} = \beta_0 + \beta_1 ART_{it} + \beta_2 ROUND2_t + \beta_3 ART_{it} * ROUND2_t \\ + \beta_4 HIV\_NOART_i * ROUND2_t + \beta_5 \delta_i + \beta_6 \tau_t + \epsilon_{it}. \end{aligned} \tag{2}$$

[7] While patient's may learn their true HIV status upon program enrollment, changes in behavior due to this knowledge will depend on how much new information is contained in this diagnosis and thus on pre-enrollment priors regarding one's HIV status.

Most variables are defined as in equation 1. HIV_NOART_{it} is a dummy taking value 1 for HIV-positive patients enrolled in AMPATH who have not started treatment as of round 2.[8] The coefficient β_4 therefore represents the change in sexual behavior between rounds for this group of HIV-positive patients, after controlling for secular trends and seasonal changes in behavior. We also estimate equation 2 without individual fixed effects and with indicator variables for each of the three groups of AMPATH patients; these indicator variables will estimate the baseline (round 1) differences in outcomes relative to the census sample.

Since both treated and untreated patients in AMPATH's HIV clinic are being exposed to similar information regarding diagnosis and preventive behaviors, an alternative approach to estimating the overall effect of enrolling in AMPATH's treatment program is to estimate a joint program effect that is independent of ART status. We therefore estimate the following individual fixed effects regression:

$$\begin{aligned} outcome_{it} &= \beta_0 + \beta_1 ROUND2_t + \beta_2 AMPATH_i * ROUND2_t \\ &\quad + \beta_3 \delta_i + \beta_4 \tau_t + \epsilon_{it}. \end{aligned} \tag{3}$$

Note that in these regressions we have not included a main effect for enrollment in the AMPATH clinic since all known HIV-positive patients in the survey are already enrolled in the clinic prior to the round 1 interview.[9] The coefficient on the interaction term $AMPATH_i * ROUND2$ represents the average change in sexual behavior outcomes for all the HIV-positive patients in our sample (treated and untreated).

In order to estimate changes in sexual behavior over time in a more flexible way, we also estimate regression models that use the distance in time between the date of the survey round and the date of ART start (or AMPATH enrollment). These regressions take the following form:

$$\begin{aligned} outcome_{it} = \beta_0 + \sum_p \alpha_i dist\_from\_ARTstart^p_{it} + \\ + \beta_1 ROUND2_t + \beta_3 \delta_i + \beta_4 \tau_t + \epsilon_{it}. \end{aligned} \tag{4}$$

[8] Since we are running fixed effects regressions, the main HIV_NOARV_i effect drops out because an HIV positive individual is either on ARVs or not and we have included an ARV_i indicator.

[9] An exception are four individuals in the random sample who enrolled in the AMPATH program between survey rounds. These four observations have been dropped from these regressions.

The variables $dist\_from\_ARTstart$ are a set of dummy variables equal to one if a person had started ART i quarters prior to time t. This more flexible specification is appealing because it allows us to estimate whether changes in behavior occur among patients in the early or late stages of treatment (or even prior to receiving treatment), for example. As such, this approach also allows us to examine the degree to which changes in sexual behavior appear to be driven by changes in health. In some specifications we substitute $dist\_from\_ARTstart$ with a set of dummy variables that measure distance from AMPATH enrollment date ($dist\_from\_AMPATHstart$).[10]

All of the results we present use a balanced panel of adults who appear in both rounds of the survey. Since some individuals exit the sample between round 1 and round 2 due to death, relocation, or loss-to-follow up (in the case of HIV-positive patients interviewed at the clinic), selective attrition could give rise to biases in the estimated treatment effects. In regressions not reported in the paper, we use our rich dataset of observable characteristics to model the sample selection process in order to reweight the sample using the inverse probability weights (IPW) technique (Fitzgerald et al. 1998; Wooldridge 2002).[11] None of our main results reported below are affected by this alternative estimation strategy.

We also explore heterogeneity in the treatment effect by performing several additional regressions that examine how the main effects vary depending on a number of background and behavioral characteristics of the patients. In particular, we estimate regressions that include interactions between the indicator variables of ART and HIV status of the individual with education and patient gender, whether they are married or co-habitating with their partner (i.e. in a union), as well as the HIV status of the individual's partner (i.e. concordant or discordant couple).

5 Results

Table 2 presents the first set of regression results, which are based on estimating equation 1. This regression compares trends in the sexual behavior of patients who started ART prior to round 2 of the survey to those of in-

[10] As previously mentioned, all individuals in the HIV sample are enrolled in the AMPATH program prior to survey start. Thus the set of dummy variables ($dist\_from\_AMPATHstart$) estimate patterns after the start of enrollment.

[11] The IPW technique uses background and sexual behavior information from round 1 to predict the probability (p_i) that an individual i will still be observed in a future round. This person receives a weight equal to $1/p_i$, thus individuals whose observable characteristics predict higher attrition rates have more weight in the regression analysis.

dividuals in the census sample. Each column in the table reflects the effect on a particular outcome. The dependent variables in the first two columns are indicators for sexual activity in the month and week prior to the survey interview, respectively. The coefficients on the interaction term between the ART status indicator variable and the round 2 indicator variable are large, positive and statistically significant. For HIV-positive already receiving ART as of round 1, there is an increase in the probability of having been sexually active of about 13 percentage points in the six months between rounds 1 and 2, suggesting that as the health of these patients improves following the start of ART, there is a corresponding increase in the frequency of sexual intercourse. The effects on sexual activity for patients who begin to receive ART *between* round 1 and 2 are even larger, as shown by the coefficient of the ART status indicator variables in column 2. For these patients, there is an *additional* increase of 18.8 percentage points in the probability of having been sexually active in the past week. This result is, perhaps, not surprising when we consider that the patients who began treatment between round 1 and round 2 (most began shortly after round 1) are likely to have been the sickest patients during round 1, and also the ones who experienced the largest improvements in health status.

One of the main results of the paper is presented in column 3 of Table 2. For patients receiving ART, we observe a large increase between rounds in self-reported condom use during the last sexual encounter. The regression estimates indicate that between the two survey rounds, HIV-positive patients who were receiving ART as of round 1 reported, on average, a large and significant increase of 25 percentage points in the probability of having used a condom during the last sexual encounter. Thus, while the HIV-positive patients receiving ART are more likely to become sexually active over time, the level of risk they may pose to their partners may not necessarily increase.

The impact of ART on sexual activity can also be displayed in graphs that are based on estimating the more flexible specification described by equation 4. Figure 1A plots the changes in the indicator of having been sexually active during the past month for the 5 quarters before and 6 quarters after the date of treatment initiation. The decline in sexual activity prior to treatment initiation is clearly visible as is the increase immediately afterwards. These results are consistent with previous work using these survey data, which documents a similar V-shape in the health status (as measured by CD4 count and body mass index) and labor supply of patients around the date of treatment initiation (Thirumurthy et al. 2008). A different picture emerges from Figure 2A, which shows changes in self-reported condom use during last sexual intercourse. We observe an increase in self-reported condom use even in the quarters prior to treatment initiation and find that this trend continues even after patients begin to receive ART – a result that will become clearer in a moment.

Next we examine the regression models that also include HIV-positive individuals who are yet to begin ART (equation 2). Columns 1 and 2 of Table 3 show no significant changes in the probability of being sexually active in the past month and week (respectively) for untreated HIV-positive patients. Since the health status for these patients is not changing substantially between survey rounds, this result provides additional evidence that it is ART-induced changes in patient morbidity that are driving changes in sexual activity. More interestingly, however, these patients do display significant increases in self-reported condom use that are similar to those of HIV-positive patients who receive ART. Thus, the condom impacts appear to be the result of the treatment program rather than the treatment itself. This behavioral response is likely the result of two important features of treatment in our setting. First, AMPATH provides extensive sex education to all patients irrespective of their ART status, which might allow patients to make more informed decisions about condom usage. Second, patients typically first learn their HIV status at precisely the moment they enroll in AMPATH's HIV clinic, which might lead to altruistic behavior changes towards one's sexual partners.

Table 4 presents the results from estimating equation 2 without without individual fixed effects but with indicator variables for each of the three groups of AMPATH patients. This enables us to test whether each of the three groups of AMPATH patients have significantly different baseline levels of sexual behavior as well as significantly different trends in sexual behavior, relative to the census sample. Estimating equation 2 without individual fixed effects also means that we can include controls for key patient characteristics. The first three rows of Table 4 indicate whether the round 1 sexual behavior outcomes of each of the three groups of AMPATH patients are significantly different from that of the census sample. Not surprisingly, in most cases this appears to be the case, with AMPATH patients having significantly lower levels of sexual activity and significantly higher condom use than adults in the census sample. When we include controls for individual characteristics, most of these differences remain significant, although for patients who did not initiate ART during the study period, there is no significant difference in round 1 levels of sexual activity in the past month (relative to the census sample). When it comes to the changes between rounds in the sexual behavior outcomes of the three different groups of AMPATH patients, the interaction terms indicate whether those changes are significantly different from the changes among adults in the census sample. Importantly, we find that in general the estimated coefficients are very similar to those reported in Table 3, which included individual fixed effects. We also test whether the estimated changes of the three different groups of AMPATH patients are equal to each other. The results of these tests, which are reported at the bottom of Table 4, indicate that we cannot reject the hypothesis that changes in sexual behavior of the three groups of AMPATH patients are similar to each other. For sexual activity in the past month, we come closer to rejecting the hypothesis but even in this case the p-value of the F-test does not indicate significance at conventional levels. Subsequent results showing a joint effect of being in the AMPATH program will also underscore this point, particularly for self-reported condom use. As for the changes in sexual behavior of each of the three groups of AMPATH patients and their difference from the census sample, we find that for condom use in particular, there is a significant difference between the census sample and the patients who initiated ART before round 1 and for patients who did not receive ART.[12]

In order to better understand the overall impact of the AMPATH treatment program on sexual behavior, we estimate equation 3, in which a joint effect is estimated for the treated and untreated HIV-positive patients. Columns 1 and 2 of Table 5 contain results for the indicator of sexual activity in the past month and week, respectively. We observe few changes in the frequency of sex between survey rounds, although these coefficients are harder to interpret since they contain two heterogenous groups (patients receiving ART and patients not yet receiving treatment) with very different trajectories in their health status. More interesting are the results in the final column, where we observe large changes in protective sexual behavior. Among all the AMPATH patients in our sample, the probability of self-reported condom use during the patients' last sexual encounter increases by 24.4 percentage points between rounds 1 and 2. A similar picture emerges from a regression that uses the distance (in three month intervals) between the survey round and the AMPATH enrollment date to estimate changes in self-reported condom use (see equation 4). These results are best shown graphically in Figure 3A; they indicate a large increases in self-reported condom use in the initial quarters after enrollment in AMPATH's HIV clinic.

Since most of the results so far were based on regression models that included individual fixed effects, it was not possible to estimate the differences in *levels* of sexual behavior between adults in the HIV sample and the representative census sample. In Figures 1B, 2B, and 3B we present coefficients

[12] The sample size of patients who initiated ART between round 1 and 2 is likely to be too small to detect significant differences.

from regressions that are similar to the regression model described by equation 4 but instead of including individual fixed effects, we control for a number of time-invariant individual characteristics (age, education, marital status, location of residence, and gender). In these graphs the average likelihood of being sexually active (in the past month) and likelihood of self-reported condom use among HIV-positive patients over time (measured by three month intervals around treatment initiation or since enrolling in AMPATH's HIV clinic) are shown in comparison to the averages among adults in the representative census sample. In Figure 1B we show that compared to the representative census sample of adults, patients on ART are significantly less likely to be sexually active only in the three quarters after treatment initiation. At all other times (including the year or so prior to treatment initiation as well as four quarters after treatment initiation and beyond), their likelihood of being sexual activity is not significantly different from that of adults in the representative census sample. Figure 2B shows that over time, HIV-positive patients receiving ART go from having levels of self-reported condom use that are not significantly different from those of adults in the representative census sample, to levels that are significantly higher. Figure 3B plots changes in self-reported condom use at last sexual intercourse in the quarters after AMPATH enrollment. While one observes the same positive trend as in Figure 3A, the more interesting finding is that, relative to adults in the representative census sample, HIV-positive patients display very similar patters of self-reported condom use in the quarter when they enroll in the treatment program.[13] This similarity provides additional support for our differencing approach and the conclusion that enrollment in the treatment program leads to large increases in self-reported condom use for the HIV-positive adults in our sample.

In addition to analyzing the average changes in sexual behavior in the sample of AMPATH patients, we also examine whether there are differences within the sample. We start by estimating equations similar to equation 2 but where the enrollment in the treatment program variables are interacted with various characteristics of patients and their partners. In Table 6 we present the results from regressions that use the indicator of having had sex in the past month as the dependent variable and we do not find evidence of significant changes between rounds in the frequency of sexual activity among individual who are enrolled in the treatment program and who have the characteristics indicated in columns 1 to 4. In Table 7, however, we find that there is substantial heterogeneity in the effect of ART on self-reported condom use. Column 1 shows that ART patients whose partners are HIV-negative (i.e. they are part

[13] The results in Figure 2B are similar and consistent with those in Figure 3B.

of a discordant couple) are more likely to use a condom over time. We find similar results for HIV-positive individuals not yet on ART, although they appear to increase condom usage with HIV-positive partners as well. In column 2 of Table 7 we find that among untreated HIV-positive patients, those in unions (either married or cohabitating with a partner) are more likely to increase their self-reported condom use. However, the heterogeneous response by union status among the treated HIV-positive patients is imprecisely estimated. On the education side, untreated HIV-positive patients who are more educated have a larger increase in self-reported condom use between rounds, while more schooling has no effect on condom usage by ART recipients. Lastly, column 4 shows that female patients that have not yet required ART are considerably more likely to increase self-reported condom use than their male counterparts. In the end, no clear story regarding the role of altruism, knowledge, or sexual bargaining power arises from this analysis.

6 Conclusions

In this paper we use panel data from a sample of HIV-positive patients enrolled in an AIDS treatment program, along with data from a control sample in the community, to examine the impact of the program on patients' sexual behavior. Consistent with the health improvement experienced by treated patients, we find increases in the frequency of self-reported sexual activity for these patients. We also find large increases in self-reported condom use over time for the entire sample of patients in the treatment program.

Our results show that the increase in self-reported condom use is not limited to patients in the late stages of HIV infection who have started receiving antiretroviral therapy, but also characterizes patients in the early stages of HIV infection who can expect to receive ART in the future. The changes in behavior therefore apply to all patients who are enrolled in the treatment program.

While our data do not allow us to identify the drivers of this program-level effect, it does not appear to be the result of increased knowledge about safe sexual practices as a result of the patient counseling and education that accompanies program enrollment (see figures 4A and 4B). [14] At least three

[14] Other evidence on the impact of information on sexual behavior is mixed. Two studies conducted in Western Kenya (Duflo et. al. 2006) and Mexico City (Walker et. al. 2006) find no effect of randomized curriculum-integrated sex education campaigns on the rates of unprotected sex. A second study in western Kenya, Dupas (2011) finds positive effects of age-specific prevalence information on the rates of unprotected inter-generational sex.

plausible mechanisms remain. First, in contrast with much of the developed world, most patients in our sample first learn their HIV status at the same moment that they enroll in the treatment program. This status 'shock' may lead patients to take greater precautions, particularly if they are altruistic towards an uninfected sexual partner.[15] Second, HIV-infected patients will have a greater life expectancy as a result of ART being available. A higher life expectancy could mean that patients have greater incentives to engage in safe sex with their partners. Lastly, even if counseling and education to patients does not increase knowledge about ways to prevent transmission of HIV it may reinforce that knowledge since it is provided to patients at each and every visit they make to the health clinic.[16] Future research should focus on disentangling the role of these behavioral channels.

Irrespective of the mechanisms underlying the treatment program effect, the results in this paper suggest that contrary to some of the evidence from the United States, concern about adverse behavioral responses among treated patients in Africa may be unwarranted. While further evidence is necessary, at least some salient characteristics of HIV/AIDS diagnosis and treatment in lower-income countries may explain why the incidence of *unprotected* sex declines over time when HIV-infected individuals enroll in treatment programs. Whether these results generalize to other, unmeasured forms of risky sexual behavior is not known, suggesting caution in the interpretation of these findings. Moreover, the impact of ART availability on the behavior of individuals in the general population who are uninfected or do not know their HIV status is a question that remains unresolved by our research and requires further investigation.

[15] As we noted earlier the extent of the shock depends on individual priors of being HIV positive. Thornton (2008) finds limited responses in the demand for condoms for individuals who learn their HIV status.

[16] Unfortunately, variation in the frequency of clinic visits is based on health status (ART versus non-ART patients) and thus is not useful for disentangling the reinforcement mechanism from others.

Figure 1A. ART and sexual behavior in past month

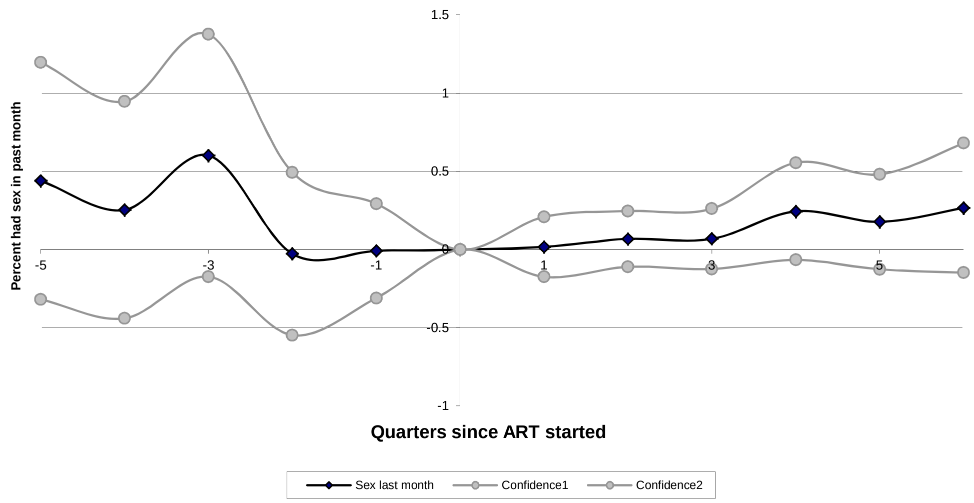
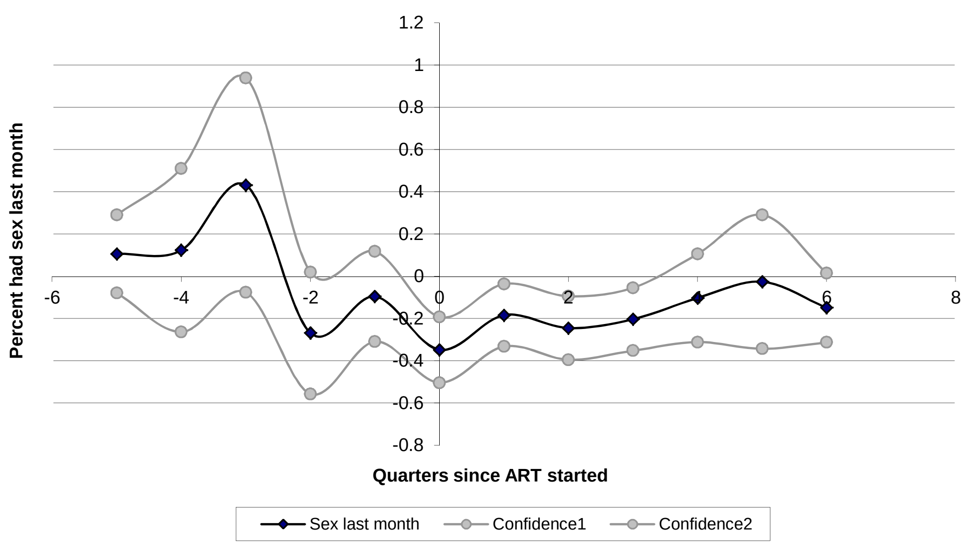


Figure 1B. ART and sexual behavior in past month



Notes: Panel A is based on a person fixed effect regression based on equation 4. Panel B is similar to Panel A but includes background controls instead of person fixed effects. The dependent variables are defined in Table 1. The graphs also plot 95% confidence intervals.

Figure 2A. ART and Condom Use

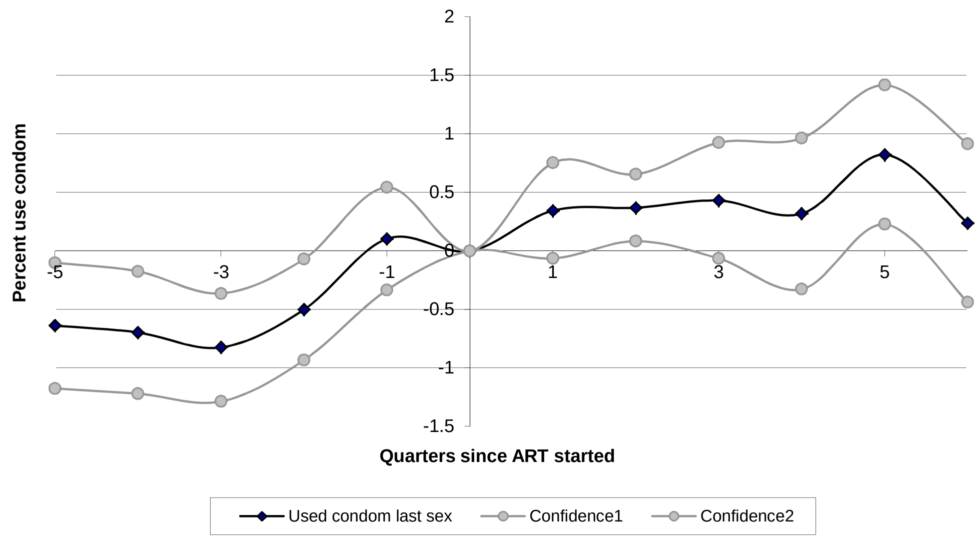
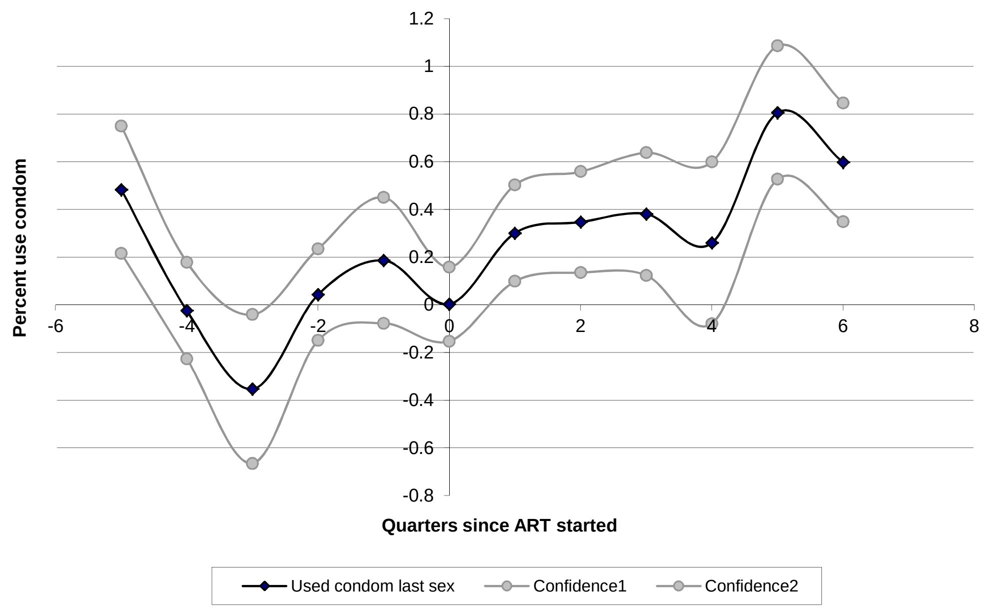


Figure 2B. ART and Condom Use



Notes: Panel A is based on a person fixed effect regression based on equation 4. Panel B is similar to Panel A but includes background controls instead of person fixed effects. The dependent variables are defined in Table 1. The graphs also plot 95% confidence intervals.

Figure 3A. AMPATH and Condom Use

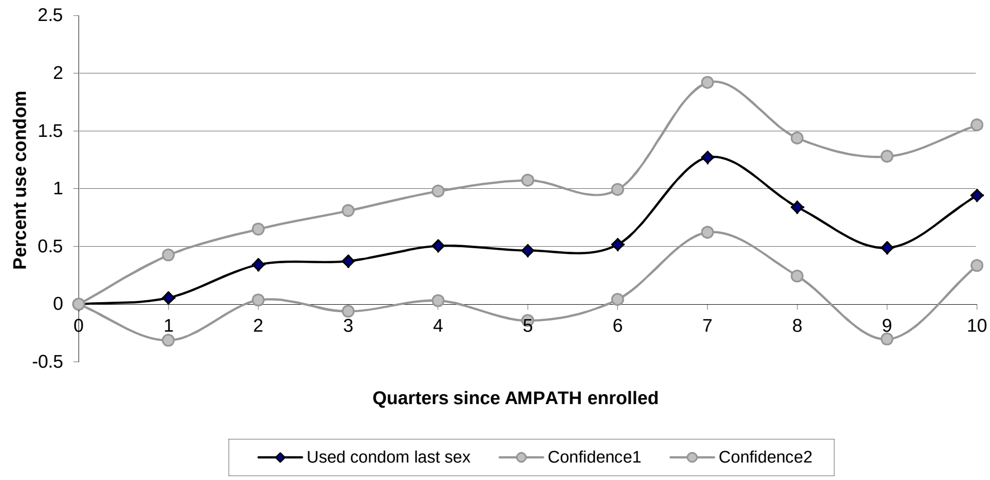
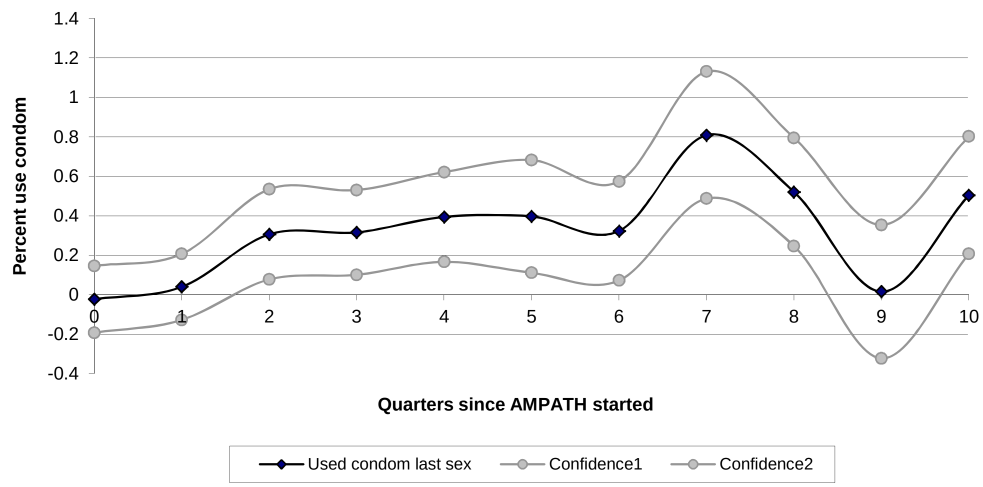


Figure 3B. AMPATH and Condom Use



Notes: Panel A is based on a person fixed effect regression based on equation 4. Panel B is similar to Panel A but includes background controls instead of person fixed effects. The dependent variables are defined in Table 1. The graphs also plot 95% confidence intervals.

Figure 4A. ART and Knowledge that Knowldege of Condom Use for Prevention

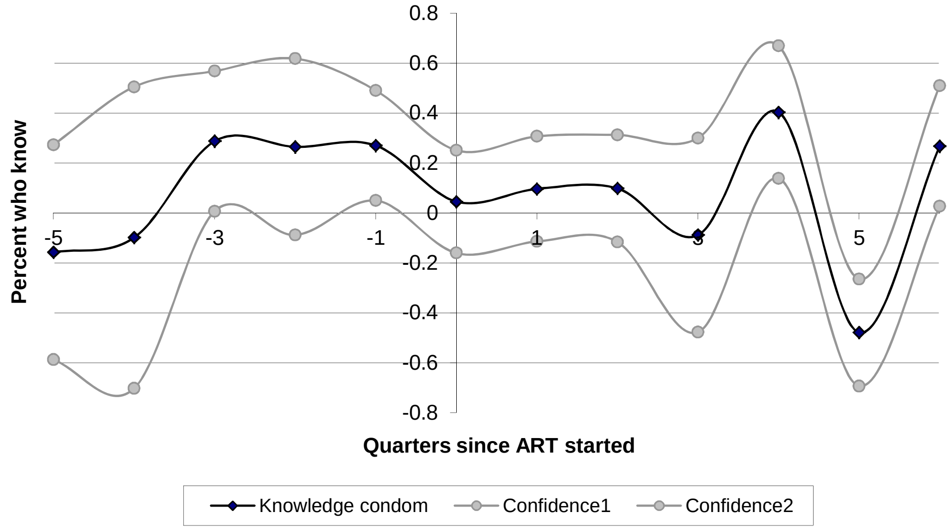
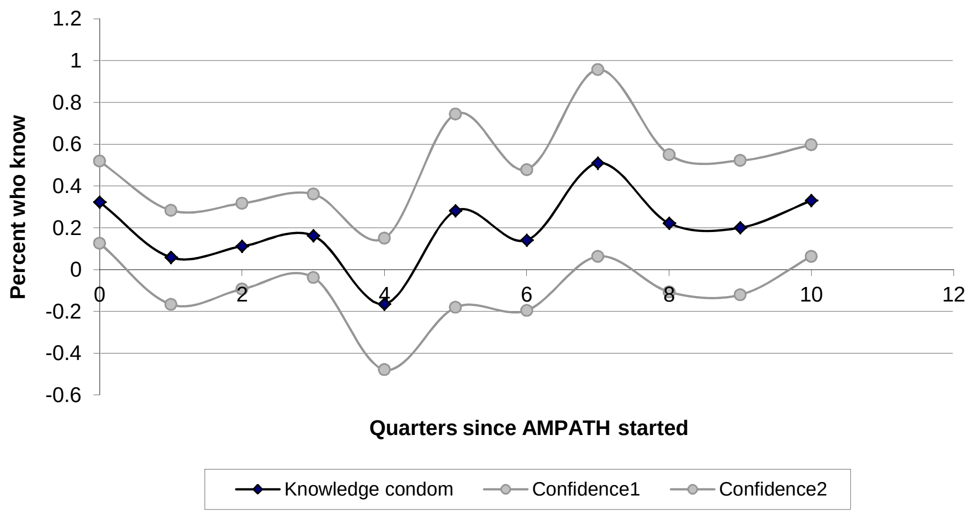


Figure 4B. AMPATH and Knowledge of Condom Use for Prevention



Notes: Panels A and B are based on a person fixed effect regression based on equation 4. The dependent variables indicates whether a person knows that condom use can prevent the transmission of HIV/AIDS. The graphs also plot 95% confidence intervals.

Table 1. Descriptive Statistics

	Census Sample		AMPATH sample		Initiated ART before round 1		Initiated ART between rounds		HIV+ but not on ART	
	Mean	N	Mean	N	Mean	N	Mean	N	Mean	N
Variables (round 1)										
Sex last month	0.76	573	0.26	223	0.19	125	0.29	24	0.42	74
Sex last week	0.57	573	0.11	223	0.10	125	0.08	24	0.19	74
Condom last sex	0.10	539	0.31	128	0.31	68	**0.21**	11	0.31	49
Variables (round 2)										
Sex last month	0.78	566	0.35	202	0.34	126	0.38	24	0.40	52
Sex last week	0.51	566	0.19	201	0.16	125	**0.33**	24	0.21	52
Condom last sex	0.09	533	0.64	114	0.58	71	0.64	11	0.66	32
Background Variables (round 1)										
Union	0.91	574	0.44	223	0.45	125	0.33	24	0.44	74
Years of schooling	8.09	572	**7.64**	223	**8.12**	125	6.25	24	6.83	74
Age	36.6	579	**35.9**	223	**36.2**	125	**35.3**	24	**35.3**	74
Female	0.55	574	0.74	223	0.74	125	**0.71**	24	0.74	74

Notes: The table presents summary statistics of the main outcome variables and patient characteristics for the following five populations: all adults in the census sample, study participants who were HIV-positive and enrolled in the AMPATH clinic, study participants from the AMPATH clinic who initiated ART before round 1, study participants from the AMPATH clinic who initiated ART between round 1 & 2, study participants from the AMPATH clinic who did not initiate ART before round 2. N refers to the sample size for which the mean is calculated. The variable "Condom last sex" refers only to individuals who were sexually active in the 6 months prior to the date of the interview. T-tests were performed to compare the means of each group to the census sample. All of the statistics were significantly different from the census sample with the exception of those in bold.

Table 2. ART and Sexual behavior

	Sex last month (1)	Sex last week (2)	Condom last sex (3)
ART	**-0.068**	**0.188***	**0.095**
	[0.112]	**[0.098]**	**[0.172]**
ROUND2	0.08	-0.075	-0.022
	[0.180]	[0.180]	[0.086]
ROUND2*ART	**0.129****	**0.114****	**0.252*****
	[0.057]	**[0.055]**	**[0.088]**
Person Fixed Effects	Y	Y	Y
Cal. month dummies	Y	Y	Y
Sample Size	1,437	1,437	1,236
R-squared	0.73	0.70	0.70

Notes: The dependent variables are defined in Table 1. Regressions include an ART indicator, individual fixed effects, round 2 indicator variable, and month-of-interview indicator variables. Standard errors are clustered at the household level for each round. ***, ** and * indicate statistical significance at the 1, 5 and 10 percent level respectively.

Table 3. ART and Sexual behavior (with HIV+ persons not on ART)

	Sex last month (1)	Sex last week (2)	Condom last sex (3)
ART	**-0.052**	**0.198****	**0.111**
	[0.111]	**[0.099]**	**[0.173]**
ROUND2	0.05	-0.087	-0.032
	[0.167]	[0.169]	[0.096]
ROUND2*ART	**0.096***	**0.095***	**0.231*****
	[0.057]	**[0.053]**	**[0.088]**
ROUND2*HIV_NOART	**-0.104**	**0.01**	**0.310*****
	[0.094]	**[0.065]**	**[0.111]**
Person Fixed Effects	Y	Y	Y
Cal. month dummies	Y	Y	Y
Sample Size	1,535	1,535	1,300
R-squared	0.73	0.71	0.72

Notes: The dependent variables are defined in Table 1. Regressions include an ART indicator, an indicator for being HIV positive but not on ART, individual fixed effects, round 2 indicator variable, and month-of-interview indicator variables. Standard errors are clustered at the household level for each round. ***, ** and * indicate statistical significance at the 1, 5 and 10 percent level respectively.

Table 4. Enrollment in HIV care and sexual behavior (no fixed effects)

	Sex last month (1)	Sex last week (2)	Condom last sex (3)	Sex last month (4)	Sex last week (5)	Condom last sex (6)
A Initiated ART before round 1	-0.485***	-0.401***	0.205***	-0.278***	-0.261***	0.183***
	[0.050]	[0.054]	[0.051]	[0.047]	[0.053]	[0.051]
B Initiated ART between round 1 & 2	-0.387***	-0.393***	0.117	-0.141	-0.239**	0.070
	[0.092]	[0.100]	[0.092]	[0.086]	[0.097]	[0.092]
C HIV-positive but did not initiate ART before round 2	-0.213***	-0.265***	0.246***	-0.028	-0.145**	0.224***
	[0.066]	[0.072]	[0.060]	[0.061]	[0.069]	[0.060]
D Round 2	-0.030	-0.142**	0.084*	0.021	-0.112*	0.078
	[0.058]	[0.063]	[0.050]	[0.053]	[0.060]	[0.050]
E Initiated ART before round 1 * Rd 2	0.072	0.080	0.259***	0.080	0.091	0.260***
	[0.067]	[0.073]	[0.068]	[0.061]	[0.069]	[0.067]
F Initiated ART between round 1 & 2 * Rd 2	0.031	0.265*	0.399***	0.034	0.271**	0.410***
	[0.130]	[0.141]	[0.138]	[0.119]	[0.134]	[0.137]
G HIV-positive but did not initiate ART	-0.128	-0.006	0.315***	-0.132	-0.006	0.326***
before round 2 * Rd 2	[0.092]	[0.100]	[0.087]	[0.084]	[0.095]	[0.086]
H Female				-0.085***	-0.139***	-0.065***
				[0.023]	[0.026]	[0.021]
I Age (years)				-0.004***	-0.009***	-0.002**
				[0.001]	[0.001]	[0.001]
J Number of years of school completed				-0.002	-0.003	0.006*
				[0.003]	[0.004]	[0.003]
K Married or cohabitating				0.460***	0.297***	-0.143***
				[0.029]	[0.033]	[0.035]
Constant	0.733***	0.571***	0.092***	0.500***	0.733***	0.308***
	[0.038]	[0.041]	[0.032]	[0.081]	[0.091]	[0.076]
Observations	1539	1539	1303	1535	1535	1299
R-squared	0.20	0.14	0.18	0.34	0.23	0.20
P-value of F-test that E=D	0.31	0.04	0.06	0.52	0.05	0.05
P-value of F-test that F=D	0.69	0.03	0.75	0.93	0.26	0.94
P-value of F-test that G=D	0.41	0.29	0.03	0.16	0.39	0.02

Notes: Standard errors are clustered at the household level for each round. ***, ** and * indicate statistical significance at the 1, 5 and 10 percent level respectively.

Table 5. AMPATH and Sexual behavior

	Sex last month	Sex last week	Condom last sex
	(1)	(2)	(3)
ROUND2	0.049	-0.081	-0.02
	[0.167]	[0.169]	[0.096]
ROUND2*AMPATH	**0.034**	**0.074**	**0.244*** **
	[0.055]	**[0.050]**	**[0.076]**
Person Fixed Effects	Y	Y	Y
Cal. month dummies	Y	Y	Y
Sample Size	1,535	1,535	1,300
R-squared	0.72	0.71	0.71

Notes: The dependent variables are defined in Table 1. Regressions include an AMPATH enrollment indicator, individual fixed effects, round 2 indicator variable, and month-of-interview indicator variables. Standard errors are clustered at the household level for each round. ***, ** and * indicate statistical significance at the 1, 5 and 10 percent level respectively.

Table 6. Interactions of ART and Frequency of Sexual Activity (with HIV+ persons not on ART)

Dependent variable: SEX LAST MONTH	Interaction = Discordant	Interaction = In Union	Interaction = Years of Schooling	Interaction= Female
	(1)	(2)	(3)	(4)
ARV	0.422	-0.094	-0.07	-0.203
	[0.312]	[0.104]	[0.237]	[0.230]
ROUND2	-0.046	-0.056	0.049	0.076
	[0.201]	[0.175]	[0.178]	[0.169]
ROUND2*ART	0.157	0.126*	0.221	0.156
	[0.118]	[0.070]	[0.149]	[0.105]
ART*INTERACTION	-0.885**	0.173	-0.002	0.204
	[0.372]	[0.268]	[0.032]	[0.267]
ROUND2*INTERACTION	-0.125	0.104	-0.001	-0.053
	[0.112]	[0.066]	[0.008]	[0.035]
ROUND2*ART*INTERACTION	**0.135**	**0.041**	**-0.013**	**-0.044**
	[0.185]	**[0.107]**	**[0.017]**	**[0.110]**
ROUND2*HIV_NOART*INTERACTION	**-0.421****	**-0.049**	**-0.003**	**-0.007**
	[0.201]	**[0.139]**	**[0.011]**	**[0.103]**
Person Fixed Effects	Y	Y	Y	Y
Cal. month dummies	Y	Y	Y	Y
Sample Size	1,176	1,535	1,535	1,535
R-squared	0.60	0.73	0.73	0.73

Notes: The dependent variables are defined in Table 1. All regressions include an ART indicator, an indicator for being HIV positive but not on ART, individual fixed effects, round 2 indicator variable, and month-of-interview indicator variables. The five interaction variables are: (1) indicator for being a concordant couple, (2) an indicator for living in union, (3) education measured as years of schooling, (5) an age dummy for being older than 35 years, and (5) a female dummy. Standard errors are clustered at the household level for each round. ***, ** and * indicate statistical significance at the 1, 5 and 10 percent level respectively.

Table 7. Interactions of ART and Condom Use (with HIV+ persons not on ART)

Dependent variable: CONDOM USE	Interaction = Discordant	Interaction = In Union	Interaction = Years of Schooling	Interaction = Female
	(1)	(2)	(3)	(4)
ART	0.39	0.334	0.446	-0.350**
	[0.331]	[0.290]	[0.303]	[0.141]
ROUND2	-0.05	-0.059	-0.092	0.033
	[0.121]	[0.129]	[0.108]	[0.101]
ROUND2*ART	0.122	0.167	0.581***	0.2
	[0.117]	[0.142]	[0.183]	[0.130]
ARV*INTERACTION	-0.833**	-0.308	-0.056	0.729***
	[0.372]	[0.350]	[0.036]	[0.250]
ROUND2*INTERACTION	-0.108	0.057	0.005	-0.109***
	[0.098]	[0.098]	[0.005]	[0.033]
ROUND2*ART*INTERACTION	**0.391***	**0.086**	**-0.044***	**0.041**
	[0.214]	**[0.169]**	**[0.025]**	**[0.181]**
ROUND2*HIV_NOART*INTERACTION	**0.314***	**0.411*****	**0.043*****	**0.304****
	[0.188]	**[0.115]**	**[0.014]**	**[0.143]**
Person Fixed Effects	Y	Y	Y	Y
Cal. month dummies	Y	Y	Y	Y
Sample Size	1,127	1,264	1,260	1,264
R-squared	0.67	0.72	0.72	0.72

Notes: The dependent variables are defined in Table 1. All regressions include an ART indicator, an indicator for being HIV positive but not on ART, individual fixed effects, round 2 indicator variable, and month-of-interview indicator variables. The five interaction variables are: (1) indicator for being a concordant couple, (2) an indicator for living in union, (3) education measured as years of schooling, (5) an age dummy for being older than 35 years, and (5) a female dummy. Standard errors are clustered at the household level for each round. ***, ** and * indicate statistical significance at the 1, 5 and 10 percent level respectively.

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