AIDS Treatment Programs and Sexual Behavior*

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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 improvements in health and socio-economic outcomes as a result of ARV 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 increase in condom use is limited not only to patients who have initiated treatment but also to HIV-positive patients who are enrolled in the program but are not sick enough to require treatment. We discuss the mechanisms that might explain these results and the implications of these findings for understanding the impact of ARV treatment programs on the course of the HIV epidemic.

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1 Introduction

The availability of medicines to treat people with AIDS in many sub-Saharan African countries has increased dramatically in recent years. Reductions in the price of highly active antiretroviral therapy (HAART) - a combination of three medications - coupled with large increases in donor support has resulted in treatment coverage rates of nearly 30 percent in developing countries as of December 2006 (World Health Organization, 2007).

As the number of individuals receiving antiretroviral therapy in sub-Saharan Africa grows, evidence has emerged that these medications are as effective in reducing mortality and morbidity among HIV-infected person 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, Duggan and Evans, 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 (Thirumurthy, Graff Zivin, and Goldstein, 2005; Habyarimana, Mbakile, and Pop-Eleches, 2007) and improvements in the well-being of children living in their households (Graff Zivin, Thirumurthy, and Goldstein, 2006).

While these benefits from the provision of antiretroviral therapy (ARV) are large, concerns have been raised that they may be undermined by the influence of treatment on incentives to engage in frequent and risky sexual behavior, and thus the further spread of HIV/AIDS. Such influences apply equally to infected and uninfected individuals, albeit through different channels, with the former being an especially important group since they serve as the repository for the disease. In this paper, we focus on a subset of this important group - those individuals known to be HIV positive who enroll in AIDS treatment programs. For this group, the effect of treatment on sexual behavior, and in turn, future HIV infections is complex and depends on five crucial factors:[1]

Firstly, as outlined above ARVs prolong life expectancy and therefore lengthen the period of infectiousness. Marin et. al (2003) reports an increase in median life expectancy of ARV patients of 58 months in a longitudinal study in Brazil. Thus, patients will

[1]ARV treatment has a direct biologic influence on it. Several studies have shown that ARV therapy reduces the infectivity of patients by lowering their viral load (Porco et al., 2004; Castilla et al. 2005). To the extent that patients are aware of this, behavioral incentives could be further altered.

typically have an additional five years to potentially infect others.

Secondly, ARV therapy might change the frequency of sexual activity. The significant health benefits associated with treatment suggest a plausible increase in the level of sexual activity following the onset of treatment. The limited evidence for this effect comes largely from the United States and Western Europe, where much of the research relies on cross-sectional comparisons of treated and untreated HIV-positive individuals (see Crepaz et al., 2004 for a survey). One notable exception is by Goldman et al. (2006) who use an IV strategy to control for the effect of confounding factors such as health status and find that the provision of ARV therapy results in a large increase in the number of new partners for HIV+ individuals, doubling the risk of HIV infection for sexually active uninfected persons.

Thirdly, a patient on ARVs might change the riskiness of sexual activity. The sign of this effect is theoretically ambiguous. On the one hand, the effectiveness and availability of ARV treatment reduces the 'costs' of infection, potentially reducing the incentives to engage in safe sexual practices. On the other hand, increased life expectancy and resulting changes in time preferences could raise the perceived costs of the future disease burden to others and might induce safer sexual practices, especially if their sexual partner is a uninfected spouse.[2] Recent evidence on this channel comes from Bunnell et al. (2006) who examine changes in behavior over time among a cohort of treated individuals in rural Uganda. They document declining rates of unprotected sex with partners of HIV-negative or unknown status over a period of six months of treatment. For a cohort of 926 HIV-infected individuals in rural Uganda, they find a 70 percent reduction in risky sexual behavior and a corresponding reduction in transmission risk.

Finally, ARV treatment programs may expand the information sets of participants through the integrated counseling and safe sex education that has become a standard component of all treatment programs. Informational updating may be especially important for individuals who enroll in an ARV treatment program immediately after learning that they are infected with HIV. The new information acquired as a result of enrollment in a treatment program could affect the patterns of sexual behavior, either because of al-

[2]Uncertainty in the status of the spouse is likely to produce a smaller, albeit positive change in rates of protected sex.

truism towards a sexual partner (who is often a spouse) and other dependents or because of risks to own health from unprotected sex between two HIV positive individuals.[3]. Evidence on the impact of information on sexual behavior is mixed. Two studies conducted in Western Kenya (Duflo et. al. (2006)) and Mexico City (Bertozzi 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 2006) finds positive effects of age-specific prevalence information on the rates of unprotected inter-generational sex.

The implications of treatment availability on the behavior of infected individuals and HIV transmission in general is an empirical question that does not depend singly on any of the channels outlined above. We utilize novel longitudinal data of individuals enrolled in an ARV treatment program in Western Kenya to study the effect of enrollment in the program on the sexual behavior of infected individuals. The treatment program, like many in the region, provides free HIV care (including ARV therapy and HIV prophylaxis) to patients and information through testing and basic counselling on the actions that patients can take to prevent further transmission of HIV. This treatment program provides an opportunity to understand the joint effect of the channels outlined above on the implications of treatment on HIV transmission. The data were collected in collaboration with a large and expanding treatment program in Kenya, the Academic Model for the Prevention and Treatment of HIV/AIDS (AMPATH).

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. Changes in these outcomes are examined at two different points in time for a cohort of 170 HIV-positive adults. The impact of enrollment in the program is identified by estimating individual fixed effects regressions.[4] An important feature of our analysis is that we are able to control for secular changes in sexual behavior in the survey region with data from a random sample of adults who reside in the catchment area of the AMPATH clinic. Furthermore,

[3]The risks to own health include reinfection and the possible transmission of drug resistant strains and other sexually transmitted infections.

[4]While there are well-known challenges in obtaining accurate and valid data on sexual behavior in any setting (Gersovitz, 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 the reporting of behavior. 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).

since some patients do not begin to receive ARV therapy until they are clinically in need of it (according to WHO criteria that are outlined below), we are able to examine whether changes in sexual behavior are being driven by enrollment in the treatment program alone or if the provision of ARV therapy is the critical element for change. Thus, we provide some insight on the relative contribution of poor health, treatment experience (as opposed to expectation), and informational exposure on the behavior of patients.

Our main results highlight several important changes in sexual behavior as a result of ARV therapy and enrollment in the treatment program. We find that sexual activity is lowest at the time that ARV therapy is initiated and increases significantly in the subsequent six months. The likelihood of having been sexually active in the past month as well as in the past week increases after treatment is provided. This result is consistent with the large improvement in health status that occurs after receiving treatment, and that has been documented for the sample of patients studied in this paper. More importantly from the standpoint of HIV prevention, we find that this increase in sexual activity is accompanied by a large and significant increase in the use of condoms during sexual intercourse. To distinguish between the information and treatment components of the treatment program, we examine the sexual behavior of a relatively small number of HIV-positive patients who do not receive ARV therapy immediately after enrolling in the program (though they do receive prophylaxis for opportunistic infections). These patients show little change in their sexual activity over the study period, but exhibit similar changes in condom use as the HIV-positive patients who receive ARV therapy. Together, they suggest an increase in sexual activity due to dramatic improvements in health and significant increases in condom use that appear to be driven by enrollment in AMPATH rather than ARV treatment per se.

Finally, since nearly all the HIV-positive patients in our study enroll in the treatment program soon after learning their HIV status, our results also provide insights into a related question of whether learning HIV status affects sexual behavior. Patients in our study are generally referred to AMPATH's HIV clinic from voluntary counselling and testing (VCT) centers or antenatal clinics (in the case of pregnant women) where they have recently learned their HIV status. Contrary to the evidence in Thornton (2006), we find that conditional on the presence of a counselling and treatment program, HIV-

positive adults may indeed reduce their levels of risky sex upon learning their HIV status.

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. Our results suggest that the concern that negative behavioral responses among ARV patients will contribute significantly to a rise in new HIV infections might be unwarranted.

The rest of the paper is organized as follows. The next section provides background on HIV/AIDS and ARV therapy. In Section 3, we describe the setting of the survey and AMPATH's services. Section 4 provides an overview of the empirical strategy and Section 5 presents the main results. Section 6 concludes the paper by discussing the implications of our findings.

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. The median time from seroconversion to AIDS in East Africa is estimated to be 9.4 years (Morgan et al., 2002).[5] 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 infec-

[5]Conversion to HIV-positive serology normally occurs 4-10 weeks after transmission. The duration of the clinical latent period has been found to vary considerably, depending upon the mode of transmission and age at transmission (Collaborative Group on AIDS Incubation and HIV Survival including the CASCADE EU Concerted Action, 2000). In developing countries, limited access to health care and greater burden of other infectious diseases may expedite the progression of HIV.

tions. In the absence of treatment with ARV therapy, death usually occurs within one year after progression to AIDS (Morgan et al., 2002; Chequer et al., 1992).

HAART[6] 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. This positive impact has been documented in numerous studies in various countries and patient populations. In Haiti, treated patients experienced weight gain and improved functional capacity within one year after the initiation of ARVs (Koenig, Leandre, and Farmer, 2004).[7] Studies in sub-Saharan Africa have also shown rapid improvements in immunological outcomes of patients (Laurent et al., 2002; Coetzee et al., 2004). 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., 2005; Wools-Kaloustian et al., 2006). In Brazil, median survival times after developing AIDS rose to 58 months with ARV therapy (Marins et al., 2003). Similar gains in life expectancy have also been confirmed by more recent studies (Goldie et al., 2006).

In addition to the health improvement and longer life expectancy that results from treatment, studies have also established that ARV therapy 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 ARV therapy. The next section discusses the survey data that we use to examine the impact of ARV therapy on treated patients' sexual behavior.

[6]In this paper, we use the terms "ARV therapy" and "ARV treatment" to refer to highly active antiretroviral therapy (HAART), which was introduced in 1996. HAART always consists of three antiretroviral medications, with a common first-line regimen of nevirapine, stavudine, and lamivudine. Generic medications that combine 3 medications in 1 pill (such as Triomune) have recently become available.

[7]Since placebo-controlled randomized trials of ARV therapy are ethically infeasible, these studies are either observational cohort studies or randomized trials that compare regimens composed of different antiretroviral medications.

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 ARV therapy) 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 Academic Model for the Prevention and Treatment of HIV/AIDS (AMPATH).[8] 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 ARV therapy to all patients who satisfy the WHO's treatment guidelines.[9] 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. The CD4+ T cell count is an important indicator of disease progression among HIV-infected individuals.[10]

We implemented two rounds of a comprehensive socio-economic survey over the course of one year (between March 2004 and March 2005).[11] There was an interval of six months between the first two rounds of the survey. The survey sample consists of households chosen randomly from Kosirai Division as well as households of HIV-positive patients at the AMPATH clinic. 507 households were chosen randomly from a census of households

[8]AMPATH is a collaboration between the Indiana University School of Medicine, Moi University School of Medicine, and Moi Teaching and Referral Hospital. Descriptions of AMPATH's work in western Kenya can be found in Mamlin et al. (2004) and Einterz et al. (2007).

[9]The WHO guidelines have been followed by many treatment programs in developing countries, including AMPATH. See Grubb, Perriens, and Schwartlander (2003) and Mamlin, Kimaiyo, Nyandiko, and Tierney (2004).

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

[11]Round 1 was between March and August 2004 and round 2 was between September 2004 and March 2005.

in Kosirai Division without an AMPATH patient in round 1 (we refer to these as the random sample of households). At the same time, 265 households with AMPATH patients were enrolled during round 1. We enrolled all AMPATH patients who resided in Kosirai Division as well as a random sample of patients from outside the Division.

The AMPATH patients enrolled in the study differ in important ways. Some had already been receiving treatment at the time of enrollment, and the duration of time on treatment varied considerably. Other patients in the sample began to receive ARV therapy in between survey rounds. Finally, some patients did not receive ARV therapy throughout the duration of their participation in the study, in large part because they had not yet progressed to the late stages of HIV disease (when ARV therapy is to be initiated). In our empirical analysis, we identify the impact of ARV therapy on sexual behavior using the variation in the timing of treatment initiation in our sample. We also examine whether enrollment in AMPATH's HIV clinic alone - without treatment initiation - is associated with changes in sexual behavior.

The survey included questions about demographic characteristics, health, agriculture, children's nutrition and schooling, and labor supply. Teams of male and female enumerators typically interviewed the household head and spouse separately. 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' spouses or other household members.

The survey obtained self-reported information on the respondents' knowledge about HIV/AIDS as well as the respondents' sexual behavior. Sexual behavior data was obtained from the adult respondents, provided they were under the age of 50 years (females) or under the age of 60 years (males). Information was collected on sexual activity during several different recall periods (ranging from one week to one year). In addition, we collected data on the use of condoms during the last sexual intercourse. Next we describe these outcomes in more detail and present an overview of the empirical strategy for analyzing the two rounds of survey data.

We use two variables for measuring the frequency of sexual intercourse. For all re-

spondents who completed the sexual 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. In addition we use two variables that try to measure protective sexual behavior. Our primary outcome variable of interest is an indicator of whether a condom was used at the last sex encounter, a common measure of safe sex that is used by many sexual behavior surveys (Wellings et al., 2006). Secondly, we also asked our respondents if they believe that their last partner has had sexual encounters with other persons in the past six months. These two questions were administered to all respondents with a partner or those who have been sexually active in the previous six months.

Table 1 presents summary statistics for the main variables used in the study. For the random sample, 77% of the respondents report having sex in the past month and about 9% used a condom the last time they had sex. In addition there are no changes in these outcomes between the two rounds. The HIV sample has on average less frequent sex in the last month (30%) although one can observe an increase from 24% to 35% between rounds. Condom use in the HIV sample is higher than in the random sample and there is also an increase from round 1 (33%) to round 2 (63%). When comparing the means between the two groups one should keep in mind that the HIV sample in a particular round contains people who are at very different stages of treatment and disease progression. Our main independent variables are indicators for being enrolled in the AMPATH treatment program and for being on ARV treatment, as well as the distance in time from program enrollment and treatment start to the date of the interview.

4 Empirical strategy

Our first approach to understanding the relationship between ARV treatment and sexual behavior is to estimate individual fixed effects regressions of the form:

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

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). ARV_{it} is an indicator of being an ARV recipient at the time of the survey round. This regression excludes those individuals in the HIV sample who had not started ARV treatment by the end of last survey round. All regressions also include observations for adult respondents from the random 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 ARV treatment between survey rounds ($\beta_1 + \beta_3$) or had already been receiving ARV treatment during round 1 (β_3).

Our 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 over time. This also deals with the possibility that there is time-invariant variation across individuals in the truthfulness of their reported sexual behavior. In addition, the data from the random 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 random sample, the group of HIV-positive patients receiving ARV therapy 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 also accompanied by several other interventions such as some provision of HIV prevention information by the treatment program. In addition, many of the patients receiving ARV therapy may also have recently learned their HIV status. Both these factors could drive a change in sexual behavior. To explore this possibility, we proceed by including all the HIV-positive patients in our sample who had not started ARV treatment 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 ARV therapy. Therefore, any changes in their sexual behavior are likely to reflect the combined effect of AMPATH's education and awareness program, learning HIV status, and also the anticipation of receiving ARV therapy upon progression to late-stage HIV disease (AIDS). We thus estimate the following regression model with individual fixed effects:

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

Most variables are defined as in equation 1. HIV_NOARV_{it} is a dummy taking value 1 for HIV-positive patients enrolled in AMPATH who have not started treatment as of round 2.[12] 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.

To the extend that both treated and untreated patients in AMPATH's HIV clinic are being exposed to similar information and are revising their beliefs about life expectancy, 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 ARV 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.[13] The coefficient on the interaction term $AMPATH_i * ROUND2$ represents the average change in sexual behavior outcomes for

[12] 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.

[13] 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.

all the HIV-positive patients in our sample (treated and untreated).

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

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

The variables $dist\_from\_ARVstart$ are a set of dummy variables equal to one if a person had started ARV therapy i quarters prior to time t. This more flexible specification is appealing because it allows 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. In some specifications we substitute $dist\_from\_ARVstart$ with a set of dummy variables that measure distance from AMPATH enrollment date ($dist\_from\_AMPATHstart$).[14]

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, Gottschalk and Moffitt (1998) and Wooldridge (2002)). None of our main results reported below are affected by these different estimation strategies.

We also perform a number of additional regressions to understand how the main effects vary depending on a number of background and behavioral characteristics of the patients. To do this, we estimate regressions that include interactions between the indicator variables of ARV and HIV status of the individual with several other individual

[14] 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 ($dist\_from\_AMPATHstart$) are only able to estimate patterns after the start of enrollment.

characteristics: age, marital status, and education, and HIV status of the individual's partner (i.e., concordant or discordant couple). These results are discussed in the final part of our results section. [15]

5 Results

Table 2 presents the first set of results based on estimating equation 1, which examines the sexual behavior of patients who started ARV treatment prior to round 2 of the survey. 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 ARV status indicator variable and the round 2 indicator variable are large, positive and statistically significant. For HIV-positive already receiving ARV therapy as of round 1, there is an increase in the probability of having been sexually active of about 10 percentage points in the six months between rounds 1 and 2, suggesting that as the health of these patients improves following the start of ARV therapy, there is a corresponding increase in the frequency of sexual intercourse. The effects on sexual activity for patients who begin to receive ARV therapy *between* round changes between round 1 and 2 are even larger, as shown by the coefficient of the ARV status indicator variables in column 2. For these patients, there is an *additional* increase of 19.2 percentage points in the probability of having been sexually active in the past week. This result is 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.

The main result of the paper is presented in column 3 of Table 2. For patients receiving ARV therapy, we observe a large increase between rounds in condom use during the last sexual encounter. The regression estimates indicate that between the two survey rounds, HIV-positive patients who were receiving ARV therapy as of round 1 reported on average

[15]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.

a large and significant increase of 22.2 percentage points in the probability of having used a condom during the last sexual encounter. This suggests that although the HIV-positive patients receiving ARV therapy are more likely to become sexually active over time, the level of risk they may pose to their partners does not necessarily increase. Furthermore, the results are evidence against the hypothesis that the availability of treatment and the reduced "cost" of becoming infected can make patients less concerned about infected their sexual partners. Finally, the result in column 4 of Table 4 shows that patients receiving treatment do not report any changes in their beliefs about their sexual partner's faithfulness.

The impact of ARV therapy on sexual activity can also be easily 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, Goldstein and Graff Zivin, 2005). A different picture emerges from Figure 2A, which shows changes in condom use during last sexual intercourse, over periods before and after treatment initiation. We observe an increase in condom use even in the quarters prior to treatment initiation and find that this trend continues even after patients begin to receive ARV therapy. We return to the interpretation of this graph after discussing the next set of regression results.

Next we turn to the regression models that also include HIV-positive individuals who are yet to begin ARV treatment (equation 2). Columns 1 and 2 of Table 3 show no significant changes in the probability of being sexual active in the past month and week (respectively) for untreated HIV-positive patients. This is not surprising in light of the fact that the health status of these patients has not deteriorated substantially between the two survey rounds (they are therefore not clinically in need of ARV therapy). More interestingly, however, these patients do display significant increases in condom use that are similar to those of HIV-positive patients who receive ARV therapy. We interpret

these results as evidence that the treated patients' increase in condom use are unlikely to be driven solely by the direct impact of becoming healthier as a result of ARV therapy. Rather, these results suggest that the changes in behavior may stem from several other factors: (1) the expectation of a longer life due to anticipation of receiving ARV therapy; (2) other AMPATH-related effects, such as the provision of sex education that targets all HIV-positive patients regardless of whether they have started ARV therapy or not; (3) learning one's HIV status, which typically precedes the patients' enrollment in AMPATH's HIV clinic.

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 4 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 ARV therapy and patients not yet receiving treatment) with very different trajectories in their health status. More interesting are the results in the final two columns, where we observe large changes in protective sexual behavior in terms of condom use. Among all the AMPATH patients in our sample, the probability of condom use during the patients' last sexual encounter increases by 24.4 percentage points between rounds 1 and 2. The results on the choice of a safe partner has the expected sign but is not statistically significant. 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 condom use (see equation 4). These results are best shown graphically in Figure 3A; they indicate a large increases in condom use in the initial quarters after enrollment in AMPATH's HIV clinic. We return to our interpretation of these results in the conclusion of this paper.

Since all 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 random sample. In Figures 1B, 2B, and 3B we present coefficients 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 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 random sample. In Figure 1B we show that compared to the random sample of adults, patients on ARVs 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 random sample. Figure 2B shows that over time, HIV-positive patients receiving ARV therapy go from having levels of condom use that are not significantly different from those of adults in the random sample, to levels are significantly higher. Figure 3B plots changes in 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 random sample, HIV-positive patients display very similar patters of condom use in the quarter when they enroll in the treatment program.[16] Given the similarity in condom use at enrollment in the treatment program when we control for observable characteristics of individuals, we feel more comfortable that the differences in trends over time are not driven by other factors. Enrollment in the treatment program leads to large increases in condom use for the HIV-positive adults in our sample.

6 Heterogenous Treatment Effects

In addition to estimating the effect of enrolling in an ARV treatment program, the household survey data allow us to explore how these effects vary according to individual characteristics of patients. In this section, we estimate equations in which the enrollment in a treatment program is interacted with characteristics such as marital status, education, age, and gender of patients. In particular, we estimate the following equation for two outcomes that describe sexual behavior: the indicator of sex in the past month, and the

[16]The results in Figure 2B are similar and consistent to those in Figure 3B.

indicator of condom use during last sexual intercourse:

$$\begin{aligned} outcome_{it} &= \beta_0 + \beta_1 ARV_{it} + \beta_2 ROUND2_t + \beta_3 ROUND2_i * INTERACTION_i \\ &\quad + \beta_4 ARV_{it} * ROUND2_t \\ &\quad + \beta_5 HIV\_NOARV_{it} * ROUND2_t + \beta_6 ARV_{it} * INTERACTION_i \\ &\quad + \beta_7 ARV_{it} * ROUND2_t * INTERACTION_i \\ &\quad + \beta_8 HIV\_NOARV_{it} * ROUND2_t * INTERACTION_i \\ &\quad + \beta_9 \delta_p + \beta_{10} \tau_t + \epsilon_{it}. \end{aligned} \tag{5}$$

The variable $INTERACTION_i$ denotes a characteristic such as the marital status, education, age, or gender of individual i. The coefficients of interest, β_7 and β_8, indicate whether AMPATH patients with certain characteristics are more or less likely to have changed their sexual behavior between rounds. Tables 5 and 6 present the results from estimating this equation for the indicators of having had sex in the past month and condom use at last sexual encounter. In Table 5, we do not find evidence of significant changes between rounds in the frequency of sexual activity among individuals who are enrolled in the treatment program and who have the characteristics indicated in columns 1 to 5.

In Table 6, however, we find that there is substantial heterogeneity in the effect of ARV treatment on condom use. Column 1 shows that patients whose partners are HIV-negative (i.e., they are part of a discordant couple) are more likely to use a condom over time. The coefficient for ARV recipients is large, positive and significant, whereas for HIV-positive individuals who do not receive ARV treatment, the coefficient is not statistically significant. We also find that ARV recipients who are more educated have a smaller increase in condom use between rounds. This suggests that to the extent that the treatment effects we observe are due to the sex education component of AMPATH's HIV care, the largest impact occurs among less educated patients. There is also some evidence that older patients are more likely to change their behavior, although the point estimates are not statistically significant. For untreated HIV-positive patients, we find that those in unions (either married or cohabitating with a partner) are more likely to

increase their condom use. Similarly, more educated patients and women exhibit larger increases in condom use.

7 Conclusion

In this paper we use panel data using a sample of HIV positive patients enrolled in an AIDS treatment program and an additional control sample from the same community in Western Kenya to understand the impact of an ARV treatment program on the sexual behavior of enrolled patients. We find increases in the frequency of sexual activity but more importantly large increases in condom use between rounds for those enrolled in the program. The increase in condom use is not limited only to those patients who have started treatment suggesting that the changes in behavior apply more broadly to all patients who are enrolled in the program. This result is consistent with a number of possible explanations: (1) increased awareness about the disease due to education and outreach, (2) the effect of treatment (or the expectation of treatment) on sexual behavior and/or (3) changes in behavior due to learning HIV status, since most patients enroll in the AMPATH treatment program soon after learning their HIV status.

While the present analysis focussed only on changes in behavior of HIV positive patients on ARV treatment, it is important to also understand the impact of treatment availability on the changes in behavior of HIV negative individuals. More generally in order to fully understand the overall impact of AIDS treatment programs on the course of the HIV epidemic, one needs to know the changes in behavior of both infected and uninfected individuals. This exploration is left for future research.

References

TO BE ADDED

Fig 1A: ARVs and Sex (last month)

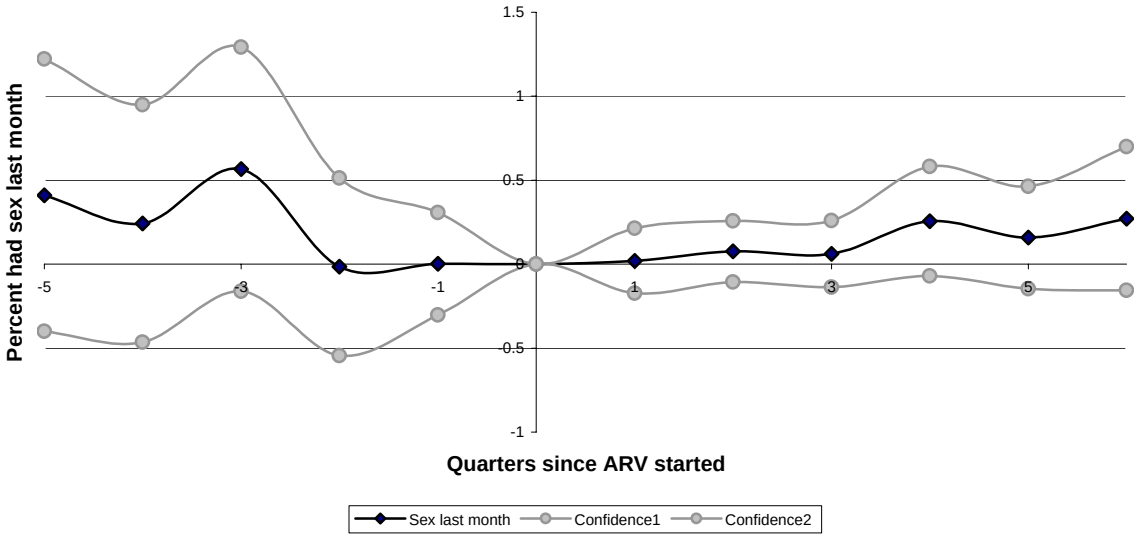
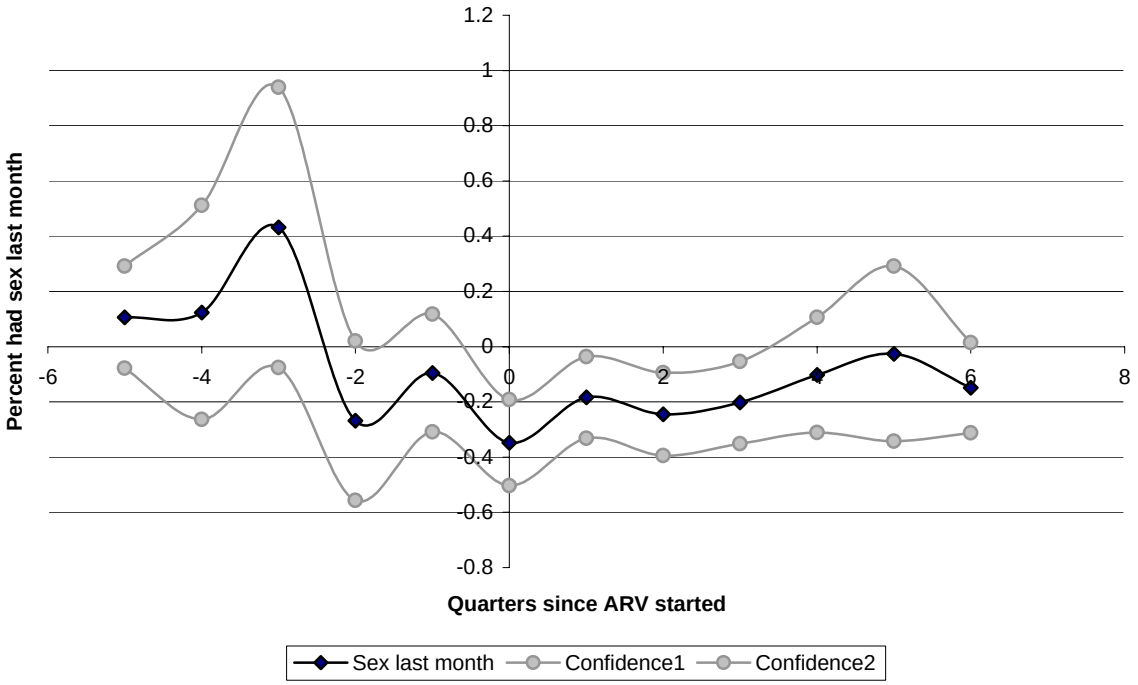


Fig1B: ARVs and Sex (last month)



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.

Fig 2A: ARVs and Condom USe

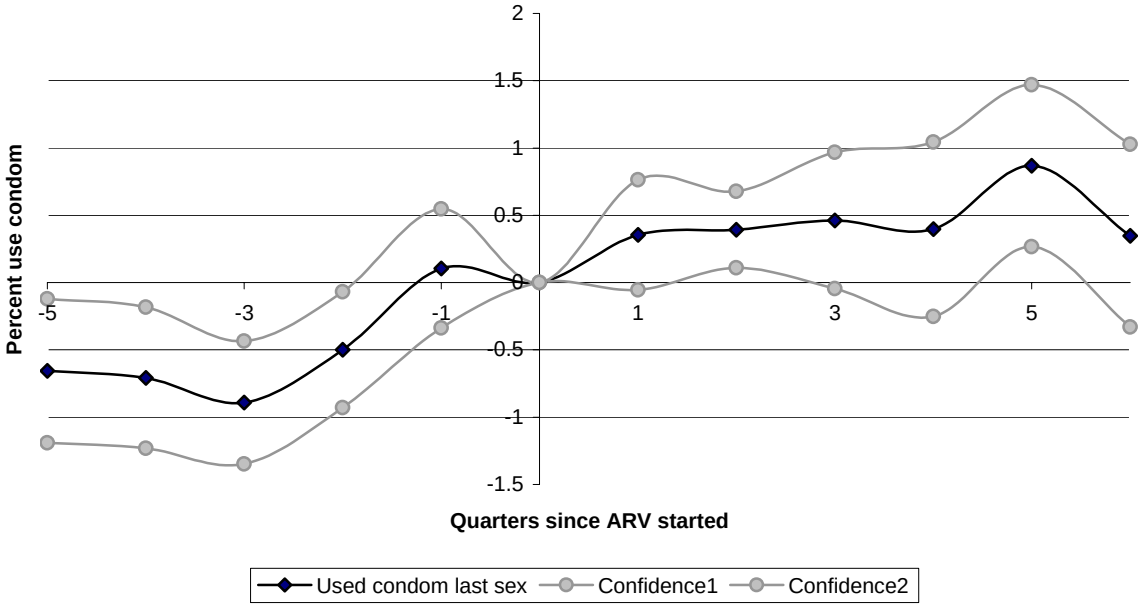
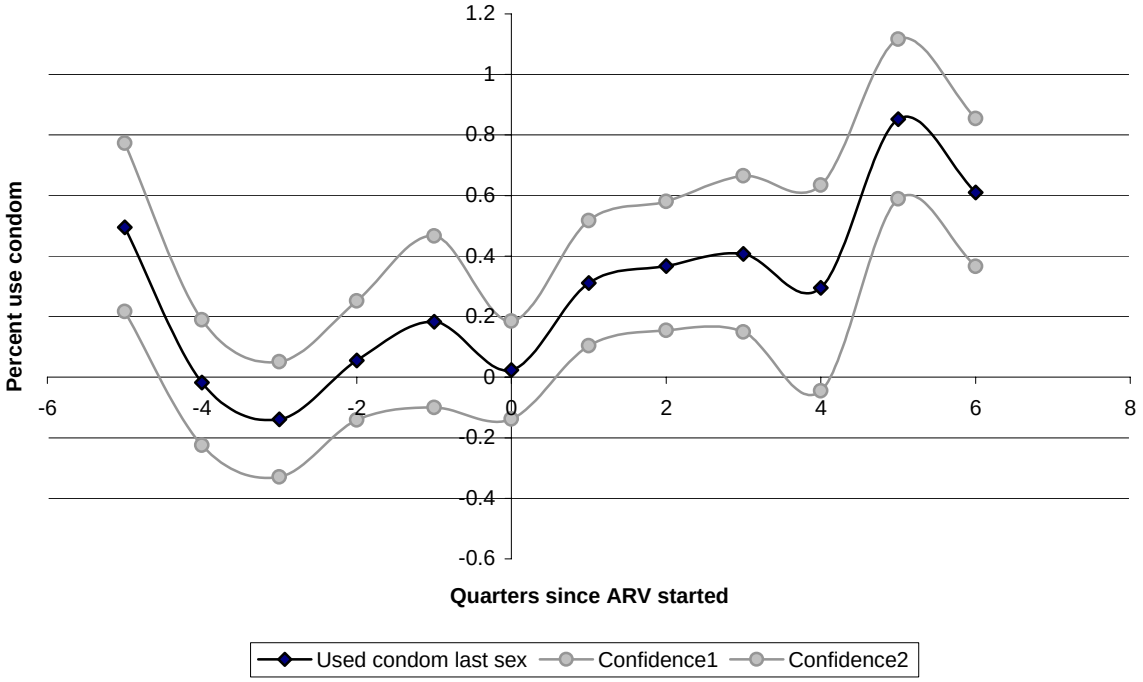


Fig2B: ARVs and Condom USe



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.

Fig3A: AMPATH and Condom USe

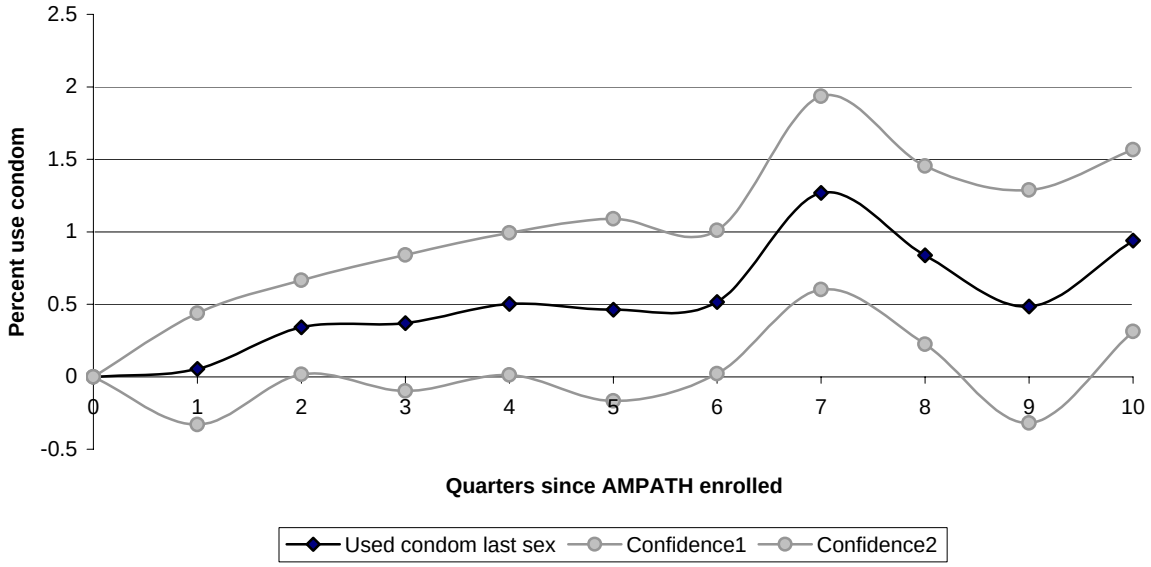
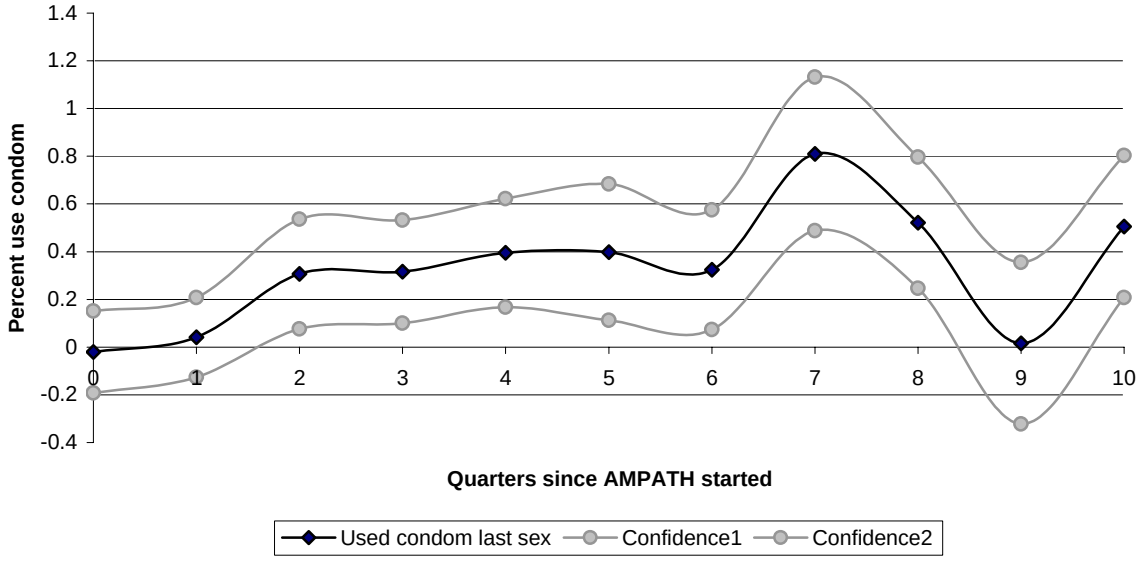


Fig3B: AMPATH and Condom USe



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.

Table 1: Descriptive Statistics

	Random Sample			HIV sample		
	Mean	SD	N	Mean	SD	N
Variables (al rounds)						
Sex last month	0.77	0.42	1141	0.30	0.46	342
Sex last week	0.54	0.50	1141	0.14	0.35	342
Condom last sex	0.09	0.29	1074	0.48	0.50	193
Last partner has other partners	0.08	0.27	1073	0.38	0.49	194
Variables (round 1)						
Sex last month	0.76	0.42	574	0.24	0.43	170
Sex last week	0.57	0.50	574	0.10	0.30	170
Condom last sex	0.10	0.30	540	0.33	0.47	97
Last partner has other partners	0.08	0.28	539	0.40	0.49	97
Variables (round 2)						
Sex last month	0.78	0.42	567	0.35	0.48	172
Sex last week	0.51	0.50	567	0.18	0.39	172
Condom last sex	0.09	0.29	534	0.63	0.49	96
Last partner has other partners	0.08	0.27	534	0.35	0.48	97

Notes: SD is the standard deviation and N is the sample size. Source: Mosoriot Round 1,2

Table 2: ARVs and Sexual behavior

	Sex last month	Sex last week	Condom last sex	Last partner has other partners
	(1)	(2)	(3)	(4)
ARV	**-0.06**	**0.192***	**0.104**	**-0.07**
	[0.112]	**[0.098]**	**[0.172]**	**[0.115]**
ROUND2	0.082	-0.071	-0.023	-0.078
	[0.172]	[0.172]	[0.086]	[0.090]
ROUND2*ARV	**0.115****	**0.105****	**0.222****	**0.038**
	[0.056]	**[0.053]**	**[0.088]**	**[0.070]**
Person Fixed Effects	Y	Y	Y	Y
Cal. month dummies	Y	Y	Y	Y
Sample Size	1,479	1,479	1,264	1,264
R-squared	0.73	0.70	0.71	0.84

Notes: The dependent variables are defined in Table 1. Regressions include an ARV 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: ARVs and Sexual behavior (with HIV+ persons not on ARVs)

	Sex last month	Sex last week	Condom last sex	Last partner has other partners
	(1)	(2)	(3)	(4)
ARV	**-0.052**	**0.198****	**0.111**	**-0.063**
	[0.111]	**[0.099]**	**[0.173]**	**[0.117]**
ROUND2	0.05	-0.087	-0.032	-0.023
	[0.167]	[0.169]	[0.096]	[0.095]
ROUND2*ARV	**0.096***	**0.095***	**0.231*****	**0.015**
	[0.057]	**[0.053]**	**[0.088]**	**[0.071]**
ROUND2*HIV_NOARV	**-0.104**	**0.01**	**0.310*****	**-0.139**
	[0.094]	**[0.065]**	**[0.111]**	**[0.104]**
Person Fixed Effects	Y	Y	Y	Y
Cal. month dummies	Y	Y	Y	Y
Sample Size	1,535	1,535	1,300	1,300
R-squared	0.73	0.71	0.72	0.83

Notes: The dependent variables are defined in Table 1. Regressions include an ARV indicator, an indicator for being HIV positive but not on ARVs, 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: AMPATH and Sexual behavior

	Sex last month	Sex last week	Condom last sex	Last partner has other partners
	(1)	(2)	(3)	(4)
ROUND2	0.049	-0.081	-0.02	-0.021
	[0.167]	[0.169]	[0.096]	[0.097]
ROUND2*AMPATH	**0.034**	**0.074**	**0.244*** **	**-0.034**
	[0.055]	**[0.050]**	**[0.076]**	**[0.064]**
Person Fixed Effects	Y	Y	Y	Y
Cal. month dummies	Y	Y	Y	Y
Sample Size	1,535	1,535	1,300	1,300
R-squared	0.72	0.71	0.71	0.83

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 5: Interactions: ARVs and Frequency of Sexual Activity (with HIV+ persons not on ARVs)

SEX LAST MONTH	Interaction = Discordant	Interaction = In Union	Interaction = Years of Schooling	Interaction = Age >35	Interaction = Female
	(1)	(2)	(3)	(4)	(4)
ARV	0.422	-0.094	-0.047	-0.07	-0.203
	[0.312]	[0.104]	[0.156]	[0.237]	[0.230]
ROUND2	-0.046	-0.056	0.016	0.049	0.076
	[0.201]	[0.175]	[0.170]	[0.178]	[0.169]
ROUND2*ARV	0.157	0.126*	0.098	0.221	0.156
	[0.118]	[0.070]	[0.076]	[0.149]	[0.105]
ARV*INTERACTION	-0.885**	0.173	-0.005	-0.002	0.204
	[0.372]	[0.268]	[0.238]	[0.032]	[0.267]
ROUND2*INTERACTION	-0.125	0.104	0.042	-0.001	-0.053
	[0.112]	[0.066]	[0.046]	[0.008]	[0.035]
ROUND2*ARV*INTERACTION	**0.135**	**0.041**	**-0.002**	**-0.013**	**-0.044**
	[0.185]	**[0.107]**	**[0.090]**	**[0.017]**	**[0.110]**
ROUND2*HIV_NOARV*INTERACTION	**-0.421****	**-0.049**	**-0.234***	**-0.003**	**-0.007**
	[0.201]	**[0.139]**	**[0.123]**	**[0.011]**	**[0.103]**
Person Fixed Effects	Y	Y	Y	Y	Y
Cal. month dummies	Y	Y	Y	Y	Y
Sample Size	1,176	1,535	1,535	1,531	1,535
R-squared	0.60	0.73	0.73	0.73	0.73

Notes: The dependent variables are defined in Table 1. All regressions include an ARV indicator, an indicator for being HIV positive but not on ARVs, 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 6: Interactions: ARVs and Condom Use (with HIV+ persons not on ARVs)

CONDOM USE	Interaction = Discordant	Interaction = In Union	Interaction = Years of Schooling	Interaction = Age>35	Interaction = Female
	(1)	(2)	(3)	(4)	(4)
ARV	0.39	0.334	0.446	0.142	-0.350**
	[0.331]	[0.290]	[0.303]	[0.215]	[0.141]
ROUND2	-0.05	-0.059	-0.092	-0.007	0.033
	[0.121]	[0.129]	[0.108]	[0.109]	[0.101]
ROUND2*ARV	0.122	0.167	0.581***	0.046	0.2
	[0.117]	[0.142]	[0.183]	[0.146]	[0.130]
ARV*INTERACTION	-0.833**	-0.308	-0.056	0.169	0.729***
	[0.372]	[0.350]	[0.036]	[0.367]	[0.250]
ROUND2*INTERACTION	-0.108	0.057	0.005	-0.017	-0.109***
	[0.098]	[0.098]	[0.005]	[0.033]	[0.033]
ROUND2*ARV*INTERACTION	**0.391***	**0.086**	**-0.044***	**0.275**	**0.041**
	[0.214]	**[0.169]**	**[0.025]**	**[0.176]**	**[0.181]**
ROUND2*HIV_NOARV*INTERACTION	**0.314***	**0.411*****	**0.043*****	**0.123**	**0.304****
	[0.188]	**[0.115]**	**[0.014]**	**[0.177]**	**[0.143]**
Person Fixed Effects	Y	Y	Y	Y	Y
Cal. month dummies	Y	Y	Y	Y	Y
Sample Size	1,127	1,264	1,260	1,264	1,264
R-squared	0.67	0.72	0.72	0.72	0.72

Notes: The dependent variables are defined in Table 1. All regressions include an ARV indicator, an indicator for being HIV positive but not on ARVs, 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.