Health and labor supply in the context of HIV/AIDS: the long-run economic impacts of antiretroviral therapy[*]

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Abstract

Using longitudinal survey data collected in Kenya, this paper estimates the longer-term impacts of antiretroviral therapy (ART) on the labor supply of treated adults and their household members. Building upon previous work in Kenya, data collected from 2004-2006 indicate that early evidence on the short-run impacts of ART tends to be upheld over the long-term as well. The results show that the labor supply response among treated adults occurs rapidly and is sustained through the 3-year observation period in our study. Since patient health would continue to decline without treatment, these labor supply responses could be viewed as underestimates of the impact of treatment on the treated. Attrition of adult patients from the study are shown to be strongly associated with poor initial health status. Lower bound estimates of the labor supply impacts, based on the assumption of zero labor supply for those not retained in the study, remain statistically significant. The responses in the labor supply of patients' household members are heterogeneous. The labor supply of adult household members declines while that of children is unchanged. The primary results for treated adults further underscore the strong relationship between health and labor supply that has been observed in other contexts.

1. Introduction

Since the advent of highly active antiretroviral therapy (ART)[1] in 1996, morbidity and mortality due to HIV/AIDS has declined substantially in industrialized countries. In developing nations, access to ART is growing but still limited. In sub-Saharan Africa, the region most heavily affected by HIV/AIDS, the number of HIV-positive people receiving treatment has risen substantially, from 100,000 in 2003 to almost 4 million by the end of 2009 (World Health Organization, 2010). Despite this progress, only 37 percent of the people in need of treatment were able to access it. Since public provision of treatment remains the primary channel through which people in developing countries can access ART, an expansion in donor support remains critical in order to achieve the international community's goal of universal access to HIV treatment for all who need it.

Greater support for the scale-up of treatment programs has been lacking for a number of reasons. These include skepticism that ART may not generate health and economic benefits that are sizable enough to offset its costs and a related debate about how best to allocate scarce resources in developing countries (for example, see Canning 2006). Since treatment, once initiated, must be taken for the entire duration of a person's life, there has also been concern about the wisdom and sustainability of current expenditures on ART. According to *The Economist,* people who begin receiving ART today will become tomorrow's "medical pensioners" whose treatment costs will become the responsibility of countries in which they live and organizations that support these countries (The Economist 2006). However, because evidence on the various impacts of providing ART has been slow to emerge, until recently it has been impossible to properly evaluate treatment programs and assess whether expenditures on such programs may be justified on economic – and not just humanitarian – grounds.

The health improvements due to ART have the potential to significantly raise economic well-being, as suggested by a growing literature that shows linkages between health and economic outcomes in developing countries. In an important contribution, Schultz and Tansel (1997) use data from Cote d'Ivoire and Ghana and report a sizable causal effect of morbidity, as

[1] In this paper, we use the terms "ART" and "treatment" to refer to highly active antiretroviral therapy (HAART), which was introduced in 1996. HAART always consists of three antiretroviral medications. Treatment for most patients begins with a first-line regimen, but these are usually altered over time. Generic medications that combine three medications in one pill (such as Triomune) have recently become available.

measured by number of self-reported days of disability, on wages. The paper deals with several key challenges that arise in the estimation of such a relationship: particularly, how to measure adult morbidity in household surveys and how to overcome the endogeneity problem that stems from the possibility that higher income can be used to improve health. Among several other papers, Schultz and Tansel (1997) as well as a broader review in Schultz (1999) provide valuable guidance for more recent work on the economic impacts of HIV/AIDS and interventions such as ART.

Whether the findings in Schultz and Tansel (1997) and related papers apply to the aspects of health that are typically associated with HIV/AIDS – such as severe and prolonged periods of moribidity – is a question that has begun to be studied as survey datasets with measures of HIV status and disease staging have emerged. Fox, Rosen, MacLeod et al. (2004) analyze retrospective longitudinal data from a Kenyan tea estate where ART was not available and find significant declines in the labor productivity of HIV-positive workers prior to their death or medical retirement. The declines in labor productivity were evident up to two years prior to death, when the symptoms of AIDS began to appear.

The impacts on labor supply and productivity that take place as health improves due to ART have been estimated by more recent longitudinal studies in Africa (Larson et al. 2008; Thirumurthy, Goldstein, and Graff Zivin 2008; and Habyarimana, Mbakile, and Pop-Eleches 2010; Thirumurthy, Jafri, Srinivas, et al. 2011). While the settings of these studies have varied, a common result has been that ART leads to a large and rapid restoration of labor supply. The pattern of this labor supply response closely resembles the health improvements from ART that have been documented in the medical literature. Thirumurthy, Graff Zivin and Goldstein (2008) focus on the first 12 months of ART and find a large response in both health outcomes and employment outcomes in rural Kenya, where households are largely engaged in subsistence agriculture. Larson et al. (2008) find that after 12 months on ART, workers at a tea plantation in Kenya worked at least twice as many days in the month than they would have in the absence of ART. Habyarimana, Mbakile, and Pop-Eleches (2010) find that subsequent to ART initiation there is a rapid decrease in absenteeism rates at a mining company in Botswana. In the period from 2–4 years after ART initiation, treated workers maintain low absenteeism rates that are similar to those of other mining workers at the same company.

In this paper, we build upon previous research in Kenya and use an additional round of follow-up surveys to examine the how ART affects the labor supply of treated patients and their household members over a period spanning the first 3 years of ART. We analyze three waves of a longitudinal household survey that was conducted at intervals of 6 months between the first two rounds and 18 months between the second and third rounds. As a result of variation in the duration of the time that patients were receiving ART at the time that we enrolled them in our survey, we are able to estimate impacts of ART on labor supply for up to 36 months after the time of treatment initiation.

To identify the response to treatment, we examine changes over time in the labor supply of treated patients and their household members. Since treatment eligibility is defined by biological markers that are not easily influenced by the behavior of patients with late-stage HIV disease, treatment and the resulting changes in health are exogenous. Using data collected simultaneously from a large random sample of non-patient households, we control for time-varying factors (such as seasonality) that could bias the estimates. The analysis is strengthened by variation in the length of time that patients had been exposed to treatment *prior* to the survey.

We find that the provision of ART leads to a large and significant increase in the labor supply of treated patients. This increase occurs very soon after the initiation of ART and from then on is sustained at levels significantly higher than at the time of treatment initiation. Since the health status of treated adults has a non-linear temporal response to treatment—it improves dramatically in the first months of treatment but more gradually thereafter—our labor supply results are quite consistent with the pattern of the health response to ART.

Given this effect on patients' labor supply, treatment can also have effects within the household on the labor supply of household members. We find that the labor supply of adults in treated households declines significantly after the initiation of ART, but that there are negligible effects on the labor supply of children. We also find that attrition of treated patients is strongly associated with the initial health status of these patients, consistent with findings in the medical literature. While our results are generalizable largely to the population of patients who are health at the time of treatment initiation and therefore more likely to be retained in care, we show that even the lower bound labor supply impacts (based on assumptions about the labor supply of those not found in follow-up survey waves) remain statistically significant.

2. Background on HIV/AIDS and antiretroviral therapy

Soon after acquiring HIV, infected individuals typically enter a clinical latent period of many years during which health status declines gradually and few symptoms are experienced. Over time, almost all HIV-infected individuals will experience a weakening of the immune system and progress to developing AIDS. Median time from seroconversion to AIDS in east Africa is estimated to be 9.4 years (Morgan et al., 2002). This later stage is very often associated with substantial weight loss (wasting) and opportunistic infections such as tuberculosis. In resource-poor settings, absent treatment with ART, death usually occurs within one year after progression to AIDS. One study in Uganda reports a median survival time of 9.2 months (Morgan et al., 2002) and another study in Brazil reports a median survival time of 5.1 months (Chequer et al., 1992). Opportunistic infections are generally the cause of death in AIDS cases.

The CD4+ T cell count is an important indicator of disease progression among HIV-infected individuals.[2] According to definitions of the Centers for Disease Control and Prevention (CDC), infected individuals with a CD4 count below 200 cells/mm^3 are classified as having developed AIDS. It is at this stage when functional capacity deteriorates and ART should be initiated (World Health Organization, 2002).[3] ART has been proven to reduce the likelihood of opportunistic infections and prolong the life of HIV-infected individuals. After several months of treatment, patients can generally be asymptomatic and have improved functional capacity. Numerous studies in various countries and patient populations have reported positive results.[4] In Haiti, patients had weight gain and improved functional capacity within one year after the initiation of ART (Koenig, Leandre, and Farmer, 2004). In Brazil, median survival time after developing AIDS rose to 58 months with ART (Marins et al., 2003). For the treatment program we collaborated with in Kenya, Wools-Kaloustian et al. (2006) have analyzed the CD4 counts and weights of all non-pregnant adult patients treated with ART. They find significant improvements in both outcomes, including a rapid increase in CD4 count during the first six

[2] Most uninfected individuals have a CD4+ T cell count of 800 to 1000 cell per mm^3 of blood.
[3] These guidelines have been followed by many treatment programs in developing countries, including the program with which we collaborated. However, more recent WHO guidelines (issued after the period of data collection for this study) recommend earlier initiation of ART.
[4] Since placebo-controlled randomized trials of ART are ethically infeasible, these studies are either observational cohort studies or randomized trials that compare regimens composed of different antiretroviral medications.

weeks of ART followed by slower increases thereafter.[5] An additional finding that is pertinent for the long-term analysis in this paper is that the CD4 count at the time of treatment initiation (baseline) is found to be a significant predictor of subsequent survival: the risk of death for patients with baseline CD4 count below 100/mm^3 is three times higher than for patients with baseline CD4 count above 100/mm^3.

The long-term retention of patients in treatment programs is an issue that has only recently begun to receive attention. Most studies, including the ones listed above, treat patient attrition as a side issue and focus solely on describing outcomes of those patients who are retained in care. As long-standing treatment programs have been established in the past five years, rates of attrition have been documented more carefully. Attrition from ART programs is generally divided into two categories. The two most common are (1) the death of the patient—several studies have reported high rates of early mortality—and (2) ''loss to follow-up,'' a catch-all category for patients who miss scheduled clinic visits or medication pickups for a specified period of time. A small minority of patients either remain in care but stop taking antiretroviral medications or transfer to other facilities and continue on ART.

In a systematic review, Rosen, Fox, and Gill (2007) have estimated that ART programs in Africa have retained about 60 percent of their patients at the end of 2 years, with loss-to-follow up being the major cause of attrition, followed by death. However, retention rates have varied widely across programs. At the time that we conducted our study, AMPATH's clinics were estimated to have a 9 month attrition rate of roughly of approximately 29 percent, in part due to the very low CD4 count of patients at the time of ART initiation (Wools-Kaloustian et al., 2006). In this paper, the 1-, 2- and 3-year impacts of ART on labor supply pertain to the cohorts of patients that are retained in care through the respective periods.

3. Sampling strategy and survey data

The socio-economic data used in this paper come from three rounds of a longitudinal household survey we conducted in Kosirai Division, a rural region near the town of Eldoret, in western Kenya. The Division 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

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[5] The reported gains in CD4 count are similar to those found by studies in Senegal and South Africa (Laurent et al. 2002; Coetzee et al. 2004).

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 Rural Health Training Center, a government health center that offers primary care services. The health center also contains a clinic that provides free medical care (including ART) to HIV-positive patients. This rural HIV clinic (one of the first in sub-Saharan Africa) was opened in November 2001 by the Academic Model Providing Access to Healthcare (AMPATH).[6] Following increased funding since late-2003, the Mosoriot HIV clinic has experienced rapid growth, with many patients coming from outside Kosirai Division.[7] During this period, adequate funding has been available to provide free ART to all patients sick enough (according to WHO treatment guidelines that are discussed in the next section) to require it.

We implemented three rounds of a comprehensive socio-economic survey between March 2004 and September 2006, with an interval of roughly 6 months between rounds 1 and 2, and 18 months between rounds 2 and 3. The entire survey sample contains three different groups of individuals and households. The *first group* comprises 503 households chosen randomly from a census of all households in Kosirai Division without an AMPATH patient (random sample households).[8] The *second group* comprises 222 patients who were included in the sample because they were HIV-positive AMPATH patients who were either receiving ART at the time of round 1 or began receiving ART shortly after their round 1 interview.[9,10] All non-pregnant AMPATH patients who enrolled in the Mosoriot HIV clinic before April 2004 and resided in Kosirai Division were considered eligible for our survey. To obtain a larger sample size, we also

[6] AMPATH is a collaboration between the Indiana University School of Medicine and the Moi University Faculty of Health Sciences (Kenya). Descriptions of AMPATH's work in western Kenya can be found in Mamlin, Kimaiyo, Nyandiko, and Tierney (2004) and Cohen et al. (2005).

[7] For reasons including limited funding, AMPATH's clinic had very few patients during its first two years of operation. Early entrants to the HIV clinic had often progressed to AIDS at the time of their first visit. In contrast, later entrants are often in early stages of the disease and do not require ARV therapy.

[8] In the random sample, the HIV status of respondents is usually unknown, unless the respondent gives a self-report of having gone for an HIV test and testing HIV-positive or HIV-negative.

[9] We include in this sample 2 adults (and their household members) who were originally part of the random sample but enrolled in the AMPATH clinic and began receiving ARV therapy between rounds. As we discuss below, several other patients in the ARV sample also initiated ARV therapy between rounds.

[10] The analysis in this paper excludes the 60 households with HIV-positive AMPATH patients who were in the early stages of HIV disease and were not yet sick enough to require ART (according to WHO treatment guidelines). We exclude this group from our analysis in this paper because these untreated HIV-positive patients would not have experienced significant health changes during the survey period. The small sample size of these HIV households also limits our ability to use them as a control group in the data analysis. All analysis in the paper is thus restricted to the 200 households with ART recipients and households from the random sample.

conducted in-clinic interviews with a random sample of non-pregnant AMPATH patients who entered the clinic before April but resided outside Kosirai Division and too far away from the clinic to be visited at home.[11] Finally, a *third group* comprises 210 additional HIV-positive ART recipients who were enrolled in the survey towards the end of round 2. Almost all of these patients began receiving ART after round 1 had concluded, and they were enrolled in our study during round 2 in order to expand the sample size for future longitudinal surveys.

It should be noted that as a result of the above sampling strategy, the longitudinal survey contains up to 3 observations for individuals and households who were first surveyed in round 1 (groups 1 and 2) whereas there are only up to 2 observations for individuals and households were first surveyed in round 2. Throughout the remainder of the paper, we refer to the treated patients in the second and third groups as "ART recipients" and to their household members as "ART households." When necessary, a distinction is made between ART recipients enrolled in the study during round 1 and those enrolled during round 2.

Each round of the survey included questions about demographic characteristics, health, agriculture, income and employment. Information on asset sales and purchases, child anthropometrics, school enrollment and attendance, and food consumption was also collected in each round. In the household visits, teams of male and female enumerators interviewed the household head and spouse as well as a youth in the household. For in-clinic interviews, all information was obtained from the AMPATH patient. The AMPATH Medical Records System, which contains clinical and treatment-related information on all patients, was used to obtain the exact date when patients in the ART sample initiated treatment as well as some additional clinical information for patients such as height, weight, and CD4 count.

Table 1 summarizes the main demographic characteristics of adults in the random sample and the two groups of ART recipients at the time they were enrolled in the study. The ART recipients are significantly older than adults in the random sample and a significantly larger fraction of them are female. The latter result is consistent with the experience of many clinics, which saw much larger numbers of women enrolling in their treatment programs during the early years of ART availability. Typically, these women had lost their husbands to HIV/AIDS, and some evidence of this can be found in the significantly higher rates of widowhood and single-

[11] Pregnant women were excluded from the sample because treatment was typically given to these women for the prevention of mother-to-child transmission of HIV, not because the women had become sick enough to require ARV therapy.

headed households in the ART samples than in the random sample. On average, households in the survey area had 6 members, whereas the households of ART recipients were significantly smaller, with 5.6 to 5.1 members on average. ART households were also significantly poorer than random sample households, based on measures of land and livestock ownership.

Another important feature of the sample that has implications for the period over which we can estimate impacts of ART is the duration of time for which patients in our sample were receiving ART at the time of enrollment in our study. As Table 2 shows, adult patients enrolled in round 1 were receiving ART for an average duration of 160 days at the time of enrollment (and a median of 124 days). Similarly, patients enrolled in round 2 were receiving ART for an average of 171 days at the time of enrollment (median of 106 days). The substantial variation in days on ART at time of study enrollment means that in our sample of patients there is variation in the amount of health improvement that patients experience between rounds (as the largest health improvements occurs in the first 3-6 months of ART). Also, it means that even though the follow-up rounds 2 and 3 of the survey occurred at 6 and 24 months after the baseline survey, there are some patients who are observed for their first 24 months of ART while there are others who observed from the end of their first year of ART to the end of their third year of ART. In practice, we are able to estimate 36-month (or 3 year) impacts of ART as a result.

Compared to the ART sample, attrition of entire households between rounds due to refusal or relocation is minimal in the random sample, and attrition of individuals due to mortality is also negligible. Attrition was larger in round 3 than in round 2, as the number of adults in random sample households for whom labor supply data was obtained declines from 1,366 to 1,173. In the ART sample, attrition was significantly higher in part due to the high rates of loss-to-follow up and mortality that is common when patients initiate ART with extremely low CD4 counts. As noted earlier, it is not uncommon for treatment programs to retain fewer than 75 percent of patients in the first few years of ART, particularly if CD4 counts at the time of treatment initiation are low. As Table 2 indicates, ART recipients enrolled in round 1 had an average CD4 count of 90 cells/mm^3 at the time they initiated ART. Patients enrolled in round 2 also had a low CD4 count of 83 cells/mm^3.

Among the ART recipients enrolled in round 1, a total of 26 patients attrite from the sample in the six months between rounds 1 and 2 (11 percent), while 38 patients attrite in the twelve months between rounds 2 and 3 (24 percent of those remaining in round 2). A total of 64 patients attrite between rounds 1 and 3 (29 percent). Among the ART recipients enrolled in round 2, there is a similar attrition rate of 24 percent in the twelve months between rounds 2 and 3. In the analysis below, we present results for a balanced panel in which individuals appear in at least two rounds of the survey.

4. Estimation strategy for patients' labor supply response

Two outcomes that measure an individual's labor supply are the primary focus of the paper: an indicator of participation in any economic activities during the past week and the total number of hours worked in the past week. For all household members older than 8 years, the survey recorded this information in each round for three types of activities: wage and salaried jobs, farming on the household's owned or rented land, and non-farm self-employed work. The main outcomes in the analysis represent an aggregate of labor supply in these three activities.

Estimating the effect of health in a reduced form equation for labor supply is difficult for well-known reasons that are discussed in the literature on health and labor outcomes: bias from omitted variables (such as ability) that are correlated with both wages and health, simultaneity problems that arise from health and income influencing each other contemporaneously, and errors in the common measures of health. Schultz (1999) as well as Strauss and Thomas (1998) provide a careful discussion of many of these challenges. Since we are interested in estimating the effect of ART on labor supply, we overcome these problems by taking advantage of the panel structure of our data and the exogenous health improvement that is known to occur due to treatment. We estimate reduced form equations that measure the response of labor supply to ART.

Specifically, we identify the response to ART by examining changes in the treatment group's labor supply between rounds. Since labor supply is also influenced by several time-varying factors such as seasonality in agriculture (which influences local prices and labor demand) and aggregate health shocks (a greater malaria burden in specific months, for example), we include data from the random sample of adults to control for secular trends in the survey area. Thus, our key identifying assumption here is that data from the random sample control for the part of the ART sample's labor supply trends that are due to factors *other than* treatment, such as seasonality. This strategy is similar to a difference-in-difference estimation strategy in which the "comparison group" is the sample of adults from the random sample.

Since ART recipients in our sample had been receiving ART for varying durations of time when they were enrolled in the study, we choose a specification in which there are 12 binary indicators of the number of three-month quarters that a patient had been receiving ART at the time of each interview, as well as one indicator for whether the patient is still one quarter away from initiating ART (in our ART sample, most patients had either just begun or had already begun ART at the time of their first interview, but a few had yet to begin receiving ART). More formally, the reduced-form treatment response is identified by estimating individual fixed effects regressions in which there are quarterly indicators of duration on treatment as well as round and month-of-interview indicators:

$$L_{it} = \alpha_i + \delta QuarterBeforeART_{it} + \sum_{\tau=1}^{12} \gamma_\tau ARTquarter_{it}^{\tau} + \beta_1 ROUND2_t + \beta_2 ROUND3_t + \sum_{\tau=1}^{11} \gamma_\tau MONTH_t^{\tau} + \varepsilon_{it} \quad (1)$$

L_{it} is the labor supply outcome of interest for individual i in time t (rounds 1-3), α_i is a fixed effect for individual i that captures the effects of time-invariant variables like demographic characteristics, schooling, family background, as well as unobservables such as ability and tastes, $ROUND2_t$ and $ROUND3_t$ indicates whether the observation is from round 2 or round 3, respectively. The round indicators and the eleven month-of-interview indicator variables together control for monthly fluctuations in labor supply in the entire community.

The key variables of interest in equation 1 are those that indicate whether individual i has been receiving ART for τ quarters at the time on an interview ($ARTquarter_t^{\tau}$). The estimated coefficients of these variables indicate the change in labor supply relative to the omitted quarter (the first three months of ART). We also include one indicator variable, $QuarterBeforeART_{it}$, for whether an ART recipient is being observed one quarter before ART initiation (as there are a small number of patients in our sample for whom this is the case). For all adults in the random sample, the indicators of the number of quarters on ART are defined to be zero in each round, and the coefficients of the month-of-interview indicators and round indictors capture changes in labor supply in this sample.

In addition, due to the small number of observations that sometimes exist for some quarters, we also estimate regressions with indicators for the number of half-year intervals that patients have been receiving ART. In this case, we include a total of six indicators in order to capture the first three years of ART, within which almost all patients in our sample are observed.

Several points about the estimation strategy in this paper should be noted. First, the labor supply trends in the random sample are not likely to represent the counterfactual scenario of no treatment (because the ART recipients would undoubtedly become much sicker without the medicines), and as such the reduced form empirical strategy we describe below estimates the treatment effect relative to baseline levels, but does not estimate the average treatment effect on the treated. Secondly, the empirical strategy allows us to pool the data from the ART recipients who enrolled in the study in round 1 as well as those who were enrolled in round 2. Nonetheless, we also verify that our findings are not being driven by any one of these two groups of ART recipients, as we separately estimate the fixed effects regressions for the sample of ART recipients who were enrolled in round 1. Finally, the individual fixed effects in all of the equations estimated will allow for ART recipients to have different *levels* of labor supply than other adults in the sample. While time varying factors such as seasonality are dealt with using the time indicators, the key assumption in identifying the treatment response is that ART recipients in the sample do not have characteristics that influence the *change* in labor supply between rounds.

5. Results for adult patients' labor supply response

We restrict the analysis of labor supply to individuals between the ages of 18 and 65 who appear in at least two rounds of the survey.[12] Table 3 presents summary statistics for the labor supply outcomes in each the three rounds, for both groups of ART recipients as well as adults in the random sample.[13] In the first round, ART recipients were significantly less likely to be working than adults in the random sample (72 percent compared to 89 percent). They also reported working significantly fewer hours in the past week. In the second round, however, these ART recipients – who had been on six additional months of ART and had significantly higher CD4 counts by then – had labor force participation rates that were not significantly different from those of adults in the random sample (86 vs. 89 percent; they did still work significantly fewer hours, however). The same pattern holds in the third round of the survey (92 percent among

[12] Adults who move into the household between rounds are thus excluded, as are adults who move out permanently. A small number of observations are dropped because the respondent did not know how many hours a specific household member worked in the past week. The role of attrition due to mortality is discussed in Section 6.4.

[13] Household members of the ARV recipients are not included in any of this analysis. To the extent that labor supply of these adult household members is affected by the changing health status of the ARV recipient, pooling them with adults in the random sample may produce biased results.

ART recipients and 90 percent among adults in the random sample). For the ART recipients who were enrolled in the second round of the survey – when they were still in the early stages of ART – labor supply is significantly lower than in the random sample. Twelve months later, in round 3, these patients have labor supply that is very similar to that of adults in the random sample.

It is worth noting that each of the figures for the two ART samples represent average labor supply among treated patients who had been receiving ART for *different* durations of time at the time of each interview, and as a result the average figures mask substantial variation within the sample that may be directly related to the amount of time that patients had been receiving of treatment. The regression results that we present next provide a clearer indication of the temporal relationship between duration of time on ART and labor supply.

Table 4 reports results from estimating equation 1. As column 1 shows, we find that ART led to a large and statistically significant increase in labor supply after two quarters of treatment, and this higher level of labor supply persists through the first three years of treatment. Consistent with the health and employment decline that others have documented in the months leading up to an AIDS diagnosis, we find that relative to the time of ART initiation, labor supply is higher one quarter before ART initiation (but the difference is not statistically significant). The limited sample size of patients who are observed before ART initiation, however, limits our ability to document any decline in labor supply that may have occurred during the period. In the first quarter after ART initiation, Table 3 shows that there was no significant change in labor force participation relative to the time that patients began ART. However, adults receiving ART were 16.2 percentage points more likely to participate in the labor force after two quarters of treatment, an increase that is statistically significant. As the above discussion of equation 1 indicates, these changes are observed after controlling for time-varying factors that are evident in both the ART sample and the random sample. In subsequent quarters, we find that labor supply remains significantly higher than at the time of ART initiation. After 1-, 2- and 3- years of ART, the estimated increases in labor force participation rates are 12.5, 32.6 and 22.2 percentage points respectively.

Column 3 of Table 4 also indicates that hours worked in the past week increase significantly in the early stages of treatment. The post-treatment levels of labor supply remain significantly above the baseline levels, as weekly hours worked are 12-17 hours higher during the second and third years of ART. Relative to the number of hours that patients report having worked at the time of treatment initiation, these increases are substantial.

Columns 2 and 4 of Table 4 show that the significant increases in labor supply can also be detected in a specification that estimates effects of ART in six-month intervals. Here again, labor force participation rates are higher in the six months prior to ART initiation but not statistically significant. Within six months after ART initiation, there is a 17 percentage point increase in the probability of being economically active. This result is consistent with the short-term impacts that were reported in Thirumurthy, Goldstein and Graff Zivin (2008). In this paper, we find that in the 30 months that follow, labor force participation rates remain significantly higher than at the time of treatment initiation. In addition, in results that are not reported here, we find that the results are robust even when we exclude all of the ART recipients who were enrolled in the study during round 2. In other words, even for the original sample of ART recipients, for whom the short-term impacts on labor supply was reported in Thirumurthy, Goldstein and Graff Zivin (2008), we find that the short-term impacts persist through the first 36 months of ART.

An important pattern in our results is that the bulk of the labor supply impact of ART occurs early on, during the first year of treatment. During the second and third years of ART, there are relatively small *additional* increases in labor force participation rates and weekly hours worked. Nonetheless it is noteworthy that the levels of labor force participation during the second and third years are still substantially (and significantly) higher than at the time when ART was initiated. Figures 1 and 2 plot the estimated coefficients of the numbers of quarterly intervals since ART initiation. As can be seen in the figures, while there tends to be continued increases in labor supply through the first 12 quarters of ART, the largest increases typically occur during the first 4 quarters after ART initiation.

To further explore whether the impacts of ART are observable for men and women, in Table 5 we report the results of estimating equation 1 (with six-month intervals rather than quarterly intervals) separately for men and women. The results indicate that by and large both men and women experience large and significant increases in labor supply. In the previous, short-term analysis that used only the sample of ART recipients who were enrolled in our study during round 1, the limited sample size did not provide adequate power to detect significant increases. Here, however, we find that there are significant increases for male and female ART recipients in the likelihood of being economically active and in weekly hours worked. At 36 months after ART initiation, however, we do not find significantly higher weekly hours worked for men, whereas for women the number of hours worked are significantly higher than at the time of ART initiation.

6. Factors associated with attrition and implications for labor supply impacts

As discussed earlier, in the absence of treatment these patients have a small probability of living for another six months. In this sense, the estimated labor supply responses are likely to be *underestimates* of the impact of treatment on the treated. However, an opposing issue is that the attrition of ART recipients from our sample (particularly in round 3) implies that the results presented so far are not generalizable to the entire population of patients who initiate ART. Retention of patients in treatment programs can be influenced by factors ranging from the health status of patients at the time of treatment initiation to daily adherence to medications. In particular, late presentation to care has previously been associated with low response to treatment and high mortality rates (Badri, Lawn and Wood 2006; Sabin, Smith, Gumley et al. 2004). These factors would need to be addressed if we are to expect even larger aggregate effects on labor supply as a result of ART provision.

While it is challenging to find exogenous variables that can predict attrition in our study, in this paper, we undertake two different analyses that provide a better understanding of attrition. Specifically, we first identify major factors that are associated with attrition (or alternatively, patient retention) in the sample of ART recipients in our study. A key finding here will be the significance of health at the time of the baseline survey. Secondly, we bound the labor supply estimates by examining what happens to the labor supply impacts of ART if it is assumed that all individuals not recorded in the follow-up waves of the survey have zero labor supply. While this is an assumption that can easily be contested – as it is certainly plausible that patients relocated or began seeking care at clinics closer to their residents – the results of such an analysis can provide a sense for how much weight one should place on the main results reported above.

Table 6 reports results of examining the predictors of attrition in our sample. While it would be ideal to use each patient's CD4 count at the time of enrollment in the study (and at the time of ART initiation), this outcome is not measured very frequently. An alternative outcome that is strongly associated with the likelihood of treatment success is the body weight of a patient, as it is a clear indicator of wasting – a symptom of advanced HIV infection. This is measured at each clinic visit and is therefore available from a large number of patients in our study.[14] Column 1 of Table 6 shows that body weight at the time of the baseline survey (either round 1 or round 2, depending on when the patient was enrolled in our study) is strongly associated with whether or not the patient attrited from our sample by the third and final wave of the survey. An increase of 1 kg in body weight at the time of study enrollment is associated with a decrease of .7 percentage points in the probability of attrition. Given the evidence that it is the very sick patients who are least likely to benefit from ART, it is not surprising in column 2 of Table 6, that patients whose baseline weights are in the lowest quartile (less than 48.75 kgs) are 25.7 percentage points more likely to not be retained in our sample. Finally, column 3 of Table 6 shows that those in the lowest decile of baseline body weight have a similar risk of not being retained. Other characteristics associated with patient retention are gender (women are less likely to attrit) and age (older patients are less likely to attrit). It is notable that even though male patients have significantly lower body weight at the time of study enrollment, the gender effect is significant even when after controlling for baseline body weight. The significance of Table 6 lies in the fact that in more recent years, as HIV testing programs become more widespread and knowledge of ART increases, the body weights and CD4 counts of patients enrolling in ART programs across Africa have risen significantly. This implies that the labor supply impacts estimated here, while not applicable to patients initiating ART with low CD4 counts and body weights, do have relevance for patients whose health has not deteriorated so much that ART is relatively ineffective in reducing long-term morbidity and mortality.

We also pursue an empirical strategy that aims to bound the labor supply impacts reported above by making the assumption that those who are not observed in follow-up surveys have zero labor supply. While this is an extreme assumption because it is not take into account the possibility that respondents may have relocated and be economically active, it is useful for bounding our results in the absence of detailed information on vital statistics of respondents. Table 7 reports the results from estimating equation 1 (with ART duration measured in both three and six month intervals). The results show that by and large, the impacts of ART remain

[14] In the AMPATH medical records system, not all patients have body weight available at the time of the baseline survey. Of the 432 patients enrolled in total, 396 have a weight measurement at the time of enrollment in our study.

significant even when labor supply is assumed to decline to zero for those who do not appear in follow-up survey rounds. Comparing column 2 of Table 7 with column 2 of Table 4, for example, we can observe a greater number of observations in the former table (representing additional individual-round observations) and lower mean levels of labor supply (as the constant term indicates). But each of the 6-month impacts of ART on labor supply remain significant in Table 7 and in general they are not more than 2 or 3 percentage points smaller as a result of adjusting for attrition. The relatively small size of the reduction can be explained by the fact that those who attrited from the sample generally had significantly lower levels of labor supply during the baseline survey; as such the upper bound on the their labor supply decline is also fairly small. Thus, although the failure to retain patients in care remains an important and pressing challenge for ART programs today, the labor supply impacts estimated in Tables 4 and 5 are not necessarily made very large because of the fact that sicker patients are not being retained in care.

7. Results for household members' labor supply response

Intrahousehold reallocation of time is known to be an important consumption smoothing mechanism of households in low-income countries. In settings with imperfect financial markets, households often adjust the time spent by children and adults in activities such as schooling, housework, and employment in response to sudden changes in income and health. These adjustments can have differential effects according to the age and gender of household members. For example, Jacoby and Skoufias (1997) find that children's school attendance in rural India is responsive to seasonal fluctuations in income. Others have examined time allocation to household activities and labor market activities in response to income and health shocks, finding that responses depend on the gender of household members (Pitt and Rosenzweig, 1990; Kochar, 1995). Such intrahousehold decisions about time allocation suggest that ART can also influence the labor supply of patients' family members. Having estimated a large increase in patients' labor supply due to ARV therapy (own-effect of health), this section examines the labor supply of children and adults in the patients' households (cross-effects of health).

To estimate the net effect of treatment on child and adult labor in ART households, we examine longitudinal data on the labor supply of non-patient individuals in these households and use data from random sample households to control for monthly fluctuations in labor supply.

Specifically, the following equation is estimated with longitudinal data for non-patient individuals in ARV households and others in the random sample:

$$L_{iht} = \alpha_i + \delta 6MonthsBeforeART_{ht} + \sum_{\tau=1}^{6} \gamma_\tau SixMonthIntervalsofART_{ht}^{\tau} + \beta_1 ROUND2_t + \beta_2 ROUND3_t + \sum_{\tau=1}^{11} \gamma_\tau MONTH_t^{\tau} + \varepsilon_{iht} \quad (2)$$

L_{iht} is the labor supply measure of interest for individual i in household h at time t (rounds 1-3), α_i is a fixed effect for individual i. The key variables of interest are those that indicate whether an adult patient in household h has been receiving ART for τ six-month intervals at the time of an interview ($SixMonthIntervalsofART_{ht}^{\tau}$). The estimated coefficients of these variables indicate the change in labor supply relative to the omitted quarter (the first three months of ART). We also include one indicator variable, $6MonthsBeforeART_{ht}$, for whether an adult ART recipient in household h is being observed one quarter before ART initiation.

Table 8 presents the results from estimating equation 2 for a sample consisting of all adults in the random sample and all adult household members of ART recipients. We exclude from the analysis all adult ART recipients. We find that unlike the case of treated adult patients' labor supply, household members of ART recipients largely experience a *decline* in their rates of being economically active. When we consider all adult household members of ART recipients (men and women, in column 1 or Table 8), we find that 12 months after ART initiation, their rates of labor force participation are 8.1 percentage points lower than at the time of ART initiation. At 36 months after ART initiation the decline in labor participation rates are even lower (16.5 percentage points) than at the time of ART initiation. Clearly, the trends in labor supply for household members of ART recipients over the course of our study are quite distinct from those of the ART recipients. There are, however, some puzzling features in these patterns, as we find some evidence that by and large it is adult male household members' whose labor force participation rates decline the most. This is suggestive that much of the substitution of labor for ART recipients comes from male household members, a result that would not be as surprising given that a majority of the ART recipients are women. One other surprising result when it comes to the labor supply of household members is that we find hardly any change in the reported number of hours worked in the past week. Figure 3 plots the changes in the likelihood of being economically active for each six-month interval before and after ART initiation. The figure shows the patterns in labor supply for both treated adults and their household members, which move in opposite directions following the initiation of ART.

In Table 9, we report the results from examining the labor supply of children in the survey households. Specifically, we seek to estimate the impact of ART on the labor supply of children who reside in households of treated patients, while adjusting for secular trends in the survey area with labor supply data from children in random sample households. In previous work we estimated that in the short-term, young boys in ART households worked significantly less. In the current results that take advantage of a larger sample and a longer period of follow-up, we find limited evidence of a significant impact on the labor supply of children. While estimated effects on weekly hours worked are generally negative, the few significant impacts on children in ART household are observed 36 months after ART initiation. In this case we find that all children in ART households work an average of 3.5 fewer hours per week than at the time of treatment initiation, and that the largest declines are experienced by boys in particular. The fact that such large impacts are observed only at 36 months raises the concern that this result could be affected by selection bias, as adult patients who survive the longest may also have better health behaviors and might be more likely to invest in their children.

8. Conclusion

This paper provides new evidence on how ART affects the labor supply of adult patients and their household members over a long-term period of 3 years. Using longitudinal data from our household survey, we find that patients have significantly higher labor supply within six months after the initiation of treatment and that these increases are sustained through a period of up to 36 months. The magnitude of the increases in labor supply are striking, as they represent increases of more than 30 percent of labor supply levels at the time of treatment initiation. Importantly, these results suggest that with treatment, the labor supply of AIDS patients can recover rapidly from periods of severe illness. We also find evidence that the labor supply of patients' family members (particularly adults) declines after the initiation of treatment. This suggests that family members may have been compensating for previously sick patients' diminished labor supply and that they too experience some of the benefits from treatment.

Consistent with the findings of a larger literature that has studied the link between health and economic outcomes the results in the present context of HIV/AIDS provide further evidence of the large private benefits that stem from health interventions. To better understand the aggregate benefits that would result from large-scale public investments in ART, it would be important to address the critical issue of patient retention. As treatment programs are scaled-up, added attention would need to be paid to medication adherence and patient outreach strategies. In this case, the labor supply gains reported here could translate into larger and longer-lasting economic benefits.

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Table 1. Comparison of Random Sample and ART Sample Households

	ART patients enrolled in round 1		ART patients enrolled in round 2		Random sample	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
	(1)	(2)	(3)	(4)	(5)	(6)
Sample size	222		210		1422	
Age	**37.2**	9.1	**39.0**	8.9	33.1	12.9
Female	**74%**		**64%**		49%	
Years of School Completed	7.8	3.4	7.8	3.4	8.1	3.3
Completed Primary	50%		50%		56%	
Household size	**5.6**	2.4	**5.1**	2.4	7.2	3.1
Single headed household	**46%**		**52%**		18%	
Resides in Kosirai Division	**41%**		**15%**		99%	
Quantity of land owned (acres)	**4.6**	8.6	**3.9**	9.0	8.2	11.3
Value of land owned (KES)	**538.5**	1098.2	**508.2**	795.1	757.5	988.7
Value of livestock owned (1,000 KES)	**39.1**	71.0	**26.2**	34.2	69.3	94.6

Table 1. Comparison of Random Sample and ART Sample Households

Notes: Values in bold denote P-value less than 0.05 from t-test for equality of means for Random sample and ART sample.

Table 2. Number of days on ART and CD4 count at ART initiation

	Sample	Number of days on ART			CD4 count at ART initiation		
	Size	Mean	Median	Std. Dev.	Mean	Median	Std. Dev.
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Adults patients enrolled in study in Round 1							
Round 1	222	160	124	217	90.3	60	107.9
Round 2	196	358	312	211			
Round 3	158	920	876	246			
Adults patients enrolled in study in Round 2							
Round 2	210	171	106	197	83.1	57.5	86.49
Round 3	160	622	582	201			

Table 3. Employment outcomes in random sample and ART sample

	Sample size	Economically active in past week	Total hours worked in past week	
		Mean	Mean	Std. Dev.
	(1)	(2)	(3)	(4)
Random Sample				
Round 1	1422	89%	35.3	26.4
Round 2	1366	89%	30.6	23.6
Round 3	1173	90%	33.5	23.1
Adults patients enrolled in study in Round 1				
Round 1	222	**72%**	**22.5**	22.8
Round 2	196	86%	**25.1**	22.2
Round 3	158	92%	30.6	20.1
Adults patients enrolled in study in Round 2				
Round 2	210	**84%**	**23.4**	22.8
Round 3	160	93%	34.3	24.7

Notes: Values in bold denote P-value less than 0.05 from t-test for equality of means for Random sample and ART sample.

Table 4. Impact of ART on Labor Supply

VARIABLES	(1) Economically active in past week	(2) Economically active in past week	(3) Total hours worked in past week	(4) Total hours worked in past week
	Full sample			
Round 2	0.018	0.015	-6.475***	-6.424***
	(0.025)	(0.025)	(1.780)	(1.775)
Round 3	0.001	0.000	-2.765***	-2.697***
	(0.012)	(0.012)	(0.857)	(0.852)
1 quarter before ART initiation	0.102		3.037	
	(0.107)		(7.668)	
Quarters after ART initiation				
1	0.074		2.885	
	(0.051)		(3.638)	
2	0.162***		10.278***	
	(0.046)		(3.304)	
3	0.203***		8.894**	
	(0.054)		(3.881)	
4	0.125**		6.794	
	(0.058)		(4.169)	
5	0.142**		14.926***	
	(0.056)		(4.018)	
6	0.234***		12.592***	
	(0.056)		(3.999)	
7	0.174***		17.573***	
	(0.058)		(4.165)	
8	0.326***		15.490***	
	(0.064)		(4.611)	
9	0.246***		17.392***	
	(0.058)		(4.147)	
10	0.285***		17.265***	
	(0.066)		(4.747)	
11	0.199***		12.666**	
	(0.072)		(5.169)	
12	0.222***		12.104**	
	(0.067)		(4.849)	
6 months before ART initiation		0.146		1.694
		(0.164)		(11.802)
6 months after ART initiation		0.174***		8.405***
		(0.034)		(2.425)
12 months after ART initiation		0.184***		9.382***
		(0.041)		(2.955)
18 months after ART initiation		0.171***		15.162***

		(0.041)		(2.932)
24 months after ART initiation		0.274***		14.993***
		(0.043)		(3.069)
30 months after ART initiation		0.260***		18.075***
		(0.047)		(3.380)
36 months after ART initiation		0.204***		11.504***
		(0.057)		(4.095)
Constant	0.833***	0.835***	33.617***	33.529***
	(0.047)	(0.046)	(3.345)	(3.304)
Month dummy variables	Yes	Yes	Yes	Yes
Observations	4739	4739	4739	4739
R-squared	0.578	0.578	0.636	0.635

Notes: Standard errors clustered at the household level for each round and reported in parentheses (* significant at 10%; ** significant at 5%; *** significant at 1%). Dependent variable "Economically active in past week" indicates whether the individual was engaged in specific labor market activity (wage, farm, or business) in the past week and "Total hours worked in past week" is total number of hours devoted to labor market activities in the past week. Regressions include individual fixed effects, round 2 and 3 indicators, and month-of-interview indicator variables.

Table 5. Impact of ART on Labor Supply, by Gender

VARIABLES	(1) Economically active in past week: Men	(2) Economically active in past week: Women	(3) Total hours worked in past week: Men	(4) Total hours worked in past week: Women
Round 2	-0.004	0.038	-8.503***	-4.022*
	(0.035)	(0.035)	(2.936)	(2.185)
Round 3	-0.019	0.021	-4.082***	-0.911
	(0.015)	(0.018)	(1.310)	(1.112)
6 months before ART initiation	0.165	0.123	17.184	-3.423
	(0.294)	(0.207)	(24.916)	(12.739)
6 months after ART initiation	0.067	0.220***	10.401**	7.944***
	(0.058)	(0.043)	(4.881)	(2.668)
12 months after ART initiation	0.215***	0.174***	15.165**	7.312**
	(0.076)	(0.052)	(6.460)	(3.180)
18 months after ART initiation	0.124*	0.183***	17.740***	13.734***
	(0.068)	(0.053)	(5.804)	(3.264)
24 months after ART initiation	0.255***	0.278***	22.711***	12.123***
	(0.076)	(0.055)	(6.409)	(3.362)
30 months after ART initiation	0.287***	0.251***	19.842***	16.612***
	(0.086)	(0.060)	(7.283)	(3.673)
36 months after ART initiation	0.206**	0.191***	4.598	13.659***
	(0.101)	(0.073)	(8.545)	(4.495)
Constant	0.890***	0.802***	43.563***	24.206***
	(0.025)	(0.066)	(2.083)	(4.071)
Month dummy variables	Yes	Yes	Yes	Yes
Observations	2247	2492	2247	2492
R-squared	0.578	0.580	0.631	0.593

Notes: Standard errors clustered at the household level for each round and reported in parentheses (* significant at 10%; ** significant at 5%; *** significant at 1%). Dependent variable "Economically active in past week" indicates whether the individual was engaged in specific labor market activity (wage, farm, or business) in the past week and "Total hours worked in past week" is total number of hours devoted to labor market activities in the past week. Regressions include individual fixed effects, round 2 and 3 indicators, and month-of-interview indicator variables.

Table 6. Factors associated with attrition from panel survey among ART recipients

	(1)	(2)	(3)
VARIABLES	Attrition from panel		
Female	-0.162***	-0.172***	-0.146***
	(0.048)	(0.047)	(0.048)
Age	-0.007***	-0.006***	-0.007***
	(0.002)	(0.002)	(0.002)
Household size	0.004	0.003	0.002
	(0.009)	(0.008)	(0.009)
Completed Primary	-0.061	-0.061	-0.067
	(0.052)	(0.051)	(0.052)
Completed Secondary	0.023	0.011	0.014
	(0.060)	(0.059)	(0.060)
Resides in Kosirai Division	-0.009	-0.014	-0.022
	(0.047)	(0.046)	(0.047)
Weight at baseline	-0.007***		
	(0.002)		
Weight in lowest quartile		0.257***	
		(0.048)	
Weight in lowest decile			0.230***
			(0.071)
Constant	1.009***	0.549***	0.602***
	(0.166)	(0.118)	(0.120)
Observations	396	396	396
R-squared	0.063	0.099	0.059

Notes: Standard errors reported in parentheses (* significant at 10%; ** significant at 5%; *** significant at 1%). Dependent variable "attrition from panel" indicates whether the ART recipient was not interviewed in the third and final wave of the survey.

Table 7. Impact of ART on labor supply, including patients who are not interviewed in follow-up survey waves

	(1)	(2)	(3)	(4)
	Economically active in past week		Total hours worked in past week	
VARIABLES				
Round 2	0.080**	0.075**	-4.259**	-4.236**
	(0.033)	(0.033)	(1.939)	(1.933)
Round 3	0.060***	0.058***	-0.306	-0.237
	(0.016)	(0.016)	(0.931)	(0.926)
1 quarter before ART initiation	0.134		3.690	
	(0.137)		(8.113)	
Quarters after ART initiation				
1	0.078		2.092	
	(0.066)		(3.905)	
2	0.155***		8.898**	
	(0.060)		(3.522)	
3	0.197***		8.211**	
	(0.070)		(4.152)	
4	0.115		5.115	
	(0.076)		(4.477)	
5	0.159**		14.545***	
	(0.073)		(4.342)	
6	0.217***		10.521**	
	(0.074)		(4.377)	
7	0.176**		16.666***	
	(0.077)		(4.528)	
8	0.325***		14.842***	
	(0.084)		(4.986)	
9	0.230***		15.596***	
	(0.076)		(4.496)	
10	0.273***		15.956***	
	(0.087)		(5.147)	
11	0.174*		9.802*	
	(0.095)		(5.619)	
12	0.210**		11.520**	
	(0.089)		(5.264)	
6 months before ART initiation		0.078		-0.435
		(0.211)		(12.486)
6 months after ART initiation		0.163***		7.720***
		(0.044)		(2.583)
12 months after ART initiation		0.181***		8.893***
		(0.054)		(3.173)
18 months after ART initiation		0.155***		13.764***
		(0.054)		(3.197)
24 months after ART initiation		0.266***		14.379***
		(0.056)		(3.330)
30 months after ART initiation		0.237***		16.425***
		(0.062)		(3.662)
36 months after ART initiation		0.181**		10.674**

		(0.075)		(4.451)
Constant	0.684***	0.681***	28.080***	28.118***
	(0.025)	(0.025)	(1.493)	(1.450)
Observations	5,443	5,443	5,443	5,443
R-squared	0.543	0.543	0.577	0.577

Notes: Standard errors clustered at the household level for each round and reported in parentheses (* significant at 10%; ** significant at 5%; *** significant at 1%). Dependent variable "Economically active in past week" indicates whether the individual was engaged in specific labor market activity (wage, farm, or business) in the past week and "Total hours worked in past week" is total number of hours devoted to labor market activities in the past week. Regressions include individual fixed effects, round 2 and 3 indicators, and month-of-interview indicator variables.

Table 8. Impact of ART on Adult Household Members' Labor Supply

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	Economically active in past week			Total hours worked in past week		
	All adults	Men	Women	All adults	Men	Women
Round 2	-0.034	-0.040	-0.037	-6.990***	-10.391***	-3.359
	(0.024)	(0.030)	(0.038)	(1.642)	(2.379)	(2.230)
Round 3	-0.004	-0.017	0.010	-2.879***	-4.356***	-1.015
	(0.012)	(0.016)	(0.019)	(0.845)	(1.250)	(1.119)
6 months before ART initiation	-0.114*	-0.218***	0.108	-1.826	0.787	-4.335
	(0.061)	(0.071)	(0.111)	(4.137)	(5.541)	(6.442)
6 months after ART initiation	-0.053	-0.025	-0.085*	0.479	2.235	-2.013
	(0.033)	(0.044)	(0.049)	(2.269)	(3.493)	(2.908)
12 months after ART initiation	-0.081**	-0.083*	-0.086	1.534	-0.236	1.894
	(0.037)	(0.049)	(0.056)	(2.530)	(3.851)	(3.304)
18 months after ART initiation	-0.142***	-0.159***	-0.140**	1.354	5.526	-3.282
	(0.038)	(0.048)	(0.060)	(2.603)	(3.802)	(3.544)
24 months after ART initiation	-0.074*	-0.090	-0.067	0.765	0.865	-1.069
	(0.043)	(0.055)	(0.065)	(2.937)	(4.348)	(3.919)
30 months after ART initiation	-0.048	-0.160**	0.050	5.781*	2.925	7.289*
	(0.048)	(0.063)	(0.073)	(3.335)	(5.076)	(4.318)
36 months after ART initiation	-0.165***	-0.251***	-0.108	0.205	-4.854	2.596
	(0.056)	(0.076)	(0.083)	(3.813)	(5.915)	(4.886)
Constant	0.827***	0.879***	0.832***	30.239***	67.230***	6.797
	(0.020)	(0.025)	(0.070)	(9.711)	(18.306)	(10.844)
Month dummy variables	Yes	Yes	Yes	Yes	Yes	Yes
Observations	5019	2624	2406	4950	2577	2385
R-squared	0.569	0.602	0.553	0.645	0.657	0.600

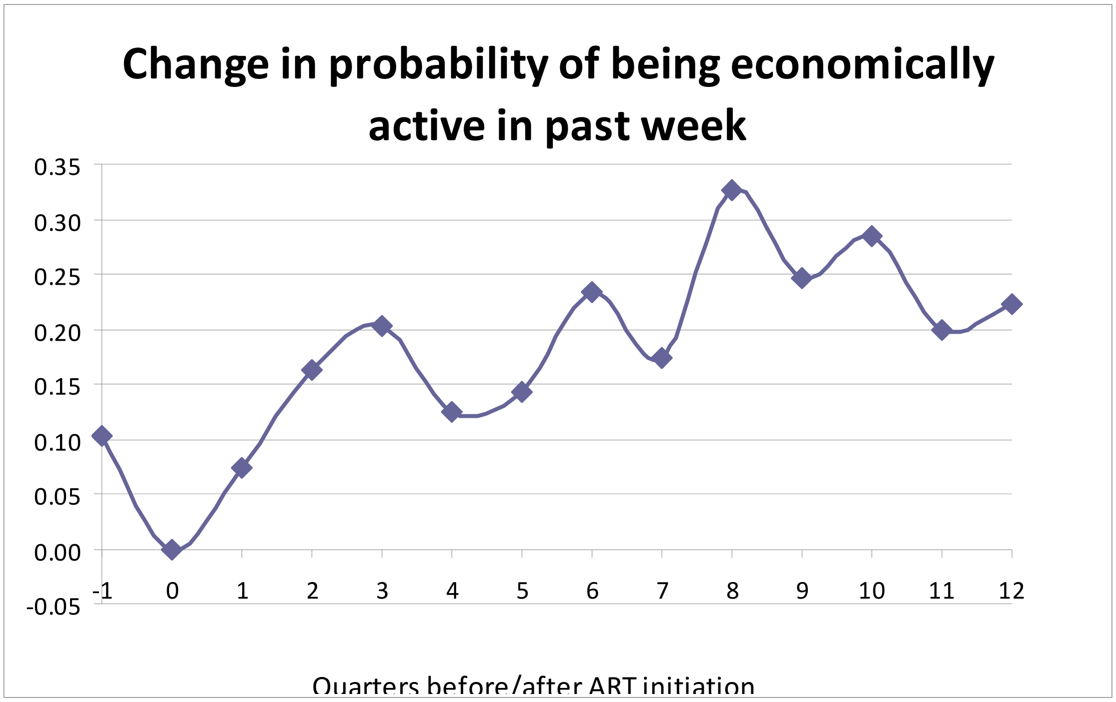
Notes: Standard errors clustered at the household level for each round and reported in parentheses (* significant at 10%; ** significant at 5%; *** significant at 1%). Dependent variable "Economically active in past week" indicates whether the individual was engaged in specific labor market activity (wage, farm, or business) in the past week and "Total hours worked in past week" is total number of hours devoted to labor market activities in the past week. Regressions include individual fixed effects, round 2 and 3 indicators, and month-of-interview indicator variables.

Table 9. Impact of ART Provision to Adults on Children's Labor Supply

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	Economically active in past week			Total hours worked in past week		
	All children	All boys	All girls	All children	All boys	All girls
Round 2	0.024	0.067	-0.027	-2.288**	-3.145**	-1.364
	(0.037)	(0.051)	(0.055)	(1.006)	(1.538)	(1.271)
Round 3	-0.107***	-0.111***	-0.100***	-1.862***	-2.572***	-0.996
	(0.022)	(0.029)	(0.034)	(0.592)	(0.879)	(0.774)
6 months before ART initiation	0.087	-0.020	0.164	-0.716	-2.538	0.932
	(0.084)	(0.123)	(0.117)	(2.273)	(3.721)	(2.682)
6 months after ART initiation	0.017	0.007	0.006	-2.433**	-2.993	-1.960
	(0.042)	(0.061)	(0.060)	(1.143)	(1.844)	(1.377)
12 months after ART initiation	0.083	0.052	0.095	0.357	-1.904	2.532
	(0.051)	(0.070)	(0.074)	(1.367)	(2.138)	(1.701)
18 months after ART initiation	0.027	0.107	-0.077	-1.211	-1.509	-1.073
	(0.052)	(0.072)	(0.077)	(1.412)	(2.180)	(1.773)
24 months after ART initiation	-0.022	-0.092	0.024	-0.298	-0.278	-0.414
	(0.056)	(0.079)	(0.082)	(1.531)	(2.420)	(1.877)
30 months after ART initiation	0.095	0.114	0.038	0.389	-0.712	1.273
	(0.062)	(0.083)	(0.096)	(1.689)	(2.522)	(2.217)
36 months after ART initiation	0.092	0.079	0.068	-3.528*	-5.530*	-1.856
	(0.073)	(0.098)	(0.111)	(1.977)	(2.979)	(2.555)
Constant	0.562***	0.665***	0.548***	23.125***	26.042***	17.383
	(0.032)	(0.098)	(0.048)	(7.459)	(10.085)	(11.265)
Month dummy variables	Yes	Yes	Yes	Yes	Yes	Yes
Observations	3688	1980	1708	3684	1980	1704
R-squared	0.536	0.528	0.549	0.563	0.566	0.546

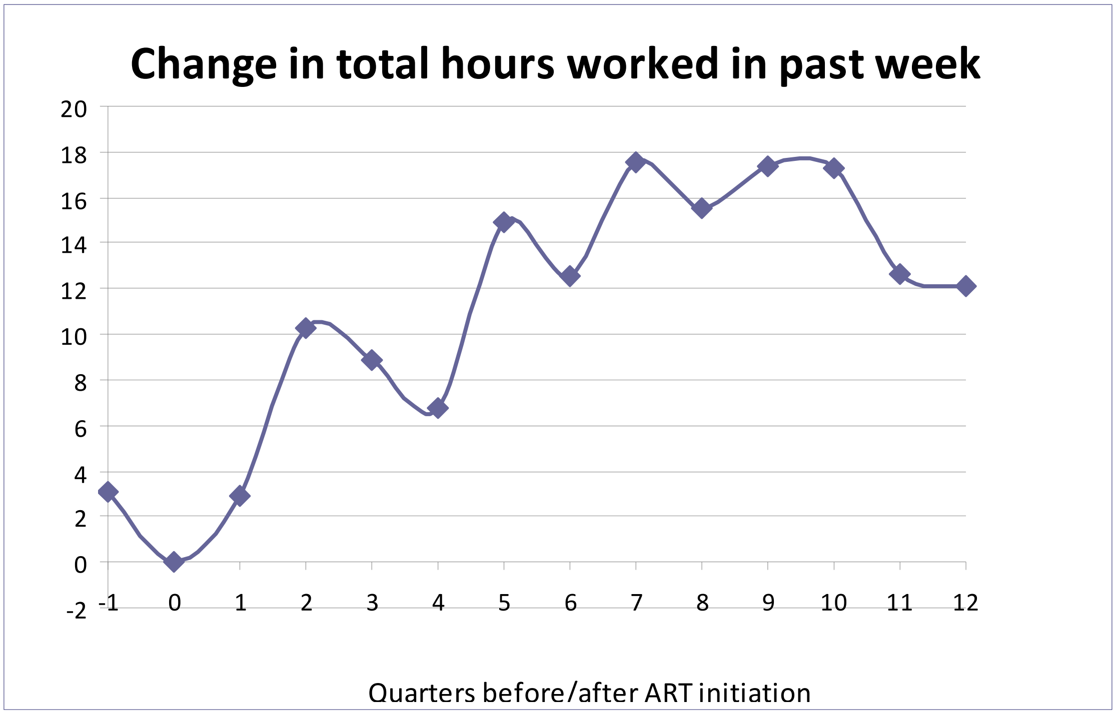
Notes: Standard errors clustered at the household level for each round and reported in parentheses (* significant at 10%; ** significant at 5%; *** significant at 1%). Dependent variable "Economically active in past week" indicates whether the individual was engaged in specific labor market activity (wage, farm, or business) in the past week and "Total hours worked in past week" is total number of hours devoted to labor market activities in the past week. Regressions include individual fixed effects, round 2 and 3 indicators, and month-of-interview indicator variables.

Figure 1. Impact of ART on probability of being economically active



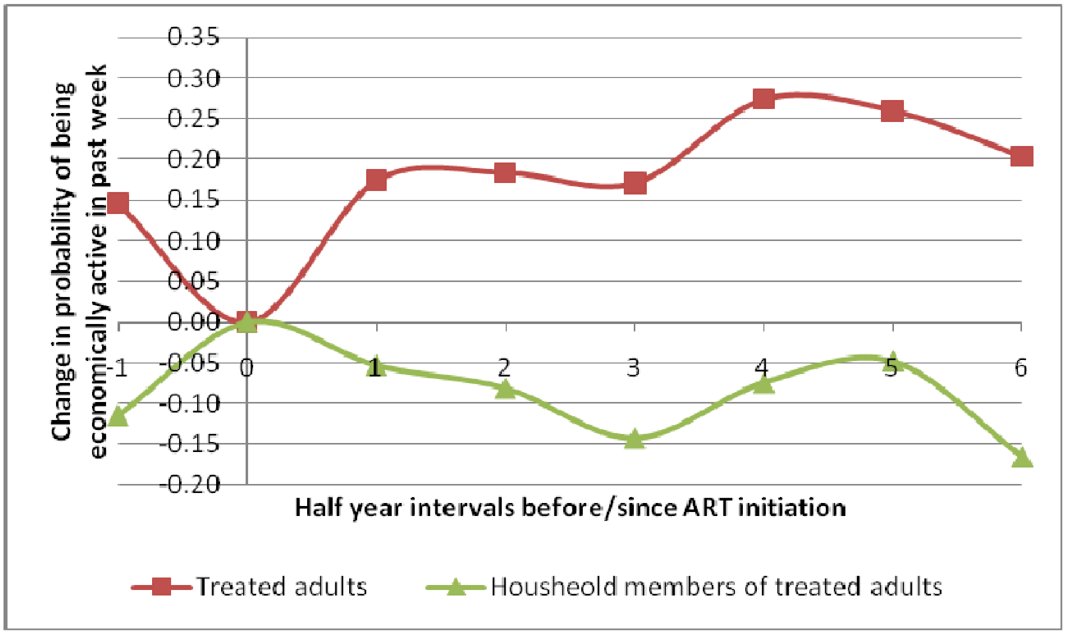
Notes: Figure displays coefficients from column 1 of Table 4, which indicates average estimated changes in the probability of being economically active, relative to the first quarter of ART initiation. The regression includes adjustments for trends in the random sample.

Figure 2. Impact of ART on weekly hours worked



Notes: Figure displays coefficients from column 1 of Table 4, which indicates average estimated changes in the probability of being economically active, relative to the first quarter of ART initiation. The regression includes adjustments for trends in the random sample.

Figure 3. Impact of ART on weekly hours worked for patients and adult household members



Notes: Figure displays coefficients from column 2 of Table 5 and column 1 of Table 6, which indicates average estimated changes in the probability of being economically active, relative to the first six months of ART initiation. The regression includes adjustments for trends in the random sample.