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Health and labor supply in the context of HIV/AIDS: the long-run economic impacts on 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. These results 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

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1In 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.

live and organizations that support these countries (The Economist 2006). However, because evidence on the various non-health impacts of providing ART has been slow to emerge, it has been difficult 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 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 morbidity – 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 as the symptoms of HIV infection began to appear, up to two years prior to death.

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. Thirumurthy, Graff Zivin and Goldstein (2008) focus on the first 12 months of ART and find a large response in both health 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.

This paper builds upon previous research in Kenya to examine how ART affects the labor supply of treated patients over a period spanning the first 3 years of treatment. The results presented here are among the only estimates of the long-term micro-economic impacts of ART in rural settings.[2] They are also noteworthy because they can be directly compared to objective measures of the health status of individuals, something that is often lacking in assessments of the economic impacts of ART.

[2]While Habyarimana, Mbakile, and Pop-Eleches (2010) also provide evidence on longer-term impacts of ART, their focus on worker absence does not capture labor effects on the intensive margin. Moreover, the results are based on employment outcomes in a mining company in southern Africa, a very different context than the one we study in this paper,

There are several reasons why the long-term impacts of ART may not be as large as those found in the short-term. While the evidence on the short-run labor market impacts of treatment has been impressive, toxicities associated with chronic exposure to ART in resource-limited settings where co-morbidities are abundant (Hawkins et al., 2007; Firnhaber et al., 2010) may undermine early health benefits. Concerns about eroding health benefits due to reduced adherence to medications underscore this importance (Gill et al. 2005).

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 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 estimate individual fixed effects regressions in which patients' labor force participation and hours worked is a function of the duration of time the patient has been receiving ART. 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 can be viewed as plausibly exogenous.

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 similar to the pattern of the health response to ART.[3]

We also find that attrition of treated patients is strongly associated with the initial health status of patients. Since health status at the time of treatment initiation is a strong predictor of patient survival (Wools-Kaloustian et al. 2006, Brinkhof et al. 2008), attrition in our study appears to be consistent with the notion that at least some of the exit from our sample is being driven by mortality. General trends of earlier diagnosis and treatment of HIV in Africa should make attrition due to early mortality considerably less common in current treatment programs. As a result, our results based on patients retained in the treatment program should paint a reasonably accurate picture of the impacts of treatment as currently offered. That said, attrition from our sample can occur for a number of reasons other than early mortality, including labor migration and other factors positively correlated with employment opportunities, suggesting that the impacts of attrition on the magnitude of our estimated labor effects remains ambiguous. Nonetheless, we are comforted that, apart from gender (which appears to matter because female patients were more likely to enroll in the program initially), patient characteristics are not significantly related to the length of time retained in treatment."

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

[3]It is also possible that these impacts are driven by other factors that are correlated with changes in health, such as changes in expectations regarding life expectancy or bequest needs. Nonetheless, our results do not appear consistent with the notion that these expectations are changing at the time of clinic enrollment for those who have not yet experienced the most serious health consequences of AIDS. Data limitations prohibit us from further disentangling these mechanisms.

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.[4] 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).[5] 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.[6] 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 weeks of ART followed by slower increases thereafter.[7] 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 (Hogg et al. 2001; Wools-Kaloustian et al. 2006; Severe et al. 2010).

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

[4]Most uninfected individuals have a CD4+ T cell count of 800 to 1000 cell per mm^3 of blood.

[5]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.

[6]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.

[7]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).

percent (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. Poor health at the time of treatment initiation appears to be among the most important predictors of attrition, as ART regimens are generally less effective when the immune system has become extremely weak and when opportunistic infections have developed (Brinkhof et al. 2008; Rosen and Fox 2011). Section 6 explores predictors of attrition and the potential implications for the interpretation of our results.

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).

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).[8] Following increased funding since late-2003, the Mosoriot HIV clinic has experienced rapid growth, with many patients coming from outside Kosirai Division.[9] 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 analysis in this paper is based on two distinct groups of individuals. The first 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.[10],[11] 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 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.[12] The second 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.

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[8]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).

[9]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 ART.

[10]We include in this sample 2 adults who were originally part of the random sample but enrolled in the AMPATH clinic and began receiving ART between rounds.

[11]The analysis in this paper excludes the 60 individuals 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.

[12]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 ART.

It should be noted that as a result of the above sampling strategy, the longitudinal survey contains up to 3 observations for individuals who were first surveyed in round 1 whereas there are only up to 2 observations for individuals who were first surveyed in round 2. Throughout the remainder of the paper, we refer to treated patients as "ART recipients." 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. Additional details can be found in Thirumurthy, Graff Zivin, and Goldstein (2008).

The AMPATH Medical Records System, which contains longitudinal 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 characterizing patient health status. AMPATH patients typically visit the HIV clinic monthly and CD4 counts are monitored at intervals of roughly six months.[13] The body weight of patients is generally recorded at each visit and this gives us a more frequently captured measure of patient health.

Table 1 summarizes the main demographic characteristics of the two groups of ART recipients at the time they were enrolled in the study. Patients enrolled in the study in round 2 were significantly more likely to be male and a few years older than patients enrolled in the study in round 1. However, there were no significant differences in their education and in several measures of their households' wealth. The gender differences highlight that proportionally more women enrolled during the early years of the program.

Importantly, as we show in Table 2, there are no major differences in the health status of patients enrolled in the two different rounds. A noteworthy feature of the study 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 the study. Adult patients enrolled in round 1 were receiving ART for an average duration of 160 days at the time of enrollment (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). There is substantial variation in the duration on ART at the time of study enrollment, which 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). It also implies 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 are 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.

Table 2 also shows that ART recipients enrolled in round 1 had an average CD4 count of 90 cells/mm3 at the time they initiated ART, significantly lower than the recommended guidelines for initiating treatment at 200 cells/mm3. Patients enrolled in round 2 also had a low CD4 count of 83 cells/mm3. Given the evidence that later initiation of treatment reduces

[13]The CD4 count was obtained less frequently and at unspecified intervals prior to 2004, when funding was more limited. As such for the sample of patients in this study, CD4 counts are not available on a frequent basis.

the efficacy of the medications, it is not surprising that 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. As noted earlier, these attrition rates are consistent with those found in other treatment programs in sub-Saharan Africa. Regrettably, the treatment program we study, like most other treatment programs in resource poor settings, does not actively monitor the vital status of patients, making it impossible to establish whether those who attrite were deceased, lost to follow up, or transferred to another clinic. The implications of this attrition are explored in Section 6.

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 patients, 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 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).

Several points about the estimation strategy in this paper should be noted. First, the reduced form empirical strategy described above estimates the treatment effect relative to baseline levels, but because the ART recipients would undoubtedly become much sicker without the medicines, it 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 (results are not reported in the paper but are available upon request). 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 in response to changes in time on treatment.

5. Results for adult patients' labor supply response

We restrict the analysis of labor supply to ART recipients between the ages of 18 and 65 who appear in at least two rounds of the survey.[14] Table 3 presents summary statistics for the labor supply outcomes in each of the three rounds for both groups of ART recipients.[15] In the first round, 72 percent of ART recipients reported having worked 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 considerably higher, at 86 percent. A further increase in the labor force participation is evident in the third round of the survey (92 percent). 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 low to begin with (84 percent) but considerably higher twelve months later, in round 3, at 93 percent.[16]

It is worth noting that the data in Table 3 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 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.

[14] 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.

[15] Household members of the ART recipients are not included in any of this analysis.

[16] It is important to keep in mind when comparing data between rounds that the Round 2 and Round 3 interviews were conducted during the annual harvest season while Round 1 included several months during which agricultural activities generally reach a nadir.

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 small 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 pre-ART period. In the first quarter after ART initiation, Table 4 shows that there was no significant change in labor force participation relative to the time that patients began ART. However, after two quarters of treatment, adults receiving ART were 17.2 percentage points more likely to participate in the labor force relative to participation levels at ART initiation, an increase that is statistically significant. As the above discussion of equation 1 indicates, these changes are observed after controlling for time trends that apply to all ART recipients. 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 13.8, 38.4 and 29.2 percentage points higher than ART initiation levels, respectively. Column 2 of Table 4 indicates that hours worked in the past week also 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 10–18 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 (16.6 hours per week), these increases are substantial. We also performed *F*-tests for the hypothesis that all post-ART quarterly indicators are 0. For both employment outcomes the hypothesis was rejected, confirming that these are indeed significant increases in employment outcomes following the initiation 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 quarterly intervals since ART initiation, with 95 percent confidence intervals for each of the quarterly treatment effects. 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 treatment initiation.

Clearly identifying the underlying mechanisms due to which the employment responses occur is challenging, but the large and substantial rebound in health status due to ART is presumably an important mechanism. Figure 3 shows the coefficients of a regression that is similar to equation 1 but has body weight (in kilograms) as the dependent variable. Body weight is an important indicator of health status for patients who have AIDS, as wasting is one of the main symptoms of AIDS, and it has also been used as a way to assess the effect of treatment on a patient's health (Wools-Kaloustian, 2006). Figure 3 shows a large and significant increase in body weight soon after treatment initiation, followed by smaller increases beyond the first year of ART. That the timing of these labor impacts mirrors the health impacts of ART so closely provides strong suggestive evidence that health is one of the primary mechanisms through which these labor impacts operate.

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

As discussed earlier, in the absence of treatment, patients with AIDS will not generally live beyond the next six to twelve 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. Attrition of patients from our sample can occur for a number of reasons, including death but also loss to follow-up due to discontinuation of care, transfer to an HIV clinic that is closer to the patient's home (over time, the number of ART centers in Kenya rose substantially), or migration due to employment. Indeed low rates of retention in care have been identified by many others as an important concern when it comes to assessing the scale-up of ART programs in Africa (Rosen, Fox, and Gill 2007). In our study, we do not have detailed information on the reasons for attrition of each patient, since the HIV clinic was underequipped to have active outreach for each patient who was not seen at the clinic for an prolonged period of time. However, of particular relevance for our analysis is that 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) and may thus be driving much of our sample attrition. While it is challenging to find exogenous variables that can predict attrition in our study, we undertake two different analyses that provide a better understanding of attrition in this setting. Specifically, we first identify major factors that are associated with attrition in the sample of ART recipients in our study. This may help identify potential selection biases in who remains on treatment also inform us about sub-groups to whom the results are most applicable. A key finding here will be the significance of health at the time of the baseline survey. Secondly, to examine whether attrition is happening in other ways that would be a concern for the estimation of the long-term impacts of ART, we pool all the observations from the longitudinal survey and regress several characteristics of patients (such as gender, education, wealth, and household structure) on indicators of the duration of time on ART.

Table 5 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.[17] Column 1 of Table 5 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 5, 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 5 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 attrite) and age (older patients attrite less). It is notable that even though male patients have significantly lower body weight at the

[17]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.

time of study enrollment, the gender effect is significant even after controlling for baseline body weight.

An important note regarding the results in Table 5 is that the body weights and CD4 counts of patients enrolling in ART programs across Africa have risen significantly in the years following our study due to the large expansions in testing and treatment programs across the continent. Thus, while the core labor supply impacts estimated in this paper may not be applicable to patients initiating ART with low CD4 counts and body weights, they may well provide an accurate picture of the impacts of treatment programs as they exist today.

We also pursue an empirical strategy in which we examine whether patients with certain characteristics are significantly more or less likely to be observed during various durations of treatment. This has implications for the generalizability of the longer-term estimates of treatment that were presented in Section 5. Specifically, we estimate regressions in which several characteristics of patients (gender, education, wealth and household structure as measured by whether or not the household head is single) are regressed on quarterly indicators of the duration of time on ART, as well as the round 2, round 3, and month-of-interview indicators. The results of this regression are reported in Table 6 of the paper. With the exception of gender, we find that the length of treatment indicators are not jointly significant. For gender, more women are observed in the sample during the latter periods of treatment duration. This is presumably due to the fact that in the clinic where our study was conducted (as in many ART programs that were operating at the time), a substantial majority of patients seeking HIV care were women. Women generally have greater access to HIV testing via antenatal services and also tended to seek care after their husband had died. Over time, as more men got tested and sought care, the clinic population contained larger numbers of men. As a result of these patterns, the greater numbers of women being observed during the later stages of treatment appears to reflect the fact that they tended to initiate treatment earlier.

7. 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 nearly a doubling in the number of hours worked from the time of treatment initiation. The pattern of labor supply results very closely match the pattern of health improvements associated with ART. Importantly, these results suggest that with treatment, the labor supply of AIDS patients can recover quickly and be sustained at higher levels for a considerable duration of time.

Importantly, the longer-term micro-economic benefits of ART reported here complement recent results that the risk of secondary transmission of HIV can be greatly reduced if infected persons receive ART during the early stages of HIV infection (Cohen et al. 2001). The latter results point to the use of ART as a prevention tool and have provided an impetus for the test-and-treat strategy recommended by Granich et al. (2009) – a strategy that calls for more widespread HIV testing and earlier initiation of ART. These varied benefits of ART can go some way toward a comprehensive cost-benefit assessment of treatment programs. However, the issue of retaining patients in care remains an important concern and one that has been expressed elsewhere (Rosen, Fox and Gill 2007). Low rates of retention would mean that the overall prevention benefits of ART will be diminished and the labor supply benefits reported here may not apply. In our study, men were significantly more likely to attrite during the study period, as were those who initiated treatment at late stages (with low CD4 counts). There is thus a vital role for interventions to promote medication adherence and increase outreach to men receiving ART. With early diagnosis of HIV infection and entry into HIV care, as well as better patient retention, the labor supply gains reported here could translate into larger and longer-lasting economic benefits.

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 such as ART. Indeed, the labor supply response we have estimated can be used to calculate a back-of-the-envelope estimate of the value of these private benefits. Median daily wage rates for all adults doing casual wage labor in our sample are 100 Kenya shillings, or about $1.50. Since this daily wage is associated with six hours of work, the hourly wage is about 17 Kenya shillings, or $0.25. Based on the average increase in weekly hours worked in years 2 and 3 after treatment initiation (Table 4), approximately 14 hours per week, this translates into an average wage benefit to patients of $175 per year (assuming individuals work 50 weeks per year). It is worth noting, however, that this estimate is based on the labor supply impact relative to labor supply at the time of ART initiation, while a true counterfactual would require a comparison to labor outcomes for those untreated. If we assume that untreated patients would have zero labor supply, the average increase in weekly hours worked would be nearly 31 hours.[18] In this case the average wage benefit to patients from treatment is approximately $388 per year, a number that exceeds the annual cost of most generic first-line ART regimens and matches the annual per-patient value of medication costs combined with other treatment delivery costs and other treatment program expenses (Campaign for Access to Essential Medicines, 2011).

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[18]Note this figure is calculating by adding our average increase from years 2 and 3 to the mean number of hours worked by ART patients at baseline in Table 4.

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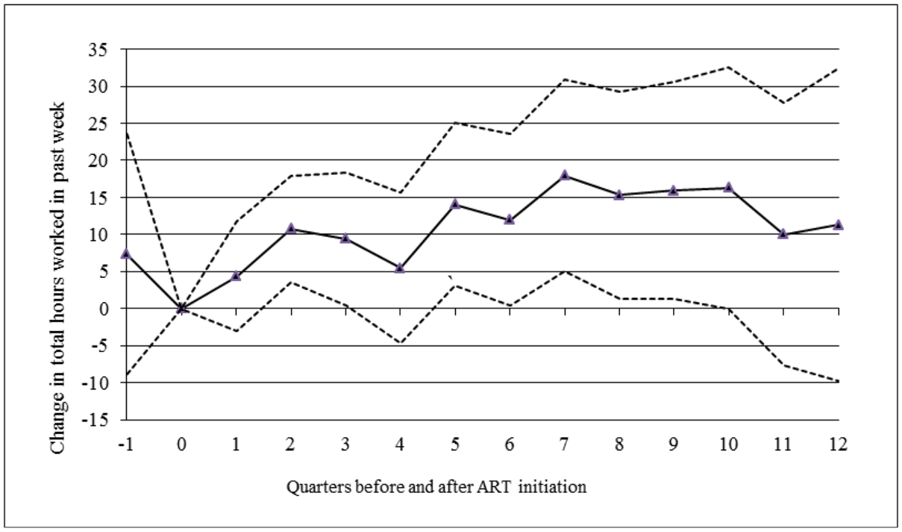

Figure 1.
Impact of ART on probability of being economically active
Notes: Figure displays coefficients from an individual fixed effects regression that indicates average estimated changes in the probability of being economically active, relative to the first quarter of ART initiation (represented by 0 quarters). The regression includes individual fixed effects, round 2 and 3 indicators, and month-of-interview indicator variables. Dotted lines represent the 95 percent confidence intervals.

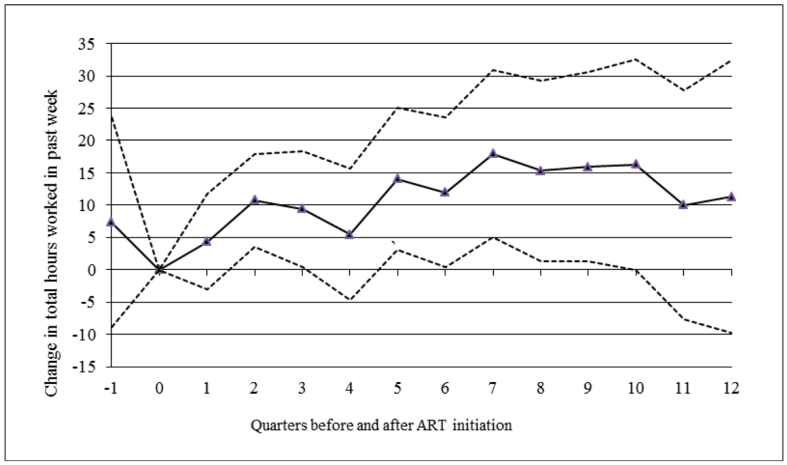

Figure 2.

Impact of ART on weekly hours worked

Notes: Figure displays coefficients from an individual fixed effects regression that indicates average estimated changes in the number of hours worked in the past week (including 0 hours for those not working), relative to the first quarter of ART initiation (represented by 0 quarters). The regression includes individual fixed effects, round 2 and 3 indicators, and month-of-interview indicator variables. Dotted lines represent the 95 percent confidence intervals.

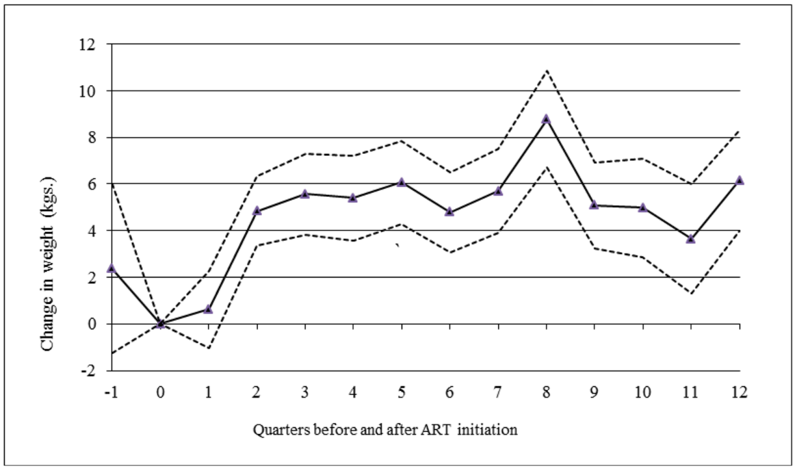

Figure 3.
Impact of ART on body weight
Notes: Figure displays coefficients from an individual fixed effects regression that indicates average estimated changes in the body weight of patients, relative to the first quarter of ART initiation (represented by 0 quarters). Dotted lines represent the 95 percent confidence intervals.

Table 1

Comparison of ART patients enrolled in round 1 and 2

	ART patients enrolled in round 1		ART patients enrolled in round 2		P-value
	Mean	**Std. Dev.**	**Mean**	**Std. Dev.**	
	(1)	**(2)**	**(3)**	**(4)**	**(5)**
Sample size	222		210		
Age	37.2	9.0	39.0	8.9	0.03
Female	75%		64%		0.02
Years of School Completed	7.8	3.4	7.8	3.4	0.96
Completed Primary	50%		50%		0.96
Household size	5.6	2.4	5.1	2.4	0.05
Single headed household	46%		51%		0.25
Resides in Kosirai Division	40%		15%		<0.01
Quantity of land owned (acres)	4.6	8.6	3.9	9.0	0.49
Value of land owned (KES)	538.5	1098.2	508.2	795.1	0.80
Value of livestock owned (1,000 KES)	39.1	71.0	26.2	34.2	0.05

Notes: Column 5 shows the *p*-value from a *t*-test for equality of means for the ART sample enrolled in rounds 1 and 2.

Table 2

Number of days on ART and CD4 count at ART initiation

	Sample Size	Number of days on ART			CD4 count at ART initiation		
		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			

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Table 3

Employment outcomes in the ART sample

	Sample size	Economically active in past week Mean	Total hours worked in past week Mean	Std. Dev.
	(1)	**(2)**	**(3)**	**(4)**
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

Table 4

Impact of ART on Labor Supply

	(1)	(2)
VARIABLES	**Economically active in past week**	**Total hours worked in past week**
1 quarter before ART initiation	0.119 (0.128)	7.295 (8.278)
Quarters after ART initiation		
1	0.087 (0.058)	4.356 (3.766)
2	0.172*** (0.057)	10.734*** (3.668)
3	0.222*** (0.071)	9.377** (4.581)
4	0.138* (0.080)	5.483 (5.184)
5	0.163* (0.087)	14.035** (5.609)
6	0.274*** (0.091)	11.969** (5.904)
7	0.220** (0.102)	17.950*** (6.616)
8	0.384*** (0.111)	15.296** (7.152)
9	0.292** (0.115)	15.948** (7.450)
10	0.332** (0.129)	16.300* (8.327)
11	0.248* (0.140)	10.003 (9.034)
12	0.292* (0.166)	11.284 (10.743)
Constant	0.661*** (0.098)	12.919** (6.336)
Mean of dependent variable in round 1 for patients initiating ART	0.58	16.6
F-test that all post-ART quarterly indicators are 0	8.54	5.52
p-value of *F*-test	<0.01	0.02
Month dummy variables	Yes	Yes
Observations	908	908
R-squared	0.607	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

Factors associated with attrition from panel survey among ART recipients

	(1)	(2)	(3)
VARIABLES		**Attrition from panel**	
Female	−0.162*** (0.048)	−0.172*** (0.047)	−0.146*** (0.048)
Age	−0.007*** (0.002)	−0.006*** (0.002)	−0.007*** (0.002)
Household size	0.004 (0.009)	0.003 (0.008)	0.002 (0.009)
Completed Primary	−0.061 (0.052)	−0.061 (0.051)	−0.067 (0.052)
Completed Secondary	0.023 (0.060)	0.011 (0.059)	0.014 (0.060)
Resides in Kosirai Division	−0.009 (0.047)	−0.014 (0.046)	−0.022 (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*** (0.166)	0.549*** (0.118)	0.602*** (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 6

Association between duration of time on ART and characteristics of ART patients

VARIABLES	(1) Female	(2) Completed primary	(3) Value of livestock	(4) Single headed household
Round 2	−0.004 (0.058)	−0.050 (0.066)	−7,260.611 (10,728.819)	0.025 (0.067)
Round 3	−0.010 (0.064)	−0.196*** (0.073)	−23,578.624** (10,296.043)	0.010 (0.073)
1 quarter before ART initiation	0.207 (0.138)	−0.247 (0.156)	−7,869.827 (20,424.643)	−0.035 (0.158)
Quarters after ART initiation				
1	0.126** (0.064)	−0.095 (0.073)	315.598 (10,483.810)	−0.063 (0.074)
2	−0.055 (0.065)	−0.064 (0.075)	−4,300.016 (10,366.327)	−0.042 (0.075)
3	0.144** (0.071)	−0.074 (0.081)	3,291.218 (11,231.440)	−0.078 (0.081)
4	0.081 (0.079)	−0.097 (0.090)	6,587.570 (12,538.615)	−0.026 (0.091)
5	0.114 (0.082)	0.119 (0.093)	5,835.244 (13,472.880)	0.070 (0.093)
6	−0.059 (0.084)	0.095 (0.096)	17,321.853 (13,564.903)	−0.128 (0.097)
7	0.033 (0.087)	0.154 (0.099)	21,970.781 (14,299.032)	−0.060 (0.100)
8	−0.054 (0.092)	0.186* (0.105)	9,892.361 (14,275.997)	−0.136 (0.106)
9	0.152* (0.089)	0.143 (0.102)	15,988.776 (14,376.221)	−0.010 (0.103)
10	0.027 (0.098)	0.195* (0.111)	8,653.053 (15,475.419)	0.110 (0.112)
11	0.087 (0.109)	0.235* (0.125)	25,566.992 (17,066.175)	−0.031 (0.125)
12	0.106 (0.100)	0.344*** (0.113)	28,588.570* (15,682.312)	−0.033 (0.114)
Constant	0.700*** (0.110)	0.506*** (0.126)	35,319.394** (17,243.895)	0.492*** (0.127)
F-test that all quarterly indicators are 0	3.65	1.62	0.47	1.36
p-value of *F*-test	0	0.0802	0.9326	0.1815
Observations	908	906	770	908

Notes: Standard errors reported in parentheses (* significant at 10%; ** significant at 5%; *** significant at 1%). Regressions include month-of-interview indicator variables.