Economic Stimulus from Public Health Programs: Externalities from Mass AIDS Treatment Provision in South Africa

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Abstract

Return on investment in international development assistance has attracted greater focus in recent years. Government programs, particularly public health programs, are likely to indirectly affect community members beyond the intended direct beneficiaries via externalities that could be many times larger than the direct benefits.

This study evaluates the direct and indirect impact of the provision of mass AIDS treatment on labor market outcomes, using biomarker data to separately identify the impact by HIV status. We used rich data from a demographic surveillance site in rural South Africa with a 99% survey response rate. We leveraged differences in access to antiretroviral therapy (ART) that are uncorrelated with unobservables, and we used a set of rigorous causal inference methods, including machine learning (lasso), to estimate a plausibly causal impact.

As ART access scaled up between 2004 and 2011, employment increased by 8.5 percentage points for HIV-infected individuals who were within 2 km from the nearest ART clinic compared to those more than 5 km away. We found sizable increases of 6.3 percentage points (22%) among HIV-uninfected individuals who had no HIV-infected household members. Labor force participation decreased over this period, which suggests that labor demand plays an important role in driving the observed employment increases.

Our results demonstrate that the economic benefits of ART are broadly distributed, operate via channels outside the household, and have properties of a public good. Investments in health-related human capital may have important stimulus effects on local economies that should be considered alongside conventional economic policy.

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1 Background

Return on investment has figured more prominently in recent years when decisions are made regarding international development assistance and program implementation (Green and Kohl 2007; Charbonnier 2013). Current levels of development assistance are generally determined based on the implicit assumption that benefits accrue only to the intended direct beneficiaries of the program and, to a lesser extent, their households. However, community members are likely to benefit indirectly via externalities (spillovers) of health programs that could be many fold larger than the direct benefits (see, e.g., Miguel and Kremer 2004). Unless these externalities are quantified and taken into consideration when making public policy decisions, effective government programs will be underfunded and government services will be underprovided relative to the optimum. It is essential to understand the distribution of benefits from government programs not only when estimating return on investment, but also when determining the likely impact on income inequality.

Public health programs have great potential for positive externalities that affect health and economic outcomes. In particular, the established robust causal link between health status and economic outcomes motivates the inclusion of economic benefits in calculations of return on investment to public health programs (see Strauss and Thomas 1998, Smith 1999). Improved physical health can positively affect economic outcomes by increasing physical strength and stamina, improving mental health, boosting productivity, and reducing absenteeism.

Countries with generalized AIDS epidemics are at risk of suffering a severe negative economic impact (Bloom and Mahal 1997; Young 2005; Bell et al. 2006; Kalemli-Ozcan 2012). HIV/AIDS strikes individuals in their prime productive years and has the potential for devastating effects because the disease is chronic, severely incapacitating in late stages, and eventually fatal. The morbidity and mortality associated with HIV/AIDS affect household employment outcomes, consumption, savings behavior, educational attainment, and investment in children (Bachmann and Booysen 2003; Collins and Leibbrandt 2007; Cohen 2002; Beegle 2005; Levinsohn et al. 2013). The labor market effects of HIV/AIDS are particularly important because income levels constrain many household decisions. The direct and indirect costs of HIV contribute to the socioeconomic vulnerability of these households and potentially reinforce existing inequalities.

In addition to improving health and enabling nearly full life expectancy of people living with HIV, antiretroviral therapy (ART) for AIDS also has positive economic impacts (Bor et al. 2013a; Egger et al. 2002; Palella et al. 1998). The improved health of ART initiators increases their labor productivity and enables them to remain in or return to the labor force, work more hours, and earn more per hour worked (Thirumurthy et al. 2008; Larson et al. 2008; Habyarimana et al. 2010; Bor et al. 2012; French et al. 2019). ART also has spillover effects on the households of patients initiating therapy, leading to changes in labor supply among other household members (Thirumurthy et al. 2008; Graff Zivin et al. 2009; Bor et al. 2012 NEUDC); less time spent providing home-based care (d'Adda et al. 2009); and improved child health (Lucas and Wilson 2018) and education (Graff Zivin et al. 2009). Additionally, ART postpones the high costs borne by households of end-of-life health care and funeral expenses associated with HIV mortality (Ardington et al. 2014), insuring households against loss of wealth (Bor et al. 2012 IAEN). McLaren (2010) shows that in the aggregate, ART scale-up led to increases in labor supply and employment in South Africa.

Whether community spillover effects of ART scale-up are positive or negative is a priori ambiguous. By increasing labor supply among HIV-infected people, mass ART provision could negatively affect incomes of HIV-*un*infected community members by increasing competition for existing jobs and thereby driving down wages. On the other hand, mass ART provision could improve labor market outcomes for HIV-uninfected community members through changes in expectations about the future that lead to increases in labor supply and productivity. Labor demand may also rise in response to higher average productivity of workers, akin to providing additional years of public education.

This study evaluates the direct and indirect impact of the provision of mass HIV treatment on labor market outcomes in South Africa, which has over seven million people living with HIV. South Africa began the rollout of ART provision in public sector health facilities in mid-2004 and enrolled more than two million patients by 2012, making it the largest AIDS treatment program in the world (Pillay 2013). Mass ART provision has led to large improvements in population health: from 2003 to 2011, adult life expectancy in rural South Africa increased by 11.3 years (Bor et al. 2013a). It is therefore likely that sizeable spillover effects indirectly benefited nonrecipients of ART.

Though the spillover effects of large-scale ART programs are potentially large with important policy implications, few studies have examined the spillover impact of ART rollout on community members, including HIV-infected persons not yet on ART and people not infected with HIV. This study contributes to the economic literature that assesses the impact of ART programs on labor market outcomes, including direct impacts on ART patients and their households and any potential labor market spillover effects on HIV-uninfected individuals (McLaren 2010; Baranov et al. 2015; Baranov and Kohler 2018). We are the first study to estimate the impact of mass ART access on labor market outcomes for non-ART-initiators by HIV status that also captures impacts on labor demand.

We use rich demographic surveillance data that cover the entire population of a rural region of South Africa. Our identification strategy leverages quasi-random, time-varying differences in distance to the nearest public ART facility as a measure of the opportunity cost of obtaining ART. We implement a set of rigorous causal inference methods, including machine learning methodologies that capitalize on the rich set of respondent characteristics in the data, to address potential confounders and identify a plausibly causal effect.

We find large increases in aggregate employment when ART is introduced in rural South Africa. Between 2004 and 2011, employment rates rose by 8.5 percentage points for HIV-infected respondents less than 2 km from the nearest ART clinic relative to those 5–12 km away. Large gains in employment were observed for HIV-uninfected community members as well. Employment increased by 6.3 percentage points for HIV-uninfected respondents with no direct exposure to HIV within their households, which represents a 22 %gain in employment off baseline employment rates of 38%. Though we find no increase in labor force participation, we do see a shift from into productive activities such as school enrollment and care-taking. Observed small decreases in the likelihood of reporting being too ill to work on the order of 1–1.5 percentage points cannot fully explain increases in employment and demonstrate other factors are driving the effects.

Our results demonstrate that the economic benefits of ART are broadly distributed, operate via channels outside the household, and have properties of a public good. Investments in health-related human capital may have important stimulus effects on local economies and should therefore be considered alongside potential economic policies in developing countries. Public sector disease-specific treatment programs may be more feasible, sustainable, and able to build more broad-based support when these spillover benefits are taken into account.

2 Conceptual Framework

The ART scale-up could affect labor market outcomes for HIV-*un*infected community members through several pathways. The increased labor supply of HIV-infected community members and their household members could increase competition for jobs and crowd out HIV-uninfected workers. This is akin to the story Young (2005) posited that HIV mortality would lead to improved labor market outcomes for survivors.

On the other hand, mass ART provision could increase employment of HIV-uninfected community members through a number of channels. The first is a *subjective expectations channel*. Mass ART provision reduces perceived mortality risk and may improve mental health among community members who are HIV-infected or at risk of becoming HIV-infected (Okeke and Wagner 2013; Baranov et al. 2015). This increases the returns to investment in human capital acquisition (increased educational attainment), job search (labor force participation), and work output (productivity) (e.g., Baranov et al. 2015; Baranov and Kohler 2018).

Second, ART could affect the labor supply of HIV-uninfected community members through a *health spillovers channel*. Untreated HIV increases the population prevalence of tuberculosis (TB) and other infectious diseases, leading to higher exposure and incidence among persons not infected with HIV. The reduction in TB transmission from HIV-infected individuals who access ART may reduce absenteeism of HIV-infected and HIV-uninfected individuals due to TB (Wood and Lawn 2011; Williams et al. 2010; McLaren et al. 2018).

Third, along with these potential increases in labor supply, *shifts in labor demand* may also drive changes in employment rates. Public sector treatment raises the average productivity of workers and partially insures firms against productivity losses from absenteeism, presenteeism, and turnover among HIV-infected workers. ART scale-up could also raise labor demand as manufacturing firms reduce their capital-to-labor ratio in response to a healthier, more productive workforce (Marinescu 2015). This could lead to increases in hiring by firms. Additionally, the scale-up of ART may have had a direct employment effect via ART clinics hiring health workers and auxiliary clinic staff. The increase in patient loads (as ART patients must attend the clinic every month) may also stimulate market activity in the vicinity of ART clinics and thereby drive increases in employment among HIV-uninfected individuals.

3 Data and Study Context

This study examines the impact of mass ART provision in the context of a large demographic surveillance area in northeastern South Africa, a high-HIV-burden region that has been studied continuously since 2000. The surveillance area is rural and poor with employment rates of about 40%. Approximately 30% of adults are infected with HIV; AIDS deaths account for upwards of 60% of deaths in the 15–44 age group (Tanser et al. 2008).

We use data from the Africa Centre health and demographic surveillance site in rural KwaZulu-Natal to examine the impact of ART scale-up on the labor market outcomes of HIV-infected and HIV-uninfected individuals. The Africa Centre has collected data on labor market outcomes, HIV biomarkers, household structure, and demographics through annual household surveys since 2001 on all households in a 438 km^2 surveillance area. Household response rates are about 99%. These data have been linked at the individual level to complete clinical records from the public-sector ART program.

The data include information on demographic, socioeconomic, and health characteristics as well as labor market status and reasons for nonemployment for all members of all households in the demographic surveillance area. Household socioeconomic surveys were repeated approximately every two years from 2001 to 2007 and then annually through 2011 for a total of seven survey waves in our analysis. Data on the HIV status of respondents were collected through a population-based HIV biomarker surveillance (2003/2004) that had a 60% participation rate (Tanser 2008).

For the study population, the primary source of access to ART was through the local public-sector ART program, the Hlabisa HIV Treatment and Care Programme. HIV care and treatment are provided free of charge, though patients bear potentially large transport costs in accessing care. Private sector care is rare in this community and is especially rare for ART due to the high cost of antiretroviral drugs and the low rates of health insurance (Bor et al. 2013b). During the period of study, six of the health facilities in the surveillance area became accredited to provide ART and began to enroll patients. Dates of ART initiation from the Hlabisa HIV Treatment and Care Programme were obtained through individual-level linkage of complete patient records to surveillance data. From 2004 through 2010, HIV patients were eligible to initiate ART if they had a CD4 count less than 200 cells/μL

(Department of Health 2004). In April 2010, eligibility was extended to pregnant women and patients with active TB with a CD4 count less than 350 cells/μL (Department of Health 2010); and in August 2011, to all adults with a CD4 count less than 350 cells/μL (Hlabisa Hospital 2011). Distance from a person's place of residence to the nearest ART clinic was calculated for the complete population. We follow Tanser et al. (2001) and use Euclidean distance as a measure of distance traveled.

The study population was defined to include only those individuals aged 18–59 who were members of a household in the demographic surveillance area prior to 2004 and could thus be assigned a "distance to clinic" exposure that predated the rollout of ART in 2004. We observed economic outcomes for migrants 18 years and over regardless of place of residence, so long as they continued to be members of a household in the surveillance area. It is appropriate to include nonresident household members in the study because they are generally economically connected and may return to the surveillance area to seek HIV care and treatment (Olgiati et al. 2012) or for end-of-life care (Welaga et al. 2009). Attrition due to loss to follow-up or permanent out-migration from the surveillance area was low, at a rate of 3.3 per 100 person-years. The analysis data set included 103,748 observations from 20,728 individuals. The study population is extensively described in Tanser et al. (2008).

3.1 Identifying assumption

Though ART is provided free of charge, there are unusually high opportunity costs of travel to health facilities in South Africa. For many patients, these present a significant barrier to accessing care. Many patients will travel by minibus, which can run on infrequent schedules and be relatively expensive. Patients incur time costs by walking as well as the risk of being a victim of a violent criminal attack, since South Africa's violent crime rate is one of the highest in the world (United Nations Office on Drugs and Crime 2019). The usual time costs of lost work or home production hours are also a factor. During this early period of ART care, several clinic visits were required in order to initiate ART. Though small differences of a few kilometers might not seem consequential, in a study in the same population, Cooke et al. (2010) found that an HIV-infected individual who lives 3 km from the nearest clinic is only half as likely to access lifesaving ART as someone living next door to it.

The six existing health facilities in the Hlabisa area began to provide ART between September 2004 and January 2005, and initiated patients on ART on a first-come, first-served basis. There were no guidelines for triage among patients who met both the World Health Organization AIDS criteria and the cutoff CD4 count of less than 200 cells/μL.

4 Methods

4.1 Main regression

Our identification strategy used differences in distance to the nearest public ART facility as a proxy for the opportunity cost of obtaining ART. We assumed that differences in distance to an ART clinic are uncorrelated with unobservables once we control for a rich set of covariates and fixed effects. We implemented a comprehensive set of methods, including balancing tests and robustness checks, to provide evidence that this assumption holds.

We evaluated labor market outcomes in the full study population, assessing the effect of clinic proximity on the probability of employment, labor force participation, school attendance, and nonemployment due to illness. We compared economic outcomes for respondents living close to ART clinics with outcomes for people living farther from clinics, over the period 2001 to 2011, using fixed-effect models of the form:

$$y_{it} = \beta_0 + \beta year_t + \gamma ClinicDist_i * year_t + \delta year_t * X_{it} + \lambda Z_{it} + \eta_i + \epsilon_{it}, \quad (1)$$

where y_{it} represents an economic outcome for individual i in period t. ClinicDist represents a vector of indicator variables for approximate tertiles of the distance from a household to the nearest ART clinic (0–2 km, 2–5 km, 5–12 km [reference group]); interactions between distance and survey year generate the coefficient matrix, γ, our main set of outcomes. The vector of control variables (X_{it}) included baseline age, gender, years of education, child grant receipt, disability grant receipt, old age pension receipt, cellphone ownership, household electrification, month of survey, urban density, Isigodi (town), as well as survey year interacted with distance to primary road, distance to secondary road, distance to primary school, distance to secondary school and age group by sex by high school completion triple interactions. We included individual fixed effects (η_i) to adjust for time-invariant unobservable individual characteristics. To further address confounders, in certain specifications we included covariates (Z_{it}) selected with the least absolute selection and shrinkage operator (lasso) as we describe below.

We include the following outcome variables: (1) employed and working for income (for all respondents 18 and over); (2) labor force participant (if they are either employed or report looking for work); (3) enrolled (if they are currently in full-time or part-time education); and (4) sick or injured (if that is reported as the reason they are not earning money). Note that the survey does not allow us to distinguish between active search activities and a desire for work, so the labor force participation category includes some discouraged workers who are not actively searching. We do not have a reliable measure of search activity to use as an outcome.

We evaluated labor market outcomes separately by respondent's HIV status and by whether they resided in a household with an HIV-infected member or an ART initiator. As only a selected subset of respondents consented to the HIV biomarker test, we use inverse probability weighting (IPW) to reweight the consenting population to resemble the full surveillance area population in terms of a rich set of observable characteristics. We use lasso-selected covariates to estimate the probability of being tested for HIV as described below.

Distance measures are generated using a respondent's residence in the 2003 survey wave, which predates the rollout of ART, to mitigate any bias from individuals moving closer to health facilities once ART became available. We group years of data into survey waves (2001, 2003/4 [ref group], 2005/7, 2008/9 and 2010/11). We included 2001 data in our models (for outcomes included in the 2001 survey) to check the parallel trends assumption prior to the scale-up of ART. Our analysis sample includes all members of the demographic surveillance area who resided there at least six months before the ART rollout began, to mitigate any bias from in-migrants seeking ART.

4.2 Covariate selection using lasso methodology

We generate regression specifications with a data-driven lasso method. The use of the lasso makes the assumption of selection on observables more plausible because it mines a richer set of observable covariates to select the most effective specification to produce unbiased estimates. Shrinkage methods such as the lasso reduce the number of covariates included in a model by imposing a constant, continuous penalty truncated at zero, where covariates with a zero-valued penalty are effectively dropped from the estimation model (Hastie et al. 2008). This is an improvement over theory-driven or ad hoc variable selection because the penalties are adaptively estimated via an efficient, systematic, data-driven process that is designed to identify the most highly correlated potential confounders from a set of all possible confounders.

The lasso relies on the assumption of approximate sparsity: that linear combinations of relatively few regressors can provide an approximation to the true specification with small approximation errors. This is weaker than the assumption of perfect model selection that implicitly underlies most mainstream analytical approaches. The lasso allows for the imperfect selection of controls and provides valid confidence intervals for causal inference.

To select a set of regressors for each regression specification, we perform the three-step, post-double selection method based on Belloni et al. (2014) using Stata version 16 package *lassopack*. First, the lasso selects a set of control variables (A_{it}) that are strong predictors of the treatment:

$$ClinicDist_i = \delta A_{it} + \eta_i + \epsilon_{it}. \tag{2}$$

Second, the lasso selects a set of control variables (B_{it}) that are strong predictors of the outcome variable, which includes important control variables for the final estimation, reduces residual variance, and provides another check that it has captured important confounding variables:

$$y_{it} = \alpha ClinicDist_i + \delta B_{it} + \eta_i + \epsilon_{it}. \tag{3}$$

Finally, we estimate the main regression of interest in Equation (1) where Z_{it} includes both selected sets of variables ($Z_{it} = A_{it} + B_{it}$).

In this paper, we input a set of over 7,500 potential covariates, including all possible interactions of covariates, from which the lasso algorithm selects between 50 and 80 covariates per specification for each outcome-distance metric dyad. Note that the regression-specific selection of control variables leads to somewhat different specifications for each outcome-sample pair.

Note that because the lasso is designed to select an *approximation* to the true model that prioritizes low variance over unbiasedness, the specific coefficients are not generally reported or discussed (see Appendix for list of Z_{it}). For example, to adhere to the principle of sparsity, the lasso will not generally select two variables that are highly correlated with each other, so relevant variables may be omitted because the selected specification contains proxies.

4.3 Inverse probability weighting to adjust for biomarker nonresponse

For analyses where we split the sample based on HIV biomarker results, we use inverse probability weighting (IPW) to reweight the respondents who acquiesced to the biomarker test in order to resemble the full surveillance area population in terms of a rich set of observables. The use of lasso methods to generate inverse probability weights increases the likelihood that the assumption of selection on observables holds, and therefore that the inverse probability weights will correct for differential selection on observables.

We calculate inverse probability weights for tested respondents:

$$IPW = 1/\Lambda(TESTED_i). \tag{4}$$

where the probability of being tested is estimated using the set of post-double selection lasso-selected covariates (Z_{it}) in a logistic regression:

$$\Lambda(TESTED_i) = \delta year_{it} * X_{it} + Z_{it} + \epsilon_{it}. \tag{5}$$

The appropriate use of the post-double selection lasso calls for using a set of covariates selected for their predictive power in Equation (5); however, for comparison purposes, we use a consistent set of covariates (Z_{it}) for each outcome-distance metric dyad across methods in alternate specifications.

4.4 Balancing tests

We performed a set of balancing tests to provide evidence to support our assumption that pre-ART-rollout characteristics and trends did not statistically significantly differ by distance to the nearest ART facility. We focused on the wave of data that predates the ART rollout (2001) and the wave of data collected just before the rollout began (2003/04), when less than 1% of the population was enrolled on ART.

We tested for differential pre-ART trends by distance for households near and far from ART clinics. We evaluated all variables available in both survey years. The 2001 survey was a pilot that included a more limited set of questions than subsequent waves, so we are therefore somewhat limited in the trends we can examine with the following specification:

$$\Delta y_{it} = \alpha ClinicDist_i \delta X_{it} + month_{it} + \epsilon_{it}. \tag{6}$$

As an additional check on balance, we examine pre-ART differences in *levels* of covariates with the following regression:

$$y_{it} = \alpha ClinicDist_i \delta X_{it} + month_{it} + \epsilon_{it}. \quad (7)$$

It is important to note that balance on *levels* of covariates is not required to hold for identification of a causal estimate but provides further evidence of pre-period balance.

5 Results

5.1 Descriptive statistics

Our analysis represents 99% of the total population of the demographic surveillance site, a predominantly rural area with high rates of poverty, unemployment, and HIV. Our analysis sample is 56% female, with an average age of 31. About one-third of the population graduated high school, 45% of the population are labor force participants, and about one-third of the population are employed (Table 1). Thirty-nine % of the population live in urban or peri-urban areas. Artisans make up about 35% of the work force while another 24% are clerical workers. As is typical of South Africa, there is little subsistence agriculture—the 8% of respondents who are farm workers primarily work for employers. In terms of assets, 17% own a car, 52% own a TV, and 79% have access to a cell phone. Thirty % of respondents self-identify as poor and another 50% say they are just "getting by." Migrants who belong to surveillance site households but work elsewhere in South Africa and other parts of southern Africa make up about 30% of the sample.

About 25% of working-age adults fall in the 30–40 age range due to high mortality rates from HIV. About 22% of those who took the HIV biomarker test were HIV-infected, but this was unadjusted for nonresponse and therefore underestimates the true HIV prevalence rate of about 30%. About 3% of the population report being too sick to work, which is primarily due to advanced AIDS.

Figure 1 shows the distribution of distance to the nearest ART clinic for our sample. There is wide variation in distance from next door to up to 10 km away, though most of the population lives within 5 km from the nearest clinic and about half live within 2.5 km. As mentioned above, these relatively small differences in distance represent fairly large differences in opportunity costs in the context of the surveillance area.

Figure 2 shows the number of patients who initiated ART over time. The first patients initiated ART in September 2004 and the program scaled up in subsequent years. It took facilities some time to streamline their enrollment processes and for word to spread; they reached the steady state of monthly patient enrollment around the end of 2007, when just under 1% of the surveillance area population had initiated ART. Women account for approximately two-thirds of patients; this reflects higher female HIV prevalence and propensity to seek health care. The wide variation in ART initiation dates enables us to disentangle the impact of ART from secular trends.

Distance to an ART clinic was strongly related to the proportion of the population on ART, which is our best measure of community-level exposure to ART—including knowledge of the availability of ART and of its positive effects on health. Figure 3 shows the relationship between distance and the proportion of the population that initiated ART by distance bands over time. ART was slow to scale up: although ART rollout began in late 2004, in 2005/2006 there were relatively few ART initiators at all distances. By 2007/08 the distance gradient becomes clearer, with just under 5% of the population initiating at the closest distances and 4% or lower farther than 2 km away. In 2010/11, the closest neighborhoods had 8% of the population initiated, but initiation drops off quickly at the 2 km mark. There is little distance decay for those who live more than 4 km from the nearest facility.

Table 2 shows ART uptake (Panel A) and HIV care-seeking (Panel B) by distance band, which represent approximate distance tertiles of the sample. Though the first patients initiated ART in July 2004, only approximately 0.1% of the population had initiated by the survey round in 2005. By the 2007 survey wave, 0.8% of the total population residing 5–12 km from the ART clinic had initiated ART; this rose each year, reaching a rate of 6.5%

in 2011 (column 1). We observe statistically significantly higher initiation rates in the population residing closest to the ART clinics. From 2009 onward, initiation rates were 1–1.4 percentage points higher—a 15–20% higher probability of take-up compared to those who live furthest from the clinics (column 2). Initiation rates were 0.6–0.8 percentage points higher in the population residing 2–5 km from the nearest ART clinic in 2010 and 2011 (column 3). HIV care-seeking exhibits similar patterns (Panel B). Overall rates of HIV care-seeking are about double those of ART uptake in the furthest distance band: 12.7 percentage points in 2011 compared to 6.5 percentage points (column 1), and the rate for those living closest to ART clinics is about 2.5 percentage points higher between 2009-2011 (column 2).

5.2 Balancing tests

Our balance tests support the validity of our identification strategy. Table 3 shows that trends in pre-period rates of employment, school attendance, death, migration, and household dissolution were balanced. Columns 1 and 2 show that even without including any controls, there were no differences between individuals living closer to facilities that subsequently provided ART compared to those living farther away that were significant at the 95% confidence level. When we add the standard set of controls (X_{it}) listed in Equation 1 the coefficients are small, and none are significant.

Table 4 compares trends in household asset holding for the pre-period and shows that with the inclusion of control variables, the assumption of parallel pre-trends in household assets holds. With the standard set of controls, the 18 household assets are mostly balanced except for statistically significant differences by distance in whether the household has a fridge, television, or electricity. The lasso method takes these potentially unbalanced variables into account by including variables that are strongly correlated with the treatment or outcome and therefore produces results robust to these imbalances.

We provide supplemental evidence that even the *levels* of covariates were balanced during the pre-ART-period (Table 5). It is important to note that balance in these tests is not a requirement for unbiasedness of our fixed-effects estimates. However, balance in the cross-sectional data with the inclusion of control variables suggests that unobservables are likely to be balanced by distance to the nearest facility when controls are included. Table 5 shows balance tests for levels of characteristics with and without our standard set of controls. Though without the controls, the majority of characteristics differ statistically significantly in the pre-period, the addition of the controls reduces the size of the coefficients and balances all but two variables.

5.3 Main regression results

Our main regression results evaluate the impact of ART access on a set of labor market outcomes. Table 6 shows the main regressions of the relationship of the likelihood of employment over time relative to distance to ART. It reports the set of γ coefficients from Equation 1, which captures the differential impact of ART by distance over time. Column 1 includes minimal controls noted in the text, column 2 includes standard controls noted in the text and column 3 uses lasso-selected controls. (See the Appendix for the full list of lasso-selected controls.) As ART coverage increased from 2004 onward, we found large and significant increases in employment among adults close to clinics relative to those living far from clinics. Our preferred specification in column 3 includes the lasso controls selected from the full set of time-varying demographic, geographic, and community controls, as well as a set of individual fixed effects. It shows that individuals closest to the nearest ART facility were a statistically significant 5.6 percentage points more likely to be employed in 2005/07 relative to individuals living more than 5 km from the nearest facility. This increased to 8.5 percentage points by 2010/11, which amounts to about a 20% gain in employment off baseline employment rates of about 40%. Individuals 2–5 km from the nearest ART facility were a statistically significant 3 percentage points more likely to be employed in 2005/07, which increased to 5.1 percentage points in 2010/11 relative to those furthest away. Coefficients for those 2–5 km from the nearest ART facility were a little over half the size of those of the nearest group, reflecting poorer access to ART. Echoing our balancing tests, we included 2001 waves in our main regressions as a check on our identifying assumption that observed changes were due to ART scale-up. We found no evidence of pre-2004 trends in employment status in any of our specifications (Table 6), which was the only employment outcome collected in 2001.

Our results are fairly robust to the choice of analysis method. The standard controls and lasso method produced similar coefficients. Our main regression results are robust to different specifications of the distance variable: distance cutoffs at 1 km and 4 km; cutoffs at 3 km and 6 km; dropping households less than 0.5 km, less than 1 km, and less than 9 km (results not shown).

Results are broadly similar when we split the sample by gender (Table 7). Our preferred specification shows that men closest to ART facilities are 3.7 percentage points more likely to be employed compared to those living furthest away, rising to 5.8 percentage points by 2010/11 (column 4). Men 2–5 km away are only about 4.9 percentage points more likely to be employed by 2010/11. Again, we see a larger impact on employment for respondents who live closer to ART facilities. We see larger impacts for women from 2005 onward, rising to 9.5 percentage points by 2010/11 for those closest to ART facilities and 5.2 for those 2–5 km away (column 6).

The results for labor force participation rates (including searching unemployed) are mixed (Table 8). Disaggregating by gender shows that rates decline for men in 2005/7 but subsequently rises to baseline levels (column 4); however, the likelihood of labor force participation for women rises approximately 4 percentage points relative to baseline levels for those 2–5 km from to ART facilities, with no changes for women living closest to facilities. We cannot evaluate pre-trends in this outcome because participation data were not collected in the 2001 pilot survey.

Table 9 presents results using an unconventionally broad definition of participation that includes schooling, care-taking of household members, and other productive activities. We find evidence that although the likelihood of engaging in these productive activities falls by a statistically significant 3.9 percentage points in 2005/7 (column 2), it rises to baseline levels for those 0–2 km from the nearest ART facility, and to 3–4 percentage points above baseline levels for those 2–5 km away. Results disaggregated by sex follow similar patterns. Again, we cannot evaluate pre-trends in this outcome.

We found some evidence of increases of 2–3 percentage points in school attendance between 2005-2009 for men living closest to ART facilities (Table 10, column 4), although these were most only marginally statistically significant. Women demonstrated a larger effect with increases of 3–3.5 percentage points for those living closest to ART facilities, and approximately 1.7 percentage points for those 2–5 km away (column 6).

One hypothesized link between ART access and changes in employment status is that patients who initiate ART when they are too ill to work will be able to regain employment. Table 11 shows some evidence of reductions in reported nonemployment due to illness of about 1–1.5 percentage points for those closest to facilities as ART was scaled up (column 2), but these changes only account for a small fraction of the observed increase in employment (see Table 7).

Because only a small fraction of the observed increase in employment is driven by workers who regain their health enough to return to work, Table 12 provides further insight into the distribution of economic impacts of ART scale-up by HIV status and ART initiation status of the respondents and their households. Columns 1, 3 and 5 present lasso results using the same methodology as previous tables. Columns 2, 4, and 6 present results with inverse probability weighting to adjust for biomarker nonresponse as described in the Methods section. We found large increases in employment among HIV-infected individuals with ART scale-up (Table 12). By 2011, employment had risen by a statistically significant 12 percentage points relative to baseline levels for respondents within 2 km of the nearest ART clinic (column 1). This amounts to a 50% increase off a base of 23% employment for HIV-infected respondents. The use of inverse probability weighting to adjust for differences in HIV biomarker response rate by distance gradient approximately quadruples the estimated impact for HIV-infected respondents closest to ART clinics to 48.7 percentage points (column 2). Note that these weighted estimates rely on the assumption that those who were tested are similar to those who were untested on unobservables once we condition on observed characteristics. Again, the lasso methodology makes this assumption more plausible.

In Table 12, columns 3–6 show the estimated impact of the ART rollout on HIV-uninfected community members. Columns 5 and 6 focus specifically on HIV-uninfected individuals in households that receive little to none of the direct impact of ART access and whose impact can therefore be limited to indirect effects exclusively. Access to ART led to large, statistically significant increases in employment among *HIV-uninfected* individuals with limited direct impact of ART. In 2010/11, employment rates were 8.9 percentage points higher for HIV-uninfected respondents less than 2 km from the nearest ART compared to those 5–12 km away, and 5.9 percentage points higher for respondents 2–5 km away (column 5). Inverse probability weighting to address differential HIV prevalence by distance gradient reduces the size of the coefficients somewhat to 6.3 percentage points and 4.1 percentage points for the closest and middle distance, respectively (column 6).

Table 13 shows mixed results for labor force participation rates (i.e. if respondents report being either employed or "looking for work") for both HIV-infected and HIV-uninfected respondents. Though the unweighted results for HIV-infected respondents show insignificant increases in labor force participation (column 1), the inverse-probability weighted results include some negative coefficients for those living closest to ART facilities (column 2). The results are also mixed for HIV-uninfected individuals, with no clear patterns emerging (columns 3–6). The results suggest we can rule out increases in labor force participation for HIV-uninfected respondents living within 0–2 kms from the nearest ART facility.

Although Table 13 showed no impact of ART access on labor force participation by the standard definition for HIV-infected respondents, Table 14 shows that HIV-infected respondents appear to be shifting from searching for work to other productive activities: point estimates are large (up to 13 percentage points) and some are statistically significant (columns 1 and 2). We see different patterns for HIV-uninfected respondents whose productive participation activities fall substantially in 2005/7 (columns 3–6), and subsequently return to approximately baseline levels.

For HIV-infected respondents, there are larger increases in the likelihood of attending school or training relative to baseline levels, with the likelihood rising over time to reach a statistically significant 5 percentage points in 2010/11 for respondents living closest to ART facilities (Table 15, column 1). Though post-period coefficients are generally positive for HIV-uninfected respondents, few are significant. There is some statistically significant evidence that school attendance rises above baseline levels for those nearest to ART facilities.

For HIV-infected respondents, Table 16 shows only small decreases in being too sick to work, and only coefficients for 2005/7 are statistically significant (column 2). For HIV-uninfected respondents, as expected, all coefficients are small and have fairly large, multiply-overlapping confidence intervals (columns 3–6).

6 Discussion

This study evaluates the direct and indirect impact of the provision of mass AIDS treatment on labor market outcomes in South Africa, using rich demographic surveillance site data. We leveraged differences in access to ART facilities that are uncorrelated with unobservables in order to estimate a plausibly causal impact. We also used a set of rigorous machine learning methods to control for a robust set of potential confounders. We used biomarker data to disentangle the impact of ART by HIV status.

We found that employment increased by 8.5 percentage points for those living less than 2 km from the nearest ART facility as ART scaled up between

2004 and 2011 compared to those 5–12 km away. We found sizable increases in employment on the order of 6.3 percentage points for HIV-uninfected individuals who did not have HIV-infected or ART-initiating household members, which represents a 22% gain in employment off baseline employment rates of 38%. Despite these marked increases in employment, there was no increase in labor force participation above baseline levels during this period, however, this is likely due to our inability to distinguish between active job searching and discouragement in the data. Increases in schooling enrollment suggest that a shift from seeking work into engaging in productive activities played a role in driving the observed results. Small decreases in the likelihood of reporting being too ill or injured to work on the order of 1–1.5 percentage points cannot explain the observed 8 percentage point increase in employment.

Our results demonstrate that mass AIDS treatment produces positive externalities in the form of an economic stimulus that benefits all community members, including those residing in households that do not receive direct benefits from AIDS treatment. The aggregate employment gains are explained primarily by gains among the HIV-uninfected population and the non-ART-initiating, HIV-infected population rather than via the improved health of the HIV-infected population. The overall impact is too large to be attributed completely to the less than 10% of all respondents who were enrolled in ART during the study. It is also unlikely that ART patients would recover their health and return to employment in such a short time frame: Rosen et al. (2010) find employment of ART patients began to increase around 18 months after initiation. The lack of significant reductions in the likelihood of reporting being too sick to work demonstrates that this is not the main channel driving the effect. Our results therefore present new evidence of positive spillover effects of ART scale-up on employment of HIV-uninfected community members through channels that operate outside the household.

In equilibrium, an increase in labor supply among HIV-infected individuals as ART scales up implies fewer employment opportunities for HIV-uninfected individuals as new HIV-infected entrants drive wages downwards and displace HIV-uninfected individuals from jobs and job queues. However, the employment increases among HIV-uninfected community members suggest that ART scale-up increased labor supply of HIV-uninfected individuals and/or increased labor demand. Although we do not observe increases in labor force participation, our results on educational enrollment suggest that investment in human capital accumulation increases. Labor supply shifts of HIV-uninfected individuals may also be in the form of increased intensity of search effort which, unfortunately, is poorly captured in the survey data. Increases in labor demand in response to ART scale-up may be driving our estimates, or at least mitigating the downward pressure on wages. Our results are consistent with increased labor demand as public ART provision raises the productivity of the average worker and partially insures firms against the low productivity of HIV-infected workers. The primary limitation of our analysis is that we are unable to rule out the direct employment effect of ART clinics hiring low-skill auxiliary workers or the stimulation of market activity near ART clinics.

Treatment-as-prevention has emerged as the leading strategy to control the HIV and TB epidemics. Chronic disease management requires continuous investment and is therefore often more expensive than traditional one-off public health approaches such as vaccinations or upstream approaches such as food fortification. However, the costs of a treatment-based approach and the critique that the benefits are highly concentrated may be mitigated by the economic spillover effects we show here. Considering these spillover economic benefits, more countries may find it cost-effective and equitable to invest in therapeutic interventions in addition to more traditional public health approaches. An emphasis on the community-wide spillover benefits will engender greater public support for these policies.

The previously ignored spillover benefits of ART on HIV-uninfected community members outweigh the direct economic effect of ART that has been the focus of most of the literature on ART provision in sub-Saharan Africa. The larger implication of our results is that the literature has underestimated the drain on the total economy caused by the HIV epidemic by failing to adequately measure the sizable negative economic spillovers on HIV-*un*infected individuals. Our results demonstrate that due to large spillovers to these individuals, the return on investment in AIDS treatment is many fold higher than has been widely acknowledged. Consequently, current levels of public provision of AIDS treatment in countries with a generalized AIDS epidemic are likely to be too low.

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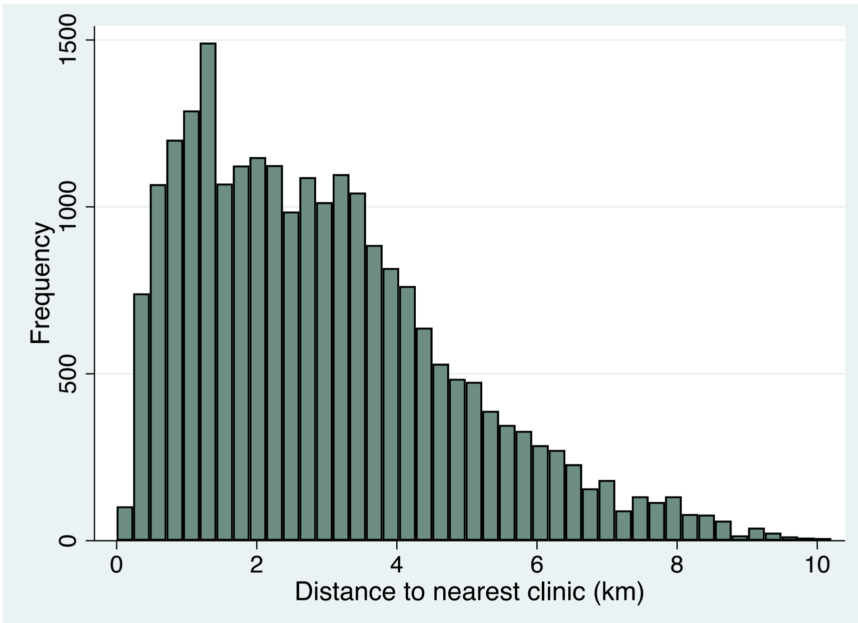
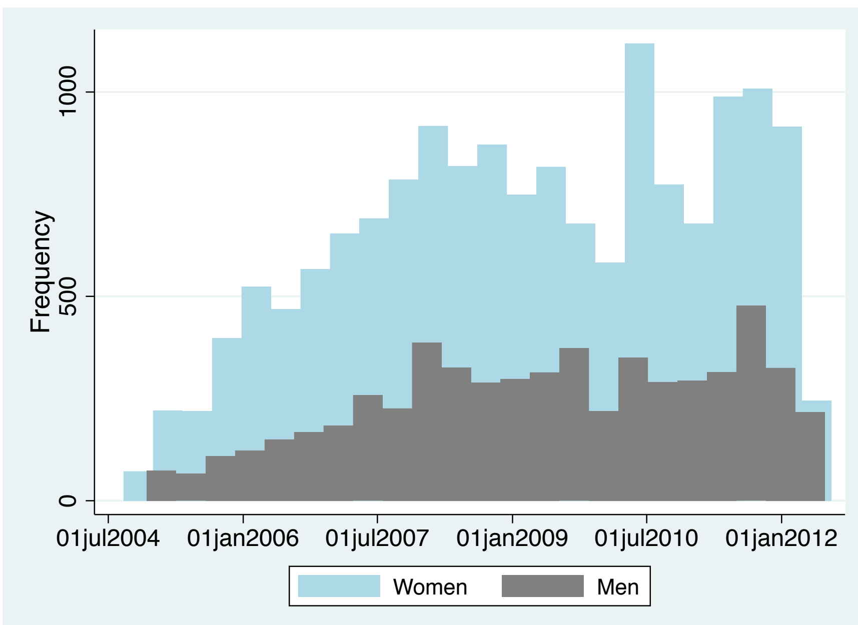
8 Figures and Tables

Figure 1: Distance to the nearest AIDS treatment clinic for residents of the surveillance area.



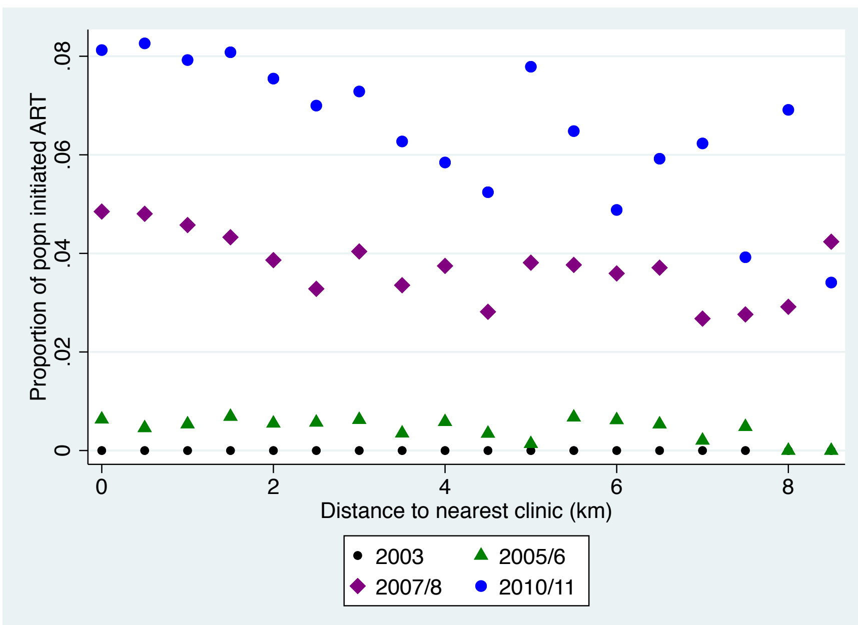
Notes: Figure shows number of survey respondents by distance.

Figure 2: New ART initiators per month during scale-up of AIDS treatment in the surveillance area



Notes: Figure shows number of patients initiated on AIDS treatment each month over the study period in the surveillance area.

Figure 3: ART coverage over time by distance to nearest AIDS treatment clinic



Notes: Figure shows proportion of population that has initiated on AIDS treatment by distance and time.

Table 1: Sample descriptive statistics

	Analysis population		Full population	
Variable	Mean	Std. Dev.	Mean	Std. Dev.
Female	0.61	0.49	0.49	0.5
Age	33.74	12.24	28.14	8.64
H.S. complete	0.27	0.44	0.45	0.5
Labor force participant	0.45	0.5	0.62	0.49
Employed	0.31	0.46	0.44	0.5
Urban/Periurban	0.38	0.49	0.41	0.49
Artisan	0.35	0.48	0.36	0.48
Clerical worker	0.22	0.41	0.27	0.44
Farm worker	0.09	0.29	0.07	0.25
Owns car	0.17	0.38	0.18	0.38
Owns TV	0.06	0.24	0.05	0.22
Owns cell phone	0.79	0.41	0.83	0.37
"Poor"	0.31	0.46	0.28	0.45
"Getting by"	0.49	0.5	0.52	0.5
HIV positive	0.22	0.41	0.18	0.38
Unemployed due to illness	0.03	0.18	0.01	0.11
Resides in area	1	0	0.28	0.45

Notes: Table shows sample descriptives for analysis sample of respondents 18-59 (excluding migrants) and full sample (including migrants).

Table 2: ART program take-up and HIV care seeking over time by distance to clinic.

Panel A: Has Initiated ART

Year	Proportion in ref group	Diff. between 0-2km and ref group	Diff. between 2-5km and ref group
2005	0.003	-0.001	-0.000
	(0.003)	(0.003)	(0.003)
2007	0.008***	0.002	0.002
	(0.003)	(0.003)	(0.003)
2008	0.027***	0.001	0.001
	(0.003)	(0.003)	(0.003)
2009	0.044***	0.011***	0.002
	(0.003)	(0.004)	(0.003)
2010	0.052***	0.014***	0.008**
	(0.003)	(0.004)	(0.004)
2011	0.065***	0.014***	0.006*
	(0.003)	(0.004)	(0.004)

Panel B: Has Sought HIV Care

Year	Proportion in ref group	Diff. between 0-2km and ref group	Diff. between 2-5km and ref group
2005	0.005	-0.002	-0.000
	(0.004)	(0.005)	(0.004)
2007	0.012***	0.001	0.002
	(0.004)	(0.005)	(0.005)
2008	0.045***	0.008*	0.003
	(0.004)	(0.005)	(0.005)
2009	0.088***	0.023***	0.011**
	(0.004)	(0.005)	(0.005)
2010	0.107***	0.025***	0.013***
	(0.004)	(0.005)	(0.005)
2011	0.127***	0.025***	0.007
	(0.004)	(0.005)	(0.005)

Notes: N=200,321. Column 1 shows predicted probabilities of ART take-up in the reference group, i.e. among persons residing 5-12km from a clinic. Columns 2 and 3 show the difference-in-difference coefficients describing the difference in ART coverage for people living 0-2km and 2-5km relative to the reference group (Column 1). Standard errors clustered by household are in parentheses. *** - Significant at the 1% level, ** - 5% level, * - 10% level.

Table 3: Balancing tests for outcomes (pre-trends between 2001-2004)

	No controls		Std. controls	
	(1)	(2)	(3)	(4)
Variable	0-2km	2-5km	0-2km	2-5km
Employed	0.006	0.004	-0.030	-0.015
	(0.014)	(0.013)	(0.023)	(0.018)
Attending School	0.015	-0.009	0.007	-0.014
	(0.027)	(0.025)	(0.046)	(0.037)
Respondent died	0.006	0.005	0.003	0.002
	(0.004)	(0.004)	(0.007)	(0.005)
Respondent migrated	0.004	-0.000	-0.002	-0.003
	(0.002)*	(0.002)	(0.003)	(0.003)
Household dissolution	0.002	0.001	0.001	0.001
	(0.001)	(0.001)	(0.003)	(0.002)

Notes: Table shows γ coefficients from Equation 6. Standard errors clustered by household are in parentheses. Sample includes surveillance area residents aged 18-59. *** - Significant at the 1% level, ** - 5% level, * - 10% level.

Table 4: Balancing tests for household assets (pre-trends between 2001-2004)

	No controls		Std. controls	
Household asset	0-2km	2-5km	0-2km	2-5km
Bicycle	-0.002	0.001	-0.019	-0.011
	(0.006)	(0.006)	(0.013)	(0.010)
Car	0.010	0.000	0.001	0.001
	(0.005)**	(0.004)	(0.008)	(0.006)
Hoe	0.002	-0.017	0.009	-0.007
	(0.008)	(0.007)**	(0.015)	(0.012)
Electric Hotplate	-0.007	0.002	-0.019	0.004
	(0.006)	(0.004)	(0.011)*	(0.006)
Fridge	0.004	0.008	0.017	0.027
	(0.007)	(0.007)	(0.013)	(0.010)**
Radio	0.070	0.021	0.018	0.010
	(0.011)***	(0.010)**	(0.020)	(0.016)
Sewing machine	0.001	-0.002	0.012	0.006
	(0.006)	(0.006)	(0.012)	(0.009)
Telephone	-0.015	-0.002	0.003	0.009
	(0.005)***	(0.004)	(0.008)	(0.006)
Television	0.006	-0.002	-0.032	-0.016
	(0.007)	(0.006)	(0.014)**	(0.010)
Wheelbarrow	-0.003	-0.003	0.002	-0.003
	(0.009)	(0.009)	(0.019)	(0.015)
Block maker	0.002	-0.005	0.017	0.005
	(0.007)	(0.007)	(0.013)	(0.011)
Electric cooker	0.015	0.004	0.016	0.007
	(0.005)***	(0.003)	(0.009)*	(0.005)
Electric kettle	0.007	-0.002	0.013	0.002
	(0.005)	(0.004)	(0.009)	(0.006)
Gas cooker	-0.032	-0.015	0.002	-0.001
	(0.010)***	(0.009)	(0.017)	(0.014)
Primus cooker	0.004	0.012	0.016	0.024
	(0.009)	(0.008)	(0.016)	(0.013)*
Cell phone	0.019	0.007	0.005	-0.000
	(0.009)**	(0.009)	(0.018)	(0.014)
VCR	-0.001	-0.000	0.006	-0.001
	(0.004)	(0.003)	(0.006)	(0.004)
Electricity	-0.011	-0.013	-0.029	-0.029
	(0.004)***	(0.003)***	(0.009)***	(0.007)***

Notes: Table shows γ coefficients from Equation 6 with household asset holding as the outcome variable (y). Standard errors clustered by household are in parentheses. Sample includes surveillance area residents aged 18-59. *** - Significant at the 1% level, ** - 5% level, * - 10% level.

Table 5: Balancing tests: Outcome levels in pre-period (2001) and baseline reference period (2003/4)

2001	No controls		Std. controls	
Variable	0-2km	2-5km	0-2km	2-5km
Employed	0.183	0.057	0.038	0.027
	(0.013)***	(0.012)***	(0.021)*	(0.017)
Attending School	-0.063	-0.020	-0.000	0.013
	(0.011)***	(0.010)*	(0.014)	(0.011)
2003/4	**No controls**		**With controls**	
Variable	0-2km	2-5km	0-2km	2-5km
Employed	0.169	0.053	0.000	0.009
	(0.010)***	(0.010)***	(0.016)	(0.012)
Attending School	-0.093	-0.048	0.021	0.016
	(0.020)***	(0.019)**	(0.026)	(0.021)
Unemployed due to illness	0.008	0.003	0.008	0.002
	(0.004)*	(0.004)	(0.007)	(0.005)
Labor force participant	0.229	0.077	0.007	-0.010
	(0.012)***	(0.011)***	(0.018)	(0.014)
Caring for sick	-0.001	-0.000	-0.001	-0.001
	(0.001)	(0.001)	(0.002)	(0.001)
HIV-infected (of all HIV tested)	0.092	0.043	-0.000	-0.001
	(0.015)***	(0.014)***	(0.025)	(0.019)

Notes: Table shows γ coefficients from Equation 7 with household asset holding as the outcome variable (y). Standard errors clustered by household are in parentheses. Sample includes surveillance area residents aged 18-59. *** - Significant at the 1% level, ** - 5% level, * - 10% level.

Table 6: Likelihood of employment by distance to nearest ART facility over time.

	Main sample		
	Min. controls	Std. controls	Lasso
Variable	(1)	(2)	(3)
2001*0-2km	0.007	0.003	0.013
	(0.016)	(0.016)	(0.013)
2001*2-5km	-0.001	-0.005	0.003
	(0.014)	(0.014)	(0.013)
2003/4			
2005/7*0-2km	0.035***	0.032**	0.056***
	(0.012)	(0.012)	(0.010)
2005/7*2-5km	0.024**	0.022**	0.031***
	(0.010)	(0.011)	(0.010)
2008/9*0-2km	0.064***	0.061***	0.072***
	(0.015)	(0.015)	(0.012)
2008/9*2-5km	0.049***	0.046***	0.059***
	(0.013)	(0.013)	(0.012)
2010/11*0-2km	0.082***	0.077***	0.085***
	(0.016)	(0.017)	(0.014)
2010/11*2-5km	0.049***	0.044***	0.051***
	(0.014)	(0.014)	(0.013)
Constant	0.183**	0.194	0.380***
	(0.078)	(0.186)	(0.030)
N	102,439	102,432	103,741
R^2	0.04	0.04	0.04
Num. hholds	9,218	9,218	9,250
Num. indivs	20,691	20,691	20,728

Notes: Table shows event study point estimates (γ) from Equation 1. Standard errors clustered by household are in parentheses. Each coefficient shows the differential change in outcomes over time for people living close to clinics (0-2, 2-5 km), relative to changes observed for people living far from clinics (5-12km). All changes over time were assessed relative to a 2003/2004 reference period. All specifications include individual fixed effects. Standard controls include set of demographic and geographic covariates as noted in the text. Lasso specifications include set of lasso-selected covariates as noted in the Appendix. Samples include respondents ages 18 to 59 who resided in surveillance area 6 months prior to rollout. *** - Significant at the 1% level, ** - 5% level, * - 10% level.

Table 7: Likelihood of employment for men and women by distance to nearest ART facility over time.

	All		Men		Women	
	Std. controls	Lasso	Std. controls	Lasso	Std. controls	Lasso
Variable	(1)	(2)	(3)	(4)	(5)	(6)
2001*0-2km	0.007	0.013	0.010	0.025	0.008	0.013
	(0.016)	(0.013)	(0.026)	(0.023)	(0.020)	(0.016)
2001*2-5km	-0.001	0.003	0.013	0.010	-0.008	0.001
	(0.014)	(0.013)	(0.022)	(0.021)	(0.017)	(0.016)
2003/4						
2005/7*0-2km	0.035***	0.056***	0.011	0.037**	0.049***	0.060***
	(0.012)	(0.010)	(0.020)	(0.017)	(0.015)	(0.013)
2005/7*2-5km	0.024**	0.030***	0.011	0.019	0.032**	0.034***
	(0.010)	(0.010)	(0.017)	(0.016)	(0.012)	(0.012)
2008/9*0-2km	0.064***	0.072***	0.063***	0.064***	0.065***	0.067***
	(0.015)	(0.012)	(0.024)	(0.021)	(0.018)	(0.015)
2008/9*2-5km	0.048***	0.059***	0.059***	0.066***	0.043***	0.053***
	(0.013)	(0.012)	(0.022)	(0.021)	(0.015)	(0.014)
2010/11*0-2km	0.082***	0.084***	0.057**	0.058**	0.096***	0.095***
	(0.016)	(0.014)	(0.028)	(0.025)	(0.020)	(0.017)
2010/11*2-5km	0.049***	0.051***	0.058**	0.049**	0.044***	0.052***
	(0.014)	(0.013)	(0.025)	(0.024)	(0.017)	(0.016)
Constant	0.239***	0.378***	0.339**	0.497***	0.173**	0.325***
	(0.067)	(0.030)	(0.133)	(0.057)	(0.078)	(0.029)
N	102,439	103,741	37,898	38,388	64,541	65,360
R^2	0.04	0.04	0.06	0.05	0.04	0.03
Num. hholds	9,218	9,250	5,805	5,822	7,910	7,929
Num. indivs	20,691	20,728	8,235	8,252	12,456	12,476

Notes: See notes for Table 6.

Table 8: Likelihood of labor force participation for men and women by distance to nearest ART facility over time.

	All		Men		Women	
	Std. controls	Lasso	Std. controls	Lasso	Std. controls	Lasso
Variable	(1)	(2)	(3)	(4)	(5)	(6)
2003/4						
2005/7*0-2km	-0.041***	-0.012	-0.076***	-0.058***	-0.022	-0.009
	(0.015)	(0.013)	(0.024)	(0.022)	(0.018)	(0.016)
2005/7*2-5km	0.001	0.006	-0.033	-0.030	0.019	0.016
	(0.013)	(0.013)	(0.021)	(0.021)	(0.016)	(0.015)
2008/9*0-2km	-0.002	-0.002	-0.000	0.010	-0.004	-0.015
	(0.017)	(0.015)	(0.027)	(0.024)	(0.021)	(0.018)
2008/9*2-5km	0.036**	0.033**	0.019	0.017	0.045**	0.041**
	(0.015)	(0.014)	(0.024)	(0.023)	(0.018)	(0.017)
2010/11*0-2km	-0.002	0.001	-0.033	-0.019	0.012	-0.005
	(0.019)	(0.017)	(0.032)	(0.028)	(0.023)	(0.020)
2010/11*2-5km	0.033*	0.031*	0.005	-0.005	0.047**	0.039**
	(0.017)	(0.016)	(0.029)	(0.028)	(0.020)	(0.019)
Constant	0.301***	0.516***	0.205	0.709***	0.311***	0.449***
	(0.086)	(0.031)	(0.140)	(0.066)	(0.106)	(0.045)
N	88,861	90,006	32,868	33,293	55,993	56,713
R^2	0.06	0.05	0.08	0.07	0.05	0.04
Num. hholds	9,207	9,248	5,799	5,819	7,900	7,926
Num. indivs	20,654	20,701	8,222	8,242	12,432	12,459

Notes: See notes for Table 6.

Table 9: Likelihood of productive activities for men and women by distance to nearest ART facility over time.

	All		Men		Women	
	Std. controls	Lasso	Std. controls	Lasso	Std. controls	Lasso
Variable	(1)	(2)	(3)	(4)	(5)	(6)
2003/4						
2005/7*0-2km	-0.079***	-0.039***	-0.067***	-0.027	-0.086***	-0.059***
	(0.017)	(0.014)	(0.024)	(0.022)	(0.021)	(0.018)
2005/7*2-5km	-0.024*	-0.018	-0.020	-0.021	-0.026	-0.018
	(0.015)	(0.014)	(0.022)	(0.021)	(0.018)	(0.018)
2008/9*0-2km	0.013	0.020	0.037	0.066***	-0.002	-0.001
	(0.018)	(0.015)	(0.027)	(0.023)	(0.022)	(0.019)
2008/9*2-5km	0.047***	0.043***	0.053**	0.058**	0.044**	0.042**
	(0.016)	(0.015)	(0.025)	(0.023)	(0.019)	(0.018)
2010/11*0-2km	0.005	0.020	-0.016	0.029	0.012	0.023
	(0.019)	(0.017)	(0.031)	(0.026)	(0.023)	(0.020)
2010/11*2-5km	0.037**	0.031*	0.019	0.017	0.043**	0.048**
	(0.017)	(0.017)	(0.028)	(0.027)	(0.021)	(0.020)
Constant	0.829***	0.724***	0.851***	0.862***	0.760***	0.658***
	(0.089)	(0.033)	(0.142)	(0.067)	(0.111)	(0.047)
N	88,861	90,006	32,868	33,293	55,993	56,713
R^2	0.05	0.04	0.04	0.04	0.05	0.05
Num. hholds	9,207	9,248	5,799	5,819	7,900	7,926
Num. indivs	20,654	20,701	8,222	8,242	12,432	12,459

Notes: See notes for Table 6.

Table 10: Likelihood of school attendance for men and women by distance to nearest ART facility over time.

	All		Men		Women	
	Std. controls	Lasso	Std. controls	Lasso	Std. controls	Lasso
Variable	(1)	(2)	(3)	(4)	(5)	(6)
2001*0-2km	0.002	0.003	0.015	0.013	-0.004	0.001
	(0.009)	(0.008)	(0.014)	(0.012)	(0.010)	(0.009)
2001*2-5km	0.008	0.009	0.018	0.017	0.003	0.008
	(0.007)	(0.007)	(0.013)	(0.012)	(0.009)	(0.009)
2003/4						
2005/7*0-2km	0.017**	0.017***	0.012	0.018*	0.020**	0.029***
	(0.007)	(0.006)	(0.012)	(0.010)	(0.009)	(0.008)
2005/7*2-5km	0.014**	0.014**	0.012	0.017*	0.015**	0.017**
	(0.006)	(0.006)	(0.011)	(0.010)	(0.007)	(0.007)
2008/9*0-2km	0.024***	0.027***	0.028**	0.021*	0.023**	0.034***
	(0.008)	(0.007)	(0.014)	(0.012)	(0.010)	(0.009)
2008/9*2-5km	0.018***	0.018**	0.028**	0.028**	0.014	0.018**
	(0.007)	(0.007)	(0.012)	(0.012)	(0.009)	(0.008)
2010/11*0-2km	0.013	0.018**	0.001	0.006	0.018*	0.029***
	(0.008)	(0.008)	(0.015)	(0.013)	(0.010)	(0.009)
2010/11*2-5km	0.009	0.010	-0.001	0.003	0.012	0.017**
	(0.007)	(0.007)	(0.013)	(0.013)	(0.008)	(0.008)
Constant	0.569***	0.214***	0.604***	0.293***	0.550***	0.227***
	(0.039)	(0.017)	(0.071)	(0.036)	(0.046)	(0.019)
N	102,439	103,741	37,898	38,388	64,541	65,360
R_2	0.25	0.20	0.32	0.31	0.19	0.17
Num. hholds	9,218	9,250	5,805	5,822	7,910	7,929
Num. indivs	20,691	20,728	8,235	8,252	12,456	12,476

Notes: See notes for Table 6.

Table 11: Likelihood of being too sick to work for men and women by distance to nearest ART facility over time.

	All		Men		Women	
	Std. controls	Lasso	Std. controls	Lasso	Std. controls	Lasso
Variable	(1)	(2)	(3)	(4)	(5)	(6)
2003/4						
2005/7*0-2km	-0.006	-0.008	-0.006	-0.009	-0.006	-0.009
	(0.006)	(0.005)	(0.012)	(0.010)	(0.007)	(0.006)
2005/7*2-5km	-0.004	-0.005	-0.010	-0.010	-0.000	-0.002
	(0.005)	(0.005)	(0.010)	(0.010)	(0.005)	(0.005)
2008/9*0-2km	-0.015**	-0.016***	-0.018	-0.012	-0.013*	-0.018***
	(0.007)	(0.006)	(0.014)	(0.012)	(0.008)	(0.007)
2008/9*2-5km	-0.005	-0.007	-0.009	-0.012	-0.002	-0.003
	(0.006)	(0.006)	(0.013)	(0.012)	(0.006)	(0.006)
2010/11*0-2km	-0.012	-0.011	-0.036**	-0.016	0.001	-0.008
	(0.008)	(0.007)	(0.016)	(0.013)	(0.009)	(0.008)
2010/11*2-5km	-0.003	-0.004	-0.022	-0.013	0.007	0.001
	(0.007)	(0.006)	(0.014)	(0.013)	(0.007)	(0.007)
Constant	0.043	0.030***	0.034	0.065**	0.016	0.022
	(0.033)	(0.011)	(0.072)	(0.027)	(0.036)	(0.015)
N	88,860	89,999	32,868	33,292	55,992	56,707
R^2	0.03	0.03	0.04	0.04	0.03	0.03
Num. hholds	9,207	9,248	5,799	5,819	7,900	7,926
Num. indivs	20,654	20,701	8,222	8,242	12,432	12,459

Notes: See notes for Table 6.

Table 12: Likelihood of employment for HIV-infected, HIV-uninfected and HIV-uninfected with no household exposure to HIV by distance to nearest ART facility over time.

	HIV-infected		HIV-		HIV- no hhold HIV	
	Lasso	IPW	Lasso	IPW	Lasso	IPW
Variable	(1)	(2)	(3)	(4)	(5)	(6)
2001*0-2km	0.064	0.235***	0.013	0.037	0.036	0.060*
	(0.044)	(0.056)	(0.023)	(0.028)	(0.027)	(0.034)
2001*2-5km	0.022	-0.035	0.011	0.000	0.005	-0.024
	(0.042)	(0.051)	(0.021)	(0.029)	(0.025)	(0.034)
2003/4						
2005/7*0-2km	0.108***	0.398***	0.050***	0.028	0.064***	0.044
	(0.035)	(0.059)	(0.018)	(0.024)	(0.021)	(0.027)
2005/7*2-5km	0.068**	0.053	0.022	0.058*	0.030	0.023
	(0.033)	(0.044)	(0.016)	(0.034)	(0.018)	(0.022)
2008/9*0-2km	0.105**	0.297***	0.092***	0.058**	0.115***	0.070**
	(0.043)	(0.052)	(0.021)	(0.026)	(0.024)	(0.030)
2008/9*2-5km	0.083**	0.097**	0.077***	0.088***	0.080***	0.065**
	(0.042)	(0.043)	(0.019)	(0.025)	(0.022)	(0.026)
2010/11*0-2km	0.120***	0.487***	0.093***	0.076***	0.089***	0.063**
	(0.046)	(0.078)	(0.024)	(0.028)	(0.028)	(0.030)
2010/11*2-5km	0.069	0.075	0.057***	0.073***	0.059**	0.041
	(0.045)	(0.053)	(0.021)	(0.028)	(0.024)	(0.027)
Constant	0.227***	0.372***	0.279***	0.320***	0.295**	0.281***
	(0.087)	(0.144)	(0.046)	(0.058)	(0.122)	(0.103)
N	9,968	9,837	30,354	30,136	22,367	22,224
R^2	0.03	0.60	0.04	0.06	0.04	0.05
Num. hholds	1,711	1,685	3,902	3,876	3,064	3,046
Num. indivs	1,978	1,945	5,564	5,509	4,335	4,297

Notes: Table shows event study point estimates (γ) from Equation 1. Columns 2, 4, and 6 present results with lasso-estimated inverse probability weighting to adjust for biomarker nonresponse. Standard errors clustered by household are in parentheses. Each coefficient shows the differential change in outcomes over time for people living close to clinics (0-2, 2-5 km), relative to changes observed for people living far from clinics (5-12km). All changes over time were assessed relative to a 2003/2004 reference period. All specifications include individual fixed effects. Standard controls include set of demographic and geographic covariates as noted in the text. Lasso specifications include set of lasso-selected covariates as noted in the Appendix. Samples include respondents ages 18 to 59 who resided in surveillance area 6 months prior to rollout. *** - Significant at the 1% level, ** - 5% level, * - 10% level..

Table 13: Likelihood of labor force participation for HIV-infected, HIV-uninfected and HIV-uninfected with no household exposure to HIV by distance to nearest ART facility over time.

	HIV+		HIV-		HIV- no hhold HIV	
	Lasso	IPW	Lasso	IPW	Lasso	IPW
Variable	(1)	(2)	(3)	(4)	(5)	(6)
2003/4						
2005/7*0-2km	0.013	0.037	-0.047**	-0.075	-0.035	-0.033
	(0.044)	(0.050)	(0.022)	(0.050)	(0.025)	(0.055)
2005/7*2-5km	0.031	0.085	-0.004	0.001	-0.007	0.005
	(0.042)	(0.052)	(0.020)	(0.044)	(0.023)	(0.040)
2008/9*0-2km	0.012	-0.047	-0.020	-0.105**	-0.006	-0.067
	(0.050)	(0.066)	(0.024)	(0.041)	(0.028)	(0.047)
2008/9*2-5km	0.075	0.071	0.039*	-0.001	0.031	0.019
	(0.048)	(0.057)	(0.022)	(0.046)	(0.025)	(0.052)
2010/11*0-2km	0.014	-0.071	-0.015	-0.123*	-0.018	-0.089
	(0.054)	(0.070)	(0.026)	(0.066)	(0.031)	(0.068)
2010/11*2-5km	0.066	0.032	0.043*	-0.010	0.038	-0.009
	(0.053)	(0.065)	(0.025)	(0.063)	(0.028)	(0.065)
Constant	0.618***	0.636***	0.395***	0.387**	0.169	0.734**
	(0.122)	(0.132)	(0.045)	(0.190)	(0.164)	(0.286)
N	8,585	7,149	26,758	23,006	19,680	16,912
R^2	0.05	0.11	0.07	0.11	0.06	0.11
Num. hholds	1,710	1,436	3,902	3,446	3,052	2,696
Num. indivs	1,977	1,631	5,563	4,724	4,319	3,664

Notes: See notes for Table 12.

Table 14: Likelihood of productive activities for HIV-infected, HIV-uninfected and HIV-uninfected with no household exposure to HIV by distance to nearest ART facility over time.

	HIV+		HIV-		HIV- no hhold HIV	
	Lasso	IPW	Lasso	IPW	Lasso	IPW
Variable	(1)	(2)	(3)	(4)	(5)	(6)
2003/4						
2005/7*0-2km	0.028	0.049	-0.077***	-0.113***	-0.079***	-0.076**
	(0.045)	(0.047)	(0.024)	(0.035)	(0.027)	(0.034)
2005/7*2-5km	0.050	0.074	-0.044**	-0.090**	-0.052**	-0.076**
	(0.044)	(0.047)	(0.022)	(0.036)	(0.024)	(0.035)
2008/9*0-2km	0.077	0.026	0.003	-0.061	0.010	-0.029
	(0.047)	(0.063)	(0.024)	(0.047)	(0.028)	(0.057)
2008/9*2-5km	0.129***	0.122**	0.038*	-0.022	0.025	-0.018
	(0.046)	(0.047)	(0.023)	(0.050)	(0.026)	(0.061)
2010/11*0-2km	0.081	0.050	-0.004	-0.055	-0.007	-0.022
	(0.050)	(0.055)	(0.027)	(0.044)	(0.032)	(0.047)
2010/11*2-5km	0.098**	0.079	0.025	-0.036	0.015	-0.029
	(0.050)	(0.053)	(0.025)	(0.044)	(0.029)	(0.047)
Constant	0.769***	0.760***	0.662***	0.410**	0.391**	0.346**
	(0.113)	(0.112)	(0.051)	(0.196)	(0.156)	(0.160)
N	8,585	8,472	26,758	26,572	19,680	19,558
R^2	0.04	0.10	0.05	0.07	0.05	0.07
Num. hholds	1,710	1,685	3,902	3,876	3,052	3,035
Num. indivs	1,977	1,945	5,563	5,509	4,319	4,283

Notes: See notes for Table 12.

Table 15: Likelihood of school attendance for HIV-infected, HIV-uninfected and HIV-uninfected with no household exposure to HIV by distance to nearest ART facility over time.

	HIV+		HIV-		HIV- no hhold HIV	
	Lasso	IPW	Lasso	IPW	Lasso	IPW
Variable	(1)	(2)	(3)	(4)	(5)	(6)
2001*0-2km	-0.002	0.052	0.023*	-0.102*	0.044***	-0.017
	(0.024)	(0.062)	(0.014)	(0.055)	(0.015)	(0.025)
2001*2-5km	0.016	0.056	0.017	-0.029	0.035***	-0.002
	(0.024)	(0.059)	(0.012)	(0.023)	(0.013)	(0.025)
2003/4						
2005/7*0-2km	0.011	0.072	0.037***	0.019	0.038***	0.049**
	(0.018)	(0.048)	(0.012)	(0.025)	(0.013)	(0.024)
2005/7*2-5km	0.010	0.070	0.017*	0.016	0.018	0.035
	(0.018)	(0.046)	(0.011)	(0.022)	(0.012)	(0.024)
2008/9*0-2km	0.052**	0.165***	0.029**	-0.015	0.029*	0.013
	(0.021)	(0.063)	(0.013)	(0.027)	(0.015)	(0.026)
2008/9*2-5km	0.051**	0.128**	0.023*	-0.006	0.021	0.019
	(0.021)	(0.062)	(0.012)	(0.024)	(0.014)	(0.027)
2010/11*0-2km	0.049**	0.007	0.020	0.022	0.015	0.036
	(0.021)	(0.070)	(0.013)	(0.026)	(0.016)	(0.025)
2010/11*2-5km	0.030	-0.002	0.008	0.018	-0.003	0.016
	(0.020)	(0.069)	(0.012)	(0.024)	(0.014)	(0.026)
Constant	0.208***	-0.053	0.274***	0.176***	0.222***	0.692***
	(0.038)	(0.106)	(0.029)	(0.057)	(0.077)	(0.069)
N	9,968	1,773	30,354	6,530	22,367	4,997
R_2	0.14	0.18	0.26	0.29	0.26	0.29
Num. hholds	1,711	320	3,902	919	3,064	744
Num. indivs	1,978	362	5,564	1,203	4,335	967

Notes: See notes for Table 12.

Table 16: Likelihood of being too sick to work for HIV-infected, HIV-uninfected and HIV-uninfected with no household exposure to HIV by distance to nearest ART facility over time.

	HIV+		HIV-		HIV- no hhold HIV	
	Lasso	IPW	Lasso	IPW	Lasso	IPW
Variable	(1)	(2)	(3)	(4)	(5)	(6)
2003/4						
2005/7*0-2km	-0.025	-0.032**	-0.014	-0.008	-0.010	-0.003
	(0.017)	(0.015)	(0.009)	(0.008)	(0.010)	(0.009)
2005/7*2-5km	-0.022	-0.031**	-0.004	-0.003	0.002	0.002
	(0.015)	(0.013)	(0.008)	(0.007)	(0.009)	(0.008)
2008/9*0-2km	-0.023	-0.022	-0.009	-0.008	-0.007	-0.005
	(0.020)	(0.020)	(0.010)	(0.009)	(0.012)	(0.011)
2008/9*2-5km	-0.020	-0.013	0.008	0.002	0.006	0.003
	(0.019)	(0.019)	(0.009)	(0.008)	(0.010)	(0.009)
2010/11*0-2km	-0.007	-0.009	-0.010	-0.013	-0.006	-0.005
	(0.020)	(0.018)	(0.012)	(0.011)	(0.014)	(0.013)
2010/11*2-5km	-0.013	-0.014	0.008	0.002	0.012	0.009
	(0.018)	(0.016)	(0.010)	(0.010)	(0.012)	(0.012)
Constant	0.024	0.039	0.029	0.021	-0.034	-0.039
	(0.041)	(0.028)	(0.019)	(0.018)	(0.037)	(0.036)
N	8,584	8,157	26,754	25,745	19,678	18,882
R^2	0.03	0.02	0.04	0.04	0.05	0.04
Num. hholds	1,710	1,626	3,902	3,796	3,052	2,962
Num. indivs	1,977	1,874	5,563	5,352	4,319	4,149

Notes: See notes for Table 12.

Appendix

List of Selected Lasso Control Variables for Each Outcome

Employed

1.SurveyYear 55.agecat Miss.educ12 50.agecat*1.female 55.agecat*1.female 4.SurveyYear*1.educ12 5.SurveyYear*1.educ12 3.SurveyYear*1.female disabilitygrant OldAgePension 0.DistToPrimaryRoad 2.DistToSecondaryRoad 2.nearestclinic 5.town 6.town 12.town 17.town 19.town 20.town 21.town 23.town 2.Urban 3.Urban 1.disabilitygrant 1.Blockmaker 1.Car 5.AssetIndexQuintile 12.educyrs*1.Fridge 12.educyrs*1.Cellphone 12.educyrs*1.Television 12.educyrs*5.AssetIndexQuint 1.educ12*1.Cellphone 1.educ12*1.Television 1.educ12*5.AssetIndexQuintile 1.ChildGrant*1.Telephone 1.disabilitygrant*1.VCR 8.educyrs*1.hhavgeducyrs 9.educyrs*1.hhavgeducyrs 11.educyrs*1.hhavgeducyrs 12.educyrs*1.hhavgeducyrs 1.educ12*1.hhavgeducyrs 1.ChildGrant*1.hhavgeducyrs 1.disabilitygrant*50.agecat Miss.educyrs*0.DistToPrimaryRoad Miss.educyrs*0.DistToSecondarySchool Miss.educ12*0.DistToPrimaryRoad 1.ChildGrant*9.MonthOfVisit 1.disabilitygrant*0.DistToPrimaryRoad KmToNearestSecondarySchool 1.Car*30.agecat 1.ElectricKettle*30.agecat 1.ElectricKettle*35.agecat 1.Fridge*30.agecat 1.Cellphone*25.agecat 1.Cellphone*30.agecat 1.Cellphone*50.agecat 1.Cellphone*55.agecat 1.VCR*25.agecat 1.VCR*30.agecat 5.AssetIndexQuintile*25.agecat 1.VCR*Miss.everHIVtested 4.AssetIndexQuintile*Miss.everHIVtested 4.AssetIndexQuintile*Miss.win1yrtested 1.Radio*2.DistToSecondaryRoad 1.Radio*2.DistToSecondarySchool 1.Wheelbarrow*0.DistToSecondarySchool 1.Hoe*c.KmToNearestSecondarySchool 1.Primus*c.KmToNearestLevel2R 1.Radio*c.KmToNearestSecondarySchool 2.electrified*c.KmToNearestLevel1Road 1.female*1.everHIVtested 50.agecat*1.everHIVtested 1.everHIVtested*2.DistToSecondaryRoad 1.everHIVtested*c.KmToNearestLevel2Road

Labor Force Participation

3.SurveyYear 25.agecat 55.agecat 1.educ12 21.agecat*1.educ12 25.agecat*1.educ12 21.agecat*1.educ12*0.female 25.agecat*1.educ12*0.female 4.SurveyYear*1.educ12 5.SurveyYear*1.educ12 4.SurveyYear*1.educ12*0.female 5.SurveyYear*1.educ12*0.female disabilitygrant OldAgePension 0.DistToPrimaryRoad 3.SurveyYear*2.DistToPrimaryRoad 3.SurveyYear*2.DistToSecondarySchool 5.town 7.town 2.Urban 12.educyrs 1.disabilitygrant 11.educyrs*1.VCR 1.ChildGrant*1.Car 1.ChildGrant*4.AssetIndexQuintile 1.OldAgePension*1.Hoe 1.OldAgePension*Miss.electrified 12.educyrs*0.female 12.educyrs*21.agecat 12.educyrs*25.agecat 4.educyrs*1.hhavgeducyrs 4.educyrs*12.hhavgeducyrs 5.educyrs*1.hhavgeducyrs 5.educyrs*11.hhavgeducyrs 5.educyrs*Miss.hhavgeducyrs 6.educyrs*1.hhavgeducyrs 7.educyrs*1.hhavgeducyrs 7.educyrs*12.hhavgeducyrs 8.educyrs*Miss.hhavgeducyrs 10.educyrs*2.hhavgeducyrs 12.educyrs*2.hhavgeducyrs 12.educyrs*Miss.hhavgeducyrs 1.ChildGrant*50.agecat 1.ChildGrant*55.agecat 1.ChildGrant*1.hhavgeducyrs 1.ChildGrant*2.hhavgeducyrs 1.ChildGrant*4.hhavgeducyrs 1.ChildGrant*6.hhavgeducyrs 1.ChildGrant*9.hhavgeducyrs 1.ChildGrant*10.hhavgeducyrs 1.disabilitygrant*0.female 1.OldAgePension*21.agecat 1.OldAgePension*11.hhavgeducyrs 2.educyrs*1.everHIVtested 2.educyrs*1.win1yrtested 12.educyrs*1.tested 1.ChildGrant*1.HIVpositive 1.ChildGrant*1.anyHIVinHH 1.educyrs*8.MonthOfVisit 1.educyrs*12.MonthOfVisit 6.educyrs*12.MonthOfVisit 1.ChildGrant*3.MonthOfVisit 1.ChildGrant*4.MonthOfVisit 1.ChildGrant*8.MonthOfVisit 1.ChildGrant*11.MonthOfVisit 1.ChildGrant*2.DistToSecondaryRoad 1.OldAgePension*6.MonthOfVisit 1.OldAgePension*8.MonthOfVisit 1.OldAgePension*12.MonthOfVisit KmToNearestSecondarySchool 1.Car*1.hhavgeducyrs 1.ElectricCooker*1.hhavgeducyrs 1.ElectricHotplate*Miss.hhavgeducyrs 1.Hoe*25.agecat 1.SewingMachine*1.hhavgeducyrs 1.Television*25.agecat 1.VCR*25.agecat 5.AssetIndexQuintile*1.hhavgeducyrs Miss.electrified*3.hhavgeducyrs 1.Radio*2.DistToSecondaryRoad 1.Telephone*11.MonthOfVisit 1.Wheelbarrow*2.DistToSecondaryRoad Miss.electrified*8.MonthOfVisit Miss.electrified*9.MonthOfVisit 21.agecat*1.everHIVtested 21.agecat*Miss.everHIVtested 25.agecat*Miss.everHIVtested 21.agecat*1.win1yrtested 21.agecat*Miss.win1yrtested 1.hhavgeducyrs*1.ARTinHH Miss.hhavgeducyrs*1.tested 0.female*0.DistToPrimaryRoad 25.agecat*0.DistToSecondarySchool 1.hhavgeducyrs*6.MonthOfVisit 1.hhavgeducyrs*12.MonthOfVisit 3.hhavgeducyrs*12.MonthOfVisit 11.hhavgeducyrs*10.MonthOfVisit Miss.hhavgeducyrs*2.MonthOfVisit Miss.hhavgeducyrs*5.MonthOfVisit Miss.hhavgeducyrs*7.MonthOfVisit Miss.hhavgeducyrs*9.MonthOfVisit

Miss.hhavgeducyrs*2.DistToPrimaryRoad 0.female*c.KmToNearestSecondarySchool Miss.HIVpositive*2.DistToSeco

Productive Labor Force Participation

5.SurveyYear 55.agecat 55.agecat*0.female 3.SurveyYear*1.educ12 5.SurveyYear*0.female 3.SurveyYear*1.educ12*0.female disabilitygrant OldAgePension 0.DistToPrimaryRoad 3.SurveyYear*2.DistToSecondarySchool 5.town 14.town 2.Urban 1.disabilitygrant 1.OldAgePension 1.Primu 1.Cellphone 1.ChildGrant*1.Car 1.ChildGrant*4.AssetIndexQuintile 1.disabilitygrant*1.Hoe 1.OldAgePension*1.Hoe 1.OldAgePension*Miss.electrified 1.educyrs*11.hhavgeducyrs 4.educyrs*1.hhavgeducyrs 4.educyrs*12.hhavgeducyrs 5.educyrs*1.hhavgeducyrs 5.educyrs*11.hhavgeducyrs 5.educyrs*Miss.hhavgeducyrs 7.educyrs*1.hhavgeducyrs 8.educyrs*Miss.hhavgeducyrs 10.educyrs*2.hhavgeducyrs 12.educyrs*2.hhavgeducyrs 12.educyrs*Miss.hhavgeducyrs 1.ChildGrant*50.agecat 1.ChildGrant*55.agecat 1.ChildGrant*1.hhavgeducyrs 1.ChildGrant*2.hhavgeducyrs 1.ChildGrant*4.hhavgeducyrs 1.ChildGrant*6.hhavgeducyrs 1.ChildGrant*9.hhavgeducyrs 1.ChildGrant*10.hhavgeducyrs 1.disabilitygrant*0.female 1.OldAgePension*21.agecat 1.OldAgePension*11.hhavgeducyrs 2.educyrs*1.everHIVtested 2.educyrs*1.win1yrtested 1.ChildGrant*1.HIVpositive 1.ChildGrant*1.anyHIVinHH 1.educyrs*8.MonthOfVisit 1.educyrs*12.MonthOfVisit 6.educyrs*12.MonthOfVisit 1.ChildGrant*3.MonthOfVisit 1.ChildGrant*4.MonthOfVisit 1.ChildGrant*8.MonthOfVisit 1.ChildGrant*11.MonthOfVisit 1.ChildGrant*2.DistToSecondaryRoad 1.OldAgePension*6.MonthOfVisit 1.OldAgePension*8.MonthOfVisit 1.OldAgePension*12.MonthOfVisit KmToNearestSecondarySchool 1.Car*1.hhavgeducyrs 1.ElectricCooker*1.hhavgeducyrs 1.ElectricHotplate*Miss.hhavgeducyrs 1.SewingMachine*1.hhavgeducyrs 1.Cellphone*0.female 5.AssetIndexQuintile*1.hhavgeducyrs Miss.electrified*3.hhavgeducyrs 1.Primus*8.MonthOfVisit 1.Radio*2.DistToSecondaryRoad 1.Telephone*11.MonthOfVisit 1.Wheelbarrow*2.DistToSecondaryRoad Miss.electrified*8.MonthOfVisit Miss.electrified*9.MonthOfVisit 21.agecat*1.everHIVtested 21.agecat*1.win1yrtested 0.female*0.DistToPrimaryRoad 1.hhavgeducyrs*6.MonthOfVisit 1.hhavgeducyrs*12.MonthOfVisit 3.hhavgeducyrs*12.MonthOfVisit 11.hhavgeducyrs*10.MonthOfVisit Miss.hhavgeducyrs*2.MonthOfVisit Miss.hhavgeducyrs*7.MonthOfVisit Miss.hhavgeducyrs*9.MonthOfVisit 0.female*c.KmToNearestSecondarySchool

Miss.HIVpositive*2.DistToSecondaryRoad

School Enrollment

1.SurveyYear 4.SurveyYear 5.SurveyYear 21.agecat 25.agecat 30.agecat 40.agecat 1.educ12 Miss.educ12 21.agecat*1.educ12 35.agecat*1.educ12 40.agecat*1.educ12 21.agecat*0.female 25.agecat*0.female 30.agecat*0.female 40.agecat*0.female Miss.educ12*0.female 35.agecat*1.educ12*0.female 1.SurveyYear*Miss.educ12 3.SurveyYear*1.educ12 1.SurveyYear*0.female 3.SurveyYear*0.female 4.SurveyYear*0.female 5.SurveyYear*0.female 0.DistToPrimaryRoad 0.DistToSecondarySchool 5.town 6.town 2.Urban 9.educyrs Miss.educyrs 1.Cellphone 9.educyrs*1.Hoe 9.educyrs*1.Primu 10.educyrs*1.Primu 11.educyrs*1.VCR 1.educyrs*Miss.electrified 2.educyrs*Miss.electrified 9.educyrs*2.electrified 1.ChildGrant*1.Car 1.ChildGrant*2.AssetIndexQuintile 9.educyrs*0.female 12.educyrs*0.female Miss.educyrs*0.female 10.educyrs*25.agecat 10.educyrs*30.agecat 10.educyrs*35.agecat 11.educyrs*25.agecat 11.educyrs*30.agecat 12.educyrs*21.agecat 12.educyrs*35.agecat 1.educyrs*10.hhavgeducyrs 4.educyrs*1.hhavgeducyrs 4.educyrs*12.hhavgeducyrs 4.educyrs*Miss.hhavgeducyrs 5.educyrs*Miss.hhavgeducyrs 7.educyrs*1.hhavgeducyrs 8.educyrs*12.hhavgeducyrs 8.educyrs*Miss.hhavgeducyrs 9.educyrs*1.hhavgeducyrs 12.educyrs*2.hhavgeducyrs 12.educyrs*Miss.hhavgeducyrs 1.educ12*Miss.hhavgeducyrs 1.ChildGrant*9.hhavgeducyrs 1.ChildGrant*10.hhavgeducyrs 1.ChildGrant*11.hhavgeducyrs 1.ChildGrant*12.hhavgeducyrs 1.OldAgePension*1.hhavgeducyrs 1.OldAgePension*2.hhavgeducyrs 12.educyrs*1.tested 1.educ12*1.tested 12.educyrs*1.KmToNearestPrimarySchool 1.educ12*1.KmToNearestPrimaryS 1.ChildGrant*4.MonthOfVisit 1.ChildGrant*7.MonthOfVisit 1.OldAgePension*7.MonthOfVisit 1.OldAgePension*8.MonthOfVisit 1.OldAgePension*11.MonthOfVisit KmToNearestSecondarySchool 1.ElectricKettle*1.hhavgeducyrs 1.ElectricKettle*Miss.hhavgeducyrs 1.Fridge*25.agecat 1.Primus*30.agecat 1.Primus*35.agecat 1.SewingMachine*2.hhavgeducyrs 1.Cellphone*0.female 1.Cellphone*21.agecat 1.Cellphone*25.agecat 1.VCR*25.agecat 5.AssetIndexQuintile*1.hhavgeducyrs 5.AssetIndexQuintile*2.hhavgeducyrs Miss.electrified*1.hhavgeducyrs Miss.electrified*3.hhavgeducyrs 1.Primus*1.tested 1.Cellphone*Miss.everHIVtested 1.Radio*2.DistToSecondaryRoad 1.Cellphone*5.MonthOfVisit 1.Wheelbarrow*2.DistToSecondaryRoad Miss.electrified*7.MonthOfVisit

Miss.electrified*9.MonthOfVisit Miss.electrified*12.MonthOfVisit 1.Primus*c.KmToNearestPrimarySchool 21.agecat*Miss.everHIVtested 21.agecat*Miss.win1yrtested 25.agecat*1.tested 3.hhavgeducyrs*1.everHIVtested Miss.hhavgeducyrs*1.win1yrtested 1.hhavgeducyrs*1.tested Miss.hhavgeducyrs*1.tested 0.female*0.DistToPrimaryRoad 40.agecat*12.MonthOfVisit 21.agecat*0.DistToSecondaryRoad 25.agecat*0.DistToSecondarySchool 1.hhavgeducyrs*7.MonthOfVisit 3.hhavgeducyrs*12.MonthOfVisit Miss.hhavgeducyrs*2.MonthOfVisit Miss.hhavgeducyrs*3.MonthOfVisit Miss.hhavgeducyrs*6.MonthOfVisit Miss.hhavgeducyrs*7.MonthOfVisit Miss.hhavgeducyrs*9.MonthOfVisit 1.hhavgeducyrs*2.DistToPrimaryRoad Miss.hhavgeducyrs*2.DistToPrimaryRoad 1.hhavgeducyrs*1.DistToSecondaryRoad 1.hhavgeducyrs*2.DistToSecondaryRoad 1.hhavgeducyrs*0.DistToSecondarySchool 1.hhavgeducyrs*2.DistToSecondarySchoo 0.female*c.KmToNearestSecondarySchool 21.agecat*c.KmToNearestSecondarySchool 1.hhavgeducyrs*c.KmToNearestSecondarySchool Miss.everHIVtested*2.DistToSecondarySchool

Too Sick To Work

disabilitygrant 0.DistToPrimaryRoad 5.town 2.Urban 12.educyrs*Miss.electrified 1.educ12*Miss.electrified 1.ChildGrant*1.BIC 1.ChildGrant*1.Car 1.ChildGrant*1.ElectricCooker 1.ChildGrant*4.AssetIndexQuintile 1.ChildGrant*5.AssetIndexQuintile 1.OldAgePension*Miss.electrified Miss.hhavgeducyrs 4.educyrs*1.hhavgeducyrs 4.educyrs*12.hhavgeducyrs 5.educyrs*1.hhavgeducyrs 5.educyrs*11.hhavgeducyrs 5.educyrs*Miss.hhavgeducyrs 7.educyrs*1.hhavgeducyrs 8.educyrs*Miss.hhavgeducyrs 10.educyrs*2.hhavgeducyrs 12.educyrs*2.hhavgeducyrs 12.educyrs*Miss.hhavgeducyrs Miss.educyrs*Miss.hhavgeducyrs 1.ChildGrant*50.agecat 1.ChildGrant*55.agecat 1.ChildGrant*1.hhavgeducyrs 1.ChildGrant*2.hhavgeducyrs 1.ChildGrant*4.hhavgeducyrs 1.ChildGrant*6.hhavgeducyrs 1.ChildGrant*9.hhavgeducyrs 1.ChildGrant*10.hhavgeducyrs 1.disabilitygrant*0.female 1.OldAgePension*21.agecat 1.OldAgePension*11.hhavgeducyrs 2.educyrs*1.everHIVtested 2.educyrs*1.win1yrtested 1.ChildGrant*1.HIVpositive 1.ChildGrant*1.anyHIVinHH 1.disabilitygrant*1.tested 1.educyrs*8.MonthOfVisit 1.educyrs*12.MonthOfVisit 6.educyrs*12.MonthOfVisit 1.ChildGrant*3.MonthOfVisit 1.ChildGrant*4.MonthOfVisit 1.ChildGrant*7.MonthOfVisit 1.ChildGrant*8.MonthOfVisit 1.ChildGrant*11.MonthOfVisit 1.ChildGrant*2.DistToPrimaryRoad 1.ChildGrant*2.DistToSecondaryRoad 1.OldAgePen-

sion*6.MonthOfVisit 1.OldAgePension*8.MonthOfVisit 1.OldAgePension*12.MonthOfVisit KmToNearestSecondarySchool 1.Car*1.hhavgeducyrs 1.ElectricCooker*1.hhavgeducyrs 1.ElectricHotplate*Miss.hhavgeducyrs 1.ElectricKettle*Miss.hhavgeducyrs 1.Fridge*Miss.hhavgeducyrs 1.GCK*Miss.hhavgeducyrs 1.Hoe*Miss.hhavgeducyrs 1.Primus*Miss.hhavgeducyrs 1.Radio*Miss.hhavgeducyrs 1.SewingMachine*1.hhavgeducyrs 1.Cellphone*Miss.hhavgeducyrs 1.Television*Miss.hhavgeducyrs 1.VCR*Miss.hhavgeducyrs 1.Wheelbarrow*Miss.hhavgeducyrs 2.AssetIndexQuintile*Miss.hhavgeducyrs 3.AssetIndexQuintile*Miss.hhavgeducyrs 4.AssetIndexQuintile*Miss.hhavgeducyrs 5.AssetIndexQuintile*1.hhavgeducyrs 2.electrified*Miss.hhavgeducyrs Miss.electrified*3.hhavgeducyrs 1.Radio*2.DistToSecondaryRoad 1.Telephone*11.MonthOfVisit 1.Wheelbarrow*2.DistToSecondaryRoad Miss.electrified*8.MonthOfVisit Miss.electrified*9.MonthOfVisit 21.agecat*1.everHIVtested 21.agecat*1.win1yrtested Miss.hhavgeducyrs*1.HIVpositive Miss.hhavgeducyrs*Miss.HIV
Miss.hhavgeducyrs*Miss.anyHIVinHH Miss.hhavgeducyrs*1.ARTinHH Miss.hhavgeducyrs*1.everHIVtested Miss.hhavgeducyrs*Miss.everHIVtested Miss.hhavgeducyrs*1.win1yrtested Miss.hhavgeducyrs*Miss.win1yrtested Miss.hhavgeducyrs*1.tested 0.female*0.DistToPrimaryRoad 1.hhavgeducyrs*6.MonthOfVisit 1.hhavgeducyrs*12.MonthOfVisit 3.hhavgeducyrs*12.MonthOfVisit 11.hhavgeducyrs*10.MonthOfVisit Miss.hhavgeducyrs*2.MonthOfVisit Miss.hhavgeducyrs*3.MonthOfVisit Miss.hhavgeducyrs*5.MonthOfVisit Miss.hhavgeducyrs*7.MonthOfVisit Miss.hhavgeducyrs*8.MonthOfVisit Miss.hhavgeducyrs*9.MonthOfVisit Miss.hhavgeducyrs*0.DistToPrimaryRoad Miss.hhavgeducyrs*0.DistToSecondaryRoad Miss.hhavgeducyrs*1.DistTo
Miss.hhavgeducyrs*2.DistToSecondaryRoad Miss.hhavgeducyrs*0.DistToSecondarySchool Miss.hhavgeducyrs*2.DistToSecondarySchool Miss.hhavgeducyrs*1.KmToNearestPrimarySchool 0.female*c.KmToNearestSecondarySchool Miss.hhavgeducyrs*c.KmToNearestLevel1Road Miss.hhavgeducyrs*c.KmToNearestLevel2Road Miss.hhavgeducyrs*c.KmToNearestSecondarySchool Miss.hhavgeducyrs*c.KmToNearestPrimarySchool Miss.HIVpositive*2.DistToSecondaryRoad