Can Antiretroviral Therapy at Scale Improve the Health of the Targeted in Sub-Saharan Africa? *

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Abstract

The single largest item in the United States foreign aid health budget is antiretroviral therapy (ART) for the treatment of HIV/AIDS. Despite the central focus on ART in global health policy and a host of behavioral studies presuming ART expansion has directly improved the health of HIV positive individuals, there is little quasi-experimental evidence on the epidemiological effects of ART expansion in Sub-Saharan Africa. We provide quasi-experimental evidence on this question using the phased roll-out of ART in Zambia, a country where approximately 1 in 6 adults is HIV positive. Using anthropometric data from national household surveys and a spatially-based triple difference estimator, we find evidence suggesting that local ART introduction increased the weight of HIV positive adult women.

JEL classification: I12; J13; O12
Keywords: foreign aid; health; HIV/AIDS; PEPFAR; targeting; Zambia

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1 Introduction

The single largest item in the United States foreign aid health budget is antiretroviral therapy (ART) for the treatment of HIV/AIDS.[1] Between 2001 and 2008, annual U.S. government expenditure on HIV/AIDS abroad increased from US$204 million to US$3.3 billion, while annual U.S. government expenditure on non-HIV international health increased from US$1.3 billion to US$1.7 billion (Government Accountability Office 2010).[2] Of the US$3.3 billion the U.S. government spent on HIV/AIDS overseas in 2008, roughly US$1.4 million appears to have been allocated to ART. Not only is antiretroviral therapy large in U.S. global health policy, but the United States President's Emergency Plan for AIDS Relief (PEPFAR) is the largest source of HIV/AIDS funding in the world (Schneider and Garrett 2009).

A growing body of research examines behavioral responses to ART expansion in Sub-Saharan Africa, the region of the world most heavily afflicted with HIV/AIDS.[3] For example, there is recent research on labor market effects (Baranov et al. (2012), McLaren (2010), Thirumurthy and Graff Zivin (2012), fertility and sexual behavior responses (de Walque et al. (2012) and Friedman (2013)), and effects on intrahousehold resource allocation (Thirumurthy et al. (2008), Graff Zivin et al. (2009), and Lucas and Wilson (2013)). Although the results of these behavioral studies are consistent with ART expansion having direct epidemiological effects, these studies largely presume

[1] In 2008, the U.S. spent US$3.3 billion on foreign assistance for HIV/AIDS and US$1.7 billion on foreign assistance for non-HIV health (Government Accountability Office 2010). The United States President's Emergency Plan for AIDS Relief (PEPFAR), the single largest source of HIV/AIDS funding worldwide (Schneider and Garrett 2009), stipulated that 41 percent (55 percent) of PEPFAR spending be allocated to antiretroviral therapy (and related care for treatment patients) (Moss 2008). It is difficult to determine the exact amount allocated to the second largest item in the US foreign health budget. Presumably, it was substantially less than the total US$1.7 million allocated to non-HIV health.

[2] In total through 2008, the U.S. spent approximately US$5 billion on ART. U.S. spending on HIV/AIDS over time is as follows: US$700 million in 2003, US$1.2 billion in 2004, US$1.7 billion in 2005, US$2.1 billion in 2006, US$2.7 billion in 2007, and US$3.3 billion in 2008 (Government Accountability Office 2010).

[3] With adult HIV prevalence of approximately 5 percent, Sub-Saharan Africa is the region of the world most heavily afflicted with HIV (UNAIDS 2010). Moreover, HIV/AIDS is arguably one of the largest health problems facing Sub-Saharan Africa. Approximately 29 percent of adult mortality in this region is due to HIV/AIDS, making it the leading cause of adult mortality in Sub-Saharan Africa (WHO 2011).

direct effects without providing evidence on this important step in the causal chain.[4]

Despite the central focus on ART in global health policy and a growing body of studies examining the behavioral responses to ART, there does not appear to be any quasi-experimental evidence on the direct epidemiological effects of ART provision at scale in Sub-Saharan Africa.[5] Bendavid et al. (2012) uses a largely cross-country difference-in-differences analysis to provide evidence suggesting HIV development assistance has reduced all-cause adult mortality in Africa.[6] Using data from patients at a single clinic in Kenya, Thirumurthy et al. (2008) and Thirumurthy and Graff Zivin (2012)) find evidence indicating that initiating ART increased CD4 counts and body mass index (BMI).

We examine the effect of ART roll-out in Zambia on the morbidity of HIV positive adult females using a spatially-based difference-in-difference-in-differences (DDD) estimator.[7] We combine anthropometric data and HIV test results from national household surveys conducted before and after ART expansion with a panel of all health facilities in Zambia documenting the expansion of ART. This empirical framework allows us to compare the changes in anthropometrics associated with the timing of local ART introduction for likely HIV positive and likely HIV negative women age 15-49 residing near and far from the health facility where ART was locally introduced.

Our results suggest that local ART introduction improved the health of the targeted. We find that ART introduction within 10 kilometers of the respondent appears to have increased the

[4] In providing evidence on the direct health effects of initiating ART, Thirumurthy et al. (2008) and Thirumurthy and Graff Zivin (2012) are notable exceptions to this claim. In contrast to many of the other aforementioned studies that use data from multiple clinics (e.g., Baranov et al. 2012) or all clinics in a national ART program (e.g., McLaren 2010), the two studies that provide direct epidemiological evidence (i.e., Thirumurthy et al. (2008) and Thirumurthy and Graff Zivin (2012)) examine the effects of ART using data from patients at a single clinic.

[5] Lucas and Wilson (2013) uses similar data and methods as the current analysis to provide evidence on the indirect effects of ART expansion in Zambia (which was largely allocated to adults during this time period) on the anthropometrics of children of likely HIV positive individuals.

[6] Notably, Bendavid et al. (2012) uses the same national households surveys we use in the current analysis: the Demographic and Health Surveys (DHS).

[7] Zambia is a particularly interesting case study for at least two reasons. First, roughly 1 in 6 adults in Zambia is HIV positive (Central Statistical Office et al. 2009). Second, Zambia is one of fifteen original PEPFAR focus countries.

weight of likely HIV positive women by approximately 2 to 10 kilograms. Consistent with a causal interpretation of this main result, we find evidence suggesting that: (1) the increase in weight was concentrated among women living closest to where ART was locally introduced, and (2) local ART introduction did not affect adult height, a health outcome that should not be affected by receiving ART. An analysis of the dynamic effects suggests the absence of a strong differential pre-introduction trend and that the health benefits of local ART introduction were relatively rapid.

These estimated effects are roughly the same magnitude as a back-of-the-envelope calculation of the effect of local ART introduction. Suppose 20 percent of HIV positive women are clinically eligible for ART and one-half of these women access and receive ART.[8] Then local ART availability should directly affect the health of approximately 10 percent of the local adult HIV positive female population. If taking ART increases body mass by an average of 10 kilograms, then the expected effect of local ART on average among the population of HIV positive adult women is a roughly 1 kilogram increase in body mass.[9,10]

To the best of our knowledge, this paper provides some of the first quasi-experimental evidence on the effects of ART on adult morbidity at scale in Sub-Saharan Africa. However, this paper contributes to the literature on the health effects of HIV/AIDS spending in Africa (Bendavid et al. 2012), the health effects of ART provision at scale in the United States (Palella et al. 1998) and the economic literature on the effects of ART (e.g., Thirumurthy et al. 2008, Graff Zivin et al. 2009,

[8] During the period examined in the current analysis, the World Health Organization (WHO) recommended initiating ART for HIV patients in WHO clinical stages "III" or "IV" and for HIV patients with CD4 counts between 200 and 350 cells/mm (WHO 2006b). Clinical practice appears to have largely followed these guidelines (Stringer et al. 2006).

[9] Clinical studies suggest a moderate range of weight gains associated with ART initiation. Koethe et al. (2010) reports that roughly one-half of a cohort of ART patients in the national treatment program in Lusaka, Zambia had gained 5 kilograms or more 6 months after initiating ART. Saghayam et al. (2008) indicated a median weight gain of 2.6 kilograms 6 months after ART initiation among a sample of adult males in India. Among a sample of ART patients in Haiti, median weight gain after 6 months of ART was 4 kilograms (Severe et al. 2005). Koenig et al. (2004) reports a median weight gain of 10.3 kilograms after one year of ART among ART patients in Haiti. In an economic analysis, Thirumurthy and Graff Zivin (2012) found that ART increased adult weight in kilograms by approximately 5 kilograms within 6 months of initiating therapy and that subsequent weight gains were minimal.

[10] Recent evidence from ART expansion in Malawi suggests local ART may affect bodyweight indirectly as well. Baranov et al. (2012) provides evidence from three rural regions in Malawi suggesting that local ART introduction may have increased household maize production by increasing mental health.

McLaren 2010, Baranov et al. 2012, de Walque et al. 2012, Thirumurthy and Graff Zivin 2012, Friedman 2013). Central to the analysis in the majority of these latter set of studies is the untested presumption that ART provision has indeed improved the health of the targeted (i.e., individuals clinically eligible for ART in recipient countries).[11] This paper also contributes to the economic literature on the health effects of large government-run public health programs in the developing world (e.g., Gruber et al. 2013, Miller et al. 2013) and elsewhere (e.g., Finkelstein 2007, Card et al. 2008, Almond et al. 2009, Hoynes and Schanzenbach 2009, Card et al. 2009, Hoynes et al. 2011, Finkelstein et al. 2012).

The paper is organized as follows. Section 2 describes antiretroviral therapy in the Sub-Saharan Africa. Section 3 describes the household survey and health facilities census data. Section 4 explains the empirical strategy we use to identify the epidemiological effects of ART scale-up. Section 5 presents the results. Section 6 concludes.

2 Antiretroviral Therapy in Sub-Saharan Africa

The discovery of antiretroviral therapies has been called "one of the greatest" "breakthroughs" in the fight against HIV/AIDS (Barre-Sinoussi 2011). Antiretroviral drugs (e.g., azidothymidine (AZT), lamivudine (3TC)) reduce the viral load and increase the general health of individuals living in the advanced stages of HIV (WHO 2006b). Similarly, when administered during pregnancy, childbirth, and/or breastfeeding, these types of drugs reduce the likelihood of mother-to-child transmission of HIV (Guay et al. 1999, Dabis and Ekpinni 2002, Jackson et al. 2003). More recently, antiretrovirals have been shown to reduce the horizontal transmission of HIV when provided to individuals living with HIV (Cohen et al. 2011) or to the partners of HIV positive individuals

[11] In providing evidence on the direct health effects of initiating ART, Thirumurthy et al. (2008) and Thirumurthy and Graff Zivin (2012) are notable exceptions to this claim.

(Thigpen et al. 2012).[12]

Expanding access to antiretroviral therapy (ART) for HIV positive individuals (i.e., primarily prime age adults) throughout much of Sub-Saharan Africa has been a central component of foreign aid over the past decade.[13] ART is the largest item in the United States foreign aid health budget and the United States President's Emergency Plan for AIDS Relief (PEPFAR) is the largest source of HIV/AIDS funding (Schneider and Garrett 2009). PEPFAR has identified 15 focus countries, the majority of which are in Sub-Saharan Africa, to provide large-scale financial support. More than one-half of PEPFAR spending has been allocated to antiretroviral therapy (ART) and care for ART patients (Moss 2008). While annual U.S. spending on HIV/AIDS in international health increased from US$204 million in 2001 to US$3.3 billion in 2008, annual U.S. spending on non-HIV international health increased from US$1.3 billion to US$1.7 billion (Government Accountability Office 2010).

Although governments have spent billions of dollars (US) on antiretroviral therapy, there is little evidence on the effectiveness of antiretroviral therapy (ART) programs at scale. Bendavid et al. (2012) is one of the few studies that has provided quasi-experimental evidence on this issue. Using a difference-in-differences approach primarily comparing PEPFAR focus countries to non-focus countries in Sub-Saharan Africa before and after the introduction of PEPFAR-financed ART, Bendavid et al. (2012) found that adult mortality fell in focus countries relative to non-focus countries.[14] In a longitudinal analysis of ART patients in the United States, Palella et al. (1998) found that morbidity and mortality declined over time coincident with the timing of

[12]The journal Science named "treatment-as-prevention" (i.e., providing ART to HIV positive individuals to reduce the transmission of HIV) the 2011 Breakthrough of the Year (United States Department of Health and Human Services 2011).

[13]The rise of ART has reflected a shift in US foreign aid from cash transfers, investment in economic infrastructure, training, technical expertise, and small grants to commodities (Tarnoff and Larson 2011).

[14]Because Bendavid et al. (2012) tracks HIV development assistance instead of ART availability and examines all-cause mortality instead of HIV-specific mortality, it is possible that these results are driven by a stimulatory effects of HIV spending and not the direct epidemiological effects of ART.

the introduction of highly active antiretrovirals (HAART), more so for patients on more intense antiretroviral regimes. In an event study analysis of the impact of ART using data from patients at a single clinic in Kenya, Thirumurthy et al. (2008) found that ARVs increased the body mass index (BMI) of patients 6 to 12 months after initiating therapy. Using a spatially-based triple difference empirical strategy, Lucas and Wilson (2013) found evidence suggesting that the local introduction of ART (primarily) for adults in Zambia improved the anthropometrics of children age 0-5 years.

Zambia, the location for the current study, is one of the PEPFAR focus countries. As such, it has received US$1.5 billion for HIV/AIDS through PEPFAR (PEPFAR 2013). The Global Fund to Fight AIDS, Tuberculosis and Malaria, the second largest HIV/AIDS donor in Zambia, has disbursed approximately US$500 million for HIV/AIDS (Global Fund to Fight AIDS, Tuberculosis and Malaria 2012).[15]

Figure 1 displays mean adult female weight and height in Zambia in 2001 and in 2007. In 2001, prior to the widespread availability of ART, the average adult female in the Zambia DHS weighed approximately 53.2 kilograms. By 2007, when nearly one-half of the Zambian population lived within 10 kilometers of a ART site, the average adult female in the Zambia DHS weighed 56.2 kilograms. Although this increase of roughly 3 kilograms is consistent with ART expansion improving health, it could also be driven by other health policies or a rising standard of living in Zambia during this period. The fact that height did not change substantially during this period suggests that the change in weight does not simply reflect a compositional change in survey respondents.

[15] These two donor agencies, PEPFAR and The Global Fund, appear to provide roughly one-half to two-thirds of HIV/AIDS donor funding in Zambia (Oomman et al. 2007, Resch et al. 2008.)

3 Data

3.1 Individual-level data

The 2001 and 2007 Zambia Demographic Health Surveys (DHS), cross-sectional national household surveys, provide data on adult female anthropometrics. We use administrative records on the primary sampling units in these surveys to calculate the approximate latitude and longitude of each survey household.[16] This process yields 6,645 adult females (i.e., ages 15-49) in the 2001 DHS and 7,039 adult females in the 2007 DHS.[17]

The 2001 and 2007 Zambia DHS also include anonymous HIV testing modules. Privacy concerns mean the 2001 HIV data are only linked to gender, age, and province of residence. In addition, the response rate for the HIV testing module was roughly 75 percent in either of the survey rounds. We use these data to construct a measure of HIV prevalence in the respondent's demographic group defined as the interaction of survey round, gender, five year age group, and province of residence. Median HIV prevalence using this measure is 0.161, the tenth percentile is 0.052, and the ninetieth percentile is 0.320.[18]

[16]The nature of the spatial information in these surveys likely introduces attenuation bias in the estimates of the anthropometric effects of local ART availability. For the 2001 DHS, we use information on the respondent's Standard Enumeration Area (SEA) of residence to define the precise location of the respondent as the centroid of this SEA. These administrative units were designed to capture approximately 1,000 individuals, so although they tend to be quite small in urban areas they may be relatively large in rural areas. The 2007 DHS contains slightly different spatial information. Instead of revealing the respondent's SEA of residence, the 2007 DHS provides GPS data points that are intentionally measured with error for each respondent to address privacy concerns associated with the HIV testing module in this DHS. In the Zambia 2007 DHS, these data points were generated by adding a random vector with length drawn from a uniform distribution on 0 to 10 kilometers to the latitude and longitude of the centroid of the SEA of residence.

[17]The digitized census map provided by the Zambia Central Statistical Office, which we use to identify the location of the primary sampling units for the respondents in the 2001 DHS survey round, is missing approximately seven percent of the Statistical Enumeration Areas (SEAs) in Zambia. Thus, we are unable to identify the precise location of approximately seven percent of the 2001 DHS survey respondents and exclude these respondents from the empirical analysis.

[18]These figures are relatively stable between the 2001 and 2007 DHS survey rounds. In the 2001 DHS, median, tenth, and ninetieth percentile HIV prevalence using this measure are 0.156, 0.053, and 0.341, respectively. In the 2007 DHS, median, tenth, and ninetieth percentile HIV prevalence using this measure are 0.163, 0.051, and 0.286, respectively.

3.2 Health facilities data

We collected retrospective data on the month and year each health facility began offering antiretroviral therapy (ART). The 2006 Japanese International Cooperation Agency (JICA) Health Facility Census (HFC) surveyed each health facility in Zambia and recorded the exact latitude and longitude of each health site. To augment these data, we re-surveyed these clinics to collect information on the month and year (if any) they began offering each of the three main HIV/AIDS services. This process effectively began in June of 2008 so this retrospective panel provides comprehensive information on the expansion of HIV/AIDS services in Zambia through the middle of 2008.

Table 1 reports descriptive statistics by survey round. Three key facts emerge from this table. First, although ART was virtually unavailable to the general public in Zambia in 2001, ART availability was relatively widespread by 2007 with 52 percent of the sample within 10 kilometers of an ART clinic by 2007. Second, although adult female weight increased during this period, adult female height remained virtually unchanged. Third, education levels and urbanization have increased consistent with rapid development and growth in Zambia over the past decade.

4 Empirical Strategy

Our primary empirical strategy is a difference-in-difference-in-differences (DDD) regression. We exploit spatial and temporal variation in exposure to ART expansion between the 2001 and 2007 survey rounds. We compare the change in anthropometric measures across survey rounds for HIV positive adult women living near a health facility where ART was locally introduced to the change for HIV positive adult women living further from the health facility. To address concerns about differential trends between women living near and far from ART facilities, we compare this difference to the analogous difference for HIV negative women. The main regression specification is:

$$health_{ijt} = \alpha_0 + \alpha_1 ART_{ij} + \alpha_2 Year2007_{ijt} + \alpha_3 HIV_{ijt} + \alpha_4 ART_{ijt} X Year2007_{ijt}$$
$$+ \alpha_5 ART_{ijt} X HIV_{ijt} + \alpha_6 Year2007_{ijt} X HIV_{ijt}$$
$$+ \alpha_7 ART_{ijt} X Year2007_{ijt} X HIV_{ijt} + X'_{ijt}\Gamma + \delta_t + \eta_j + \epsilon_{ijt} \quad (1)$$

where $health_{ijt}$ denotes the anthropometrics of female respondent i residing in province j and interviewed in month-year combination t, ART_{ij} is an indicator variable equal to one if a health clinic located near respondent i ever offered ART even if it was subsequent to the interview date for the survey respondent, $Year2007$ is an indicator variable equal to one if the respondent comes from the 2007 DHS survey round, HIV_{ijt} is a measure of the respondent's likely HIV status, X_{ijt} is a vector of individual and household level demographic controls (i.e., indicator variables for five year age group, primary school completion, secondary school completion, local PMTCT availability, local VCT availability, household bed net ownership, and piped water access), δ_t are interview month times interview year fixed effects, and η_j are province fixed effects. As in a standard triple difference specification, we interpret α_7 as the causal effect of local ART introduction on adult female anthropometrics.

The baseline specification defines the household as being near a health clinic if the respondent lives within 10 kilometers of the nearest health clinic. We explore alternative specifications that relax the restriction that the local introduction of ART has the same effect on health invariant of distance conditional on whether distance was greater or less than 10 kilometers.

We cluster standard errors at the Statistical Enumeration Area (SEA) level as our distance based measure of ART availability varies at the level of the SEA. Because we have more than 300 SEAs in each of the two DHS surveys, standard asymptotic tests are appropriate (Cameron et al.

2008).

5 Results

5.1 Effect of local ART on ART cascade and migration

Table 2 shows the estimated effect of local ART on two important steps required to receive ART and on migration. The DHS asks female respondents whether they visited a health clinic (for themselves or their child) in the 12 months leading up the survey date and if the respondent has ever taken a HIV test. We find little evidence of an effect of local ART availability on these steps or on the likelihood the respondent had resided in the survey household for one year or less. However, there are several reasons to interpret these results with caution. First, there was a large secular decline between 2001 and 2007 in the proportion of female respondents visiting a health clinic, suggesting that the wording and/or interpretation of this question changed across survey rounds. Second, it is not clear that we should expect local ART introduction to increase HIV testing rates among likely HIV positive women relative to likely HIV negative women. For example, if the cost of taking a HIV test is sufficiently low, then we might expect likely and unlikely HIV positive women alike to respond to local ART availability by taking a HIV test.[19]

5.2 Effect of local ART on adult female anthropometrics

Table 3 shows simple before-after differences for each of four groups: (1) ART within 10km in 2007, high HIV prevalence demographic group, (2) ART within 10km in 2007, low HIV prevalence demographic group, (3) ART further than 10km in 2007, high HIV prevalence demographic group, and (4) ART further than 10km in 2007, low HIV prevalence demographic group. Panel A displays adult female weight in kilograms and Panel B displays adult female height in centimeters. For

[19]Voluntary counseling and testing (VCT) in Zambia during this period was fully subsidized.

each panel, we calculate the triple difference (i.e., the before-after difference for group (1) minus the before-after difference for group (2) minus the analogous difference for groups (3) and (4).) The triple difference estimate for weight in kilograms suggests local ART availability increased the weight of HIV positive women by approximately 2 kilograms. The triple difference estimate for height in centimeters suggests local ART availability had little effect on the height of HIV positive women, consistent with clinical evidence on the physiological effects of receiving ART.

Table 4 shows the estimated effect of local ART of adult female weight in kilograms. Panel A presents results using a continuous measure of likely HIV status (i.e., HIV prevalence in the respondent's demographic group, defined as the interaction of survey year, gender, province of residence, and five-year age group). Panel B presents results using a binary measure of likely HIV status (i.e., an indicator variable equal to one if HIV prevalence in the respondent's demographic group is above the median). Column (1) reports the results of the basic triple-difference regression with interview month times interview year fixed effects, province of residence fixed effects, and an urban fixed effect. In Column (2) we further include controls for five-year age group (i.e., age group fixed effects), primary school completion, secondary school completion, and marital status. In Column (3) we add controls for other HIV/AIDS services and household access to other important health inputs including piped water and bed nets. Throughout, local ART availability is associated with roughly a 2 to 9 kilogram increase in weight, or approximately a 5 percent increase relative to mean adult female weight.[20]

Table 5 shows the estimated effect of local ART on adult female height in centimeters. Panel A reports results using the continuous measure of likely HIV status and Panel B reports results using the binary measure of likely HIV status. In the baseline specification in Column (1), local

[20] One channel through which ART availability may have affected weight gain is through any associated ART patient nutriton programs. ART clinics in Zambia provide nutrition counseling to ART patients (Koethe et al. 2010). In addition, the World Health Organization (WHO) ran a pilot food supplementation program in Lusaka, Zambia from 2004 to 2006 (Cantrell et al. 2008).

ART availability appears to be associated with a (albeit statistically insignificant) reduction in height. However, once we include additional controls the estimated effect of local ART availability on height diminishes and in none of the regression specifications is it statistically significant at conventional levels.

5.3 Spatial heterogeneity

Table 6 examines spatial heterogeneity in the estimated effect of local ART of adult female weight in kilograms. Panel A reports results using the continuous measure of likely HIV status and Panel B reports results using the binary measure of likely HIV status. We include an additional indicator variable for ART within 20 kilometers (as well as the required triple difference interactions).[21] The results suggest that the effect of local ART introduction on female health was concentrated among respondents residing closest to the location where ART was locally introduced.

5.4 Dynamic effects

We examine the identification assumption in our main regressions by providing evidence on possible differences in pre-local ART introduction trends in the anthropometrics of likely HIV positive and likely HIV negative women residing near and far from local ART introduction. Figure 2 plots the semi-parametric triple difference parameters from the following regression specification:

$$\begin{aligned} health_{ijt} = & \sum_{k=-60(+)}^{36(+)} \alpha_k 1(\tau_{ijt} = k) XART_{ij} + \sum_{k=-60(+)}^{36(+)} \beta_k 1(\tau_{ijmt} = k) XART_{ij} XHIV_{ijt} \\ & + \gamma_1 Year2007_{ijt} + \gamma_2 HIV_{ijt} + \gamma_3 Year2007_{ijt} XHIV_{ijt} \\ & + X'_{ijmt}\Gamma + \delta_t + \eta_j + \epsilon_{ijmt} \end{aligned} \quad (2)$$

[21] These distance measures are not mutually exclusive. A household that resides within 10 kilometers of ART also resides within 20 kilometers of ART.

where τ_{ijt} denotes the twelve (or eleven) month event window and is defined such that $\tau = 0$ for respondents surveyed 0 to 11 months after the local introduction of ART, $\tau = 1$ for respondents surveyed 12 to 23 months after the local introduction of PMTCT, $\tau = 2$ for respondents surveyed 24 to 35 months after the local introduction of PMTCT, and $\tau = 3$ for respondents surveyed 36 months or more after the local introduction of PMTCT. For $\tau < 0$, respondents were surveyed prior to the local introduction of ART. Aside from the semi-parametric triple difference study parameters, this specification is identical to the specification in Equation (1). We estimate the parameters of Equation (2) in a linear probability model (i.e., using ordinary least squares (OLS) regression). We focus on the continuous measure of likely HIV status.

The estimates of the semi-parametric triple difference parameters (i.e., β_k in Equation (2)) plotted in Figure 2 support a causal interpretation of the baseline anthropometric results. There does not appear to have been a clear differential pre-local ART introduction trend for likely HIV positive individuals. In addition, the timing of the increase in adult female weight is closely associated with the timing of local introduction.[22]

Table 7 continues this dynamic analysis by re-parameterizing the main regression specification to examine the estimated dynamic effects of local ART of adult female weight in kilograms. We explore the dynamic effects of local ART availability by testing for whether local ART availability had a differential effect in locations where ART had been available for at least 24 months instead of at least 12 months. Panel A reports result using the continuous measure of likely HIV status and Panel B reports results using the binary measure of likely HIV status. The results suggest that the effect of local ART may have been increasing in the duration ART was locally available, but that the much of the increase in weight occurred during the 12-24 months after local ART introduction.

[22] In Figure 2, “12-23” on the X-axis denotes 12-23 months after local ART introduction and corresponds to the first period we include in the main measure of ART availability in the main regression specification (i.e., Equation (1)). “11-0” denotes 0-11 months before local ART introduction, ”23-12” denotes 12-23 months before local ART introduction, and so forth.

6 Conclusion

A fundamental debate in development and growth is whether foreign aid can be effective at promoting sustained improvements in quality of life (e.g., Boone 1996, Burnside and Dollar 2000, Collier and Dollar 2002, Easterly 2003, Collier and Dollar 2004, Easterly et al. 2004, Easterly 2007, Easterly 2009). We raise a related and more narrowly defined question: can targeted aid improve the health of the targeted? We examine this topic in the context of arguably the single largest foreign aid health program in the history of the world: the United States President's Emergency Plan for AIDS Relief (PEPFAR). Our findings suggest that local ART introduction in Zambia, a PEPFAR focus country, increased likely HIV positive adult female weight by between approximately 2 and 10 kilograms, or as much as roughly 5 percent relative to mean weight. These results suggest the largest foreign health aid program in the history of the world can indeed improve the health of the targeted.

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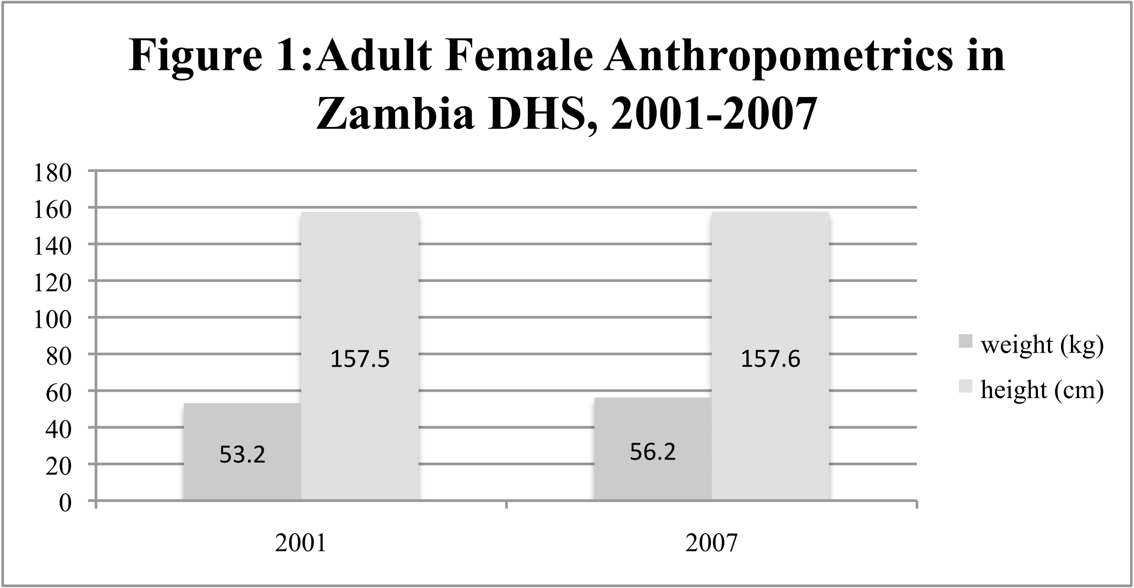
Figure 1:Adult Female Anthropometrics in Zambia DHS, 2001-2007
180
160
140
120
100
80
60
40
20
0
157.5
157.6
53.2
56.2
2001
2007
weight (kg)
height (cm)

Figure 2: Semi-Parametric Difference-in-Difference-Differences Analysis of Effect of Local ART Introduction on Adult Female Weight in Kilograms

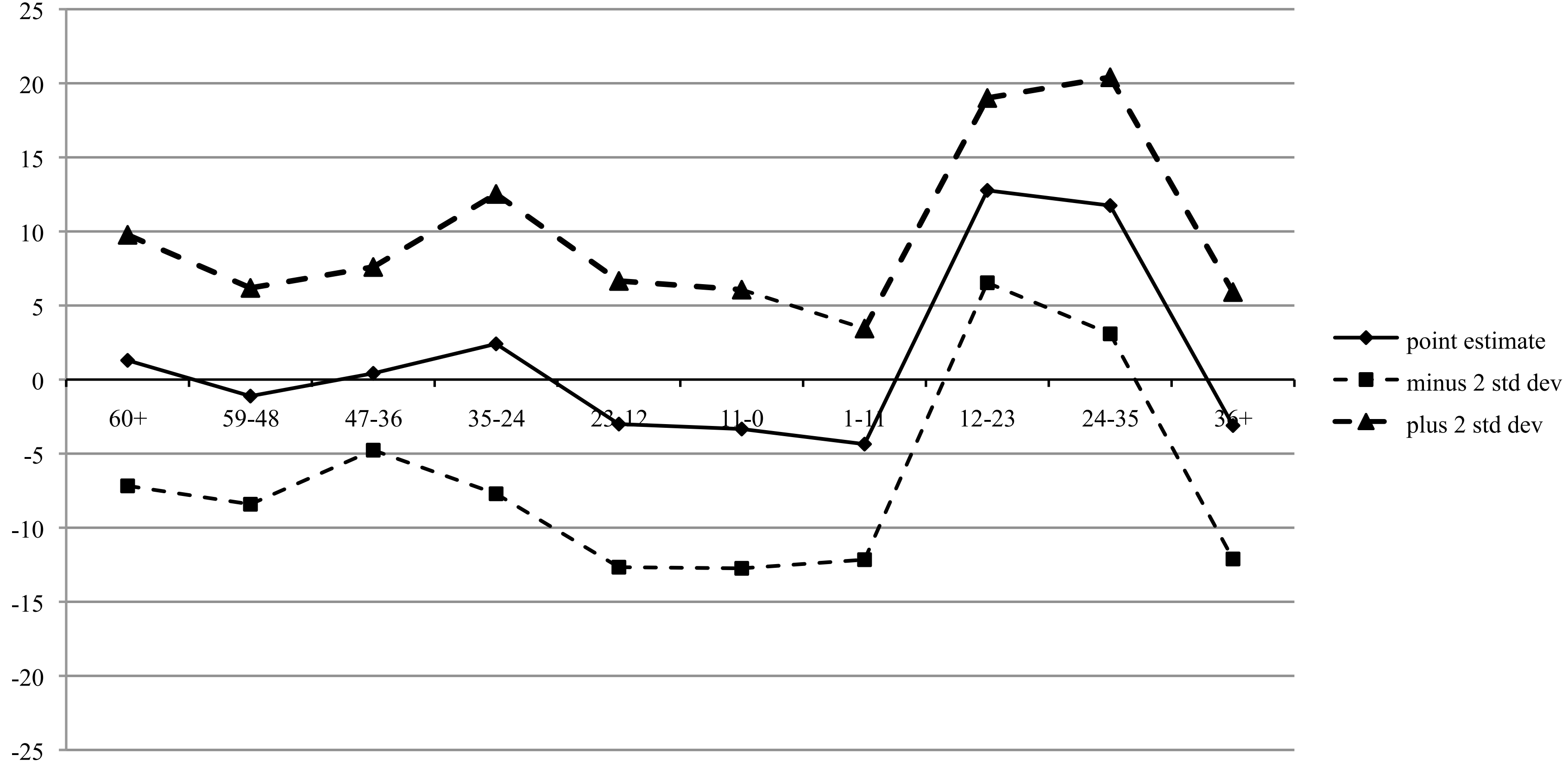

Table 1: Descriptive Statistics for Adult Female Respondents in the 2001 and 2007 Demographic Health Surveys

Survey round:	2001	2007
	(1)	(2)
ART ever within 10km	0.43	0.52
	(0.50)	(0.50)
ART ever within 20km	0.61	0.68
	(0.49)	(0.47)
ART ever within 30km	0.74	0.78
	(0.44)	(0.41)
ART within 10km at least 24 months	0.00	0.35
	(0.00)	(0.48)
Visited clinic in past 12 months	0.66	0.45
	(0.47)	(0.50)
Ever took a HIV test	0.09	0.41
	(0.29)	(0.49)
Weight, kilograms	53.20	56.20
	(9.47)	(11.00)
Height, centimeters	157.50	157.60
	(6.38)	(6.82)
HIV prevalence	0.17	0.17
	(0.11)	(0.10)
Age	27.40	27.90
	(8.30)	(9.22)
Primary school completion	0.45	0.55
	(0.50)	(0.50)
Secondary school completion	0.06	0.11
	(0.24)	(0.31)
Urban	0.31	0.45
	(0.46)	(0.50)
Observations	6,645	7,039

Notes: Data come from the 2001 and 2007 Zambia Demographic Health Surveys. Entries are sample means. Standard deviations are in parentheses.

Table 2: Effect of Local ART on ART Cascade

Dependent variable:	visited clinic	ever tested	resident less than 1 year
	(1)	(2)	(3)
Panel A: Continuous measure of HIV prevalence			
ART ever within 10km	-0.002	-0.008	0.037
	(0.028)	(0.022)	(0.025)
Year 2007	-0.306***	0.155***	-0.042
	(0.087)	(0.035)	(0.028)
HIV +	0.156	-0.350***	-0.142
	(0.111)	(0.077)	(0.089)
ART ever within 10km X Year 2007	0.042	0.057*	-0.038
	(0.036)	(0.032)	(0.034)
ART ever within 10km X HIV +	-0.157	0.043	-0.118
	(0.115)	(0.077)	(0.096)
Year 2007 X HIV +	0.088	0.836***	0.039
	(0.134)	(0.107)	(0.105)
ART ever within 10km X Year 2007 X HIV +	0.138	-0.046	0.191
	(0.166)	(0.143)	(0.141)
Observations	13,878	13,795	13,869
Panel B: Binary measure of HIV prevalence			
ART ever within 10km	-0.016	-0.003	0.025
	(0.024)	(0.020)	(0.021)
Year 2007	-0.288***	0.221***	-0.043*
	(0.084)	(0.032)	(0.024)
HIV +	-0.003	-0.049***	-0.003
	(0.018)	(0.012)	(0.015)
ART ever within 10km X Year 2007	0.047	0.038	-0.012
	(0.029)	(0.025)	(0.026)
ART ever within 10km X HIV +	-0.027	0.001	-0.016
	(0.023)	(0.016)	(0.020)
Year 2007 X HIV +	-0.006	0.131***	0.015
	(0.024)	(0.018)	(0.018)
ART ever within 10km X Year 2007 X HIV +	0.038	0.035	0.019
	(0.032)	(0.029)	(0.028)
Observations	13,878	13,795	13,869

Notes: Data come from the 2001 and 2007 Zambia Demographic Health Surveys All dependent variables are indicator variables. "ART within 10km" is an indicator variable equal to one if a health clinic with 10 kilometers of the respondent offered ART at least twelve months prior to the survey date. Continuous measure of HIV is prevalence in respondent's demographic group. Binary measure of HIV prevalence is an indicator variable equal to one if respondent is in a demographic group with HIV prevalence above median. All specifications include the full set of controls indicated in Equation (1). Parameters estimated using ordinary least squares (OLS) regression. Standard errors are in parentheses and are clustered by Standard Enumeration Area (SEA).

*** Significant at the 1 percent level, ** Significant at the 5 percent level, * Significant at the 10 percent level.

Table 3: Adult Female Anthropometrics in Zambia by Proximity to ART, HIV Prevalence, and Survey Year

	survey round		
	2001	2007	difference
	(1)	(2)	(3)
Panel A: Weight, kilograms			
ART within 10km, high HIV	57.44	61.37	3.93
ART within 10km, low HIV	52.88	54.42	1.54
ART further than 10km, high HIV	53.14	56.03	2.89
ART further than 10km, low HIV	50.39	52.88	2.49
Triple difference			1.99
Panel B: Height, centimeters			
ART within 10km, high HIV	159.08	159.47	0.39
ART within 10km, low HIV	157.30	157.13	-0.17
ART further than 10km, high HIV	158.12	158.19	0.07
ART further than 10km, low HIV	155.89	155.73	-0.16
Triple difference			0.33

Notes: Anthropometric data come from the 2001 and 2007 Zambia Demographic Health Surveys. Entries are sample means. "ART within 10km" and "ART further than 10km" refer to ART availability at least twelve months prior to the 2007 survey date. "high HIV" and "low HIV" refer to whether HIV prevalence in the respondent's demographic group is above or below the median HIV prevalence demographic group.

Table 4: Effect of Local ART on Adult Female Weight in Kilograms

Dependent variable:	weight (kg)		
	(1)	(2)	(3)
Panel A: Continuous measure of HIV prevalence			
ART ever within 10km	0.845	0.533	-0.590
	(0.637)	(0.568)	(0.585)
Year 2007	0.007	0.197	1.650
	(0.670)	(0.641)	(1.439)
HIV +	16.486***	0.796	0.134
	(2.127)	(2.459)	(0.585)
ART ever within 10km X Year 2007	-0.876	-1.549**	-1.203*
	(0.767)	(0.704)	(0.715)
ART ever within 10km X HIV +	-1.620	-1.032	0.343
	(3.009)	(2.726)	(2.603)
Year 2007 X HIV +	9.232***	5.293**	4.455*
	(2.949)	(2.685)	(2.642)
ART ever within 10km X Year 2007 X HIV +	6.082	9.378**	9.044**
	(4.434)	(3.913)	(3.858)
Observations	13,684	13,684	13,681
Panel B: Binary measure of HIV prevalence			
ART ever within 10km	0.361	0.464	-0.564
	(0.501)	(0.433)	(0.474)
Year 2007	1.113**	0.693	2.026
	(0.517)	(0.520)	(1.401)
HIV +	2.471***	-0.240	-0.288
	(0.350)	(0.365)	(0.361)
ART ever within 10km X Year 2007	-1.277**	-0.947*	-0.593
	(0.541)	(0.485)	(0.528)
ART ever within 10km X HIV +	0.345	-0.269	-0.016
	(0.566)	(0.502)	(0.479)
Year 2007 X HIV +	0.414	0.654	0.524
	(0.461)	(0.432)	(0.426)
ART ever within 10km X Year 2007 X HIV +	2.533***	1.969***	1.822***
	(0.789)	(0.688)	(0.678)
Observations	13,684	13,684	13,681

Notes: Data come from the 2001 and 2007 Zambia Demographic Health Surveys All dependent variables are indicator variables. "ART within 10km" is an indicator variable equal to one if a health clinic with 10 kilometers of the respondent offered ART at least twelve months prior to the survey date. Continuous measure of HIV is prevalence in respondent's demographic group. Binary measure of HIV is an indicator variable equal to one if respondent is in a demographic group with HIV prevalence above median. Controls in column (1): interview month times interview year indicator variables, urban indicator variable, and province indicator variables. Additional controls in column (2): indicator variables for primary and secondary school completion, indicator variables for five-year age group, and a marital status indicator variable. Additional controls in column (3): indicator variables for PMTCT availaibility, VCT availability, household access to piped water, and bednet ownership. Parameters estimated using ordinary least squares (OLS) regression. Standard errors are in parentheses and are clustered by Standard Enumeration Area (SEA).

*** Significant at the 1 percent level, ** Significant at the 5 percent level, * Significant at the 10 percent level.

Table 5: Effect of Local ART on Adult Female Height in Centimeters

Dependent variable:	height (cm)		
	(1)	(2)	(3)
Panel A: Continuous measure of HIV prevalence			
ART ever within 10km	0.430	0.153	-0.075
	(0.381)	(0.361)	(0.403)
Year 2007	-0.363	-0.664	-0.718
	(0.542)	(0.519)	(0.547)
HIV +	8.343***	-1.489	-1.559
	(1.240)	(1.499)	(1.508)
ART ever within 10km X Year 2007	0.731	0.388	0.423
	(0.480)	(0.473)	(0.490)
ART ever within 10km X HIV +	-1.311	-0.614	-0.473
	(1.604)	(1.563)	(1.602)
Year 2007 X HIV +	5.498***	3.427*	3.335*
	(1.874)	(1.811)	(1.817)
ART ever within 10km X Year 2007 X HIV +	-3.438	-1.706	-1.715
	(2.254)	(2.224)	(2.233)
Observations	13,668	13,668	13,665
Panel B: Binary measure of HIV prevalence			
ART ever within 10km	0.120	0.100	-0.120
	(0.296)	(0.273)	(0.323)
Year 2007	0.056	-0.345	-0.407
	(0.435)	(0.447)	(0.482)
HIV +	1.140***	-0.407*	-0.417*
	(0.216)	(0.229)	(0.230)
ART ever within 10km X Year 2007	-0.071	0.154	0.193
	(0.362)	(0.343)	(0.365)
ART ever within 10km X HIV +	0.188	-0.094	-0.065
	(0.330)	(0.311)	(0.316)
Year 2007 X HIV +	0.377	0.522*	0.507*
	(0.306)	(0.293)	(0.294)
ART ever within 10km X Year 2007 X HIV +	0.300	-0.037	-0.051
	(0.446)	(0.421)	(0.425)
Observations	13,668	13,668	13,665

Notes: Data come from the 2001 and 2007 Zambia Demographic Health Surveys All dependent variables are indicator variables. "ART within 10km" is an indicator variable equal to one if a health clinic with 10 kilometers of the respondent offered ART at least twelve months prior to the survey date. Continuous measure of HIV is prevalence in respondent's demographic group. Binary measure of HIV is an indicator variable equal to one if respondent is in a demographic group with HIV prevalence above median. Controls in column (1): interview month times interview year indicator variables, urban indicator variable, and province indicator variables. Additional controls in column (2): indicator variables for primary and secondary school completion, indicator variables for five-year age group, and a marital status indicator variable. Additional controls in column (3): indicator variables for PMTCT availaibility, VCT availability, household access to piped water, and bednet ownership. Parameters estimated using ordinary least squares (OLS) regression. Standard errors are in parentheses and are clustered by Standard Enumeration Area (SEA).

*** Significant at the 1 percent level, ** Significant at the 5 percent level, * Significant at the 10 percent level.

Table 6: Spatial Heterogeneity in Effect of Local ART on Adult Female Weight in Kilograms

Dependent variable:	weight (kg)		
	(1)	(2)	(3)
Panel A: Continuous measure of HIV prevalence			
ART ever within 10km X Year 2007 X HIV +	10.299*	11.585**	10.349**
	(5.640)	(5.256)	(5.218)
ART ever within 20km X Year 2007 X HIV +	-6.819	-3.693	-2.232
	(5.656)	(5.019)	(4.934)
Observations	13,684	13,684	13,681
Panel B: Binary measure of HIV prevalence			
ART ever within 10km X Year 2007 X HIV +	2.811***	2.134**	1.811**
	(1.039)	(0.915)	(0.903)
ART ever within 20km X Year 2007 X HIV +	-0.439	-0.274	-0.011
	(0.916)	(0.855)	(0.833)
Observations	13,684	13,684	13,681

Notes: Data come from the 2001 and 2007 Zambia Demographic Health Surveys All dependent variables are indicator variables. "ART within 10km" is an indicator variable equal to one if a health clinic with 10 kilometers of the respondent offered ART at least twelve months prior to the survey date. "ART within 20km" is defined analogously. Continuous measure of HIV is prevalence in respondent's demographic group. Binary measure of HIV is an indicator variable equal to one if respondent is in a demographic group with HIV prevalence above median. All specifications include the standard lower-level triple-difference interactions. Controls in column (1): interview month times interview year indicator variables, urban indicator variable, and province indicator variables. Additional controls in column (2): indicator variables for primary and secondary school completion, indicator variables for five-year age group, and a marital status indicator variable. Additional controls in column (3): indicator variables for PMTCT availaibility, VCT availability, household access to piped water, and bednet ownership. Parameters estimated using ordinary least squares (OLS) regression. Standard errors are in parentheses and are clustered by Standard Enumeration Area (SEA).

*** Significant at the 1 percent level, ** Significant at the 5 percent level, * Significant at the 10 percent level.

Table 7: Dynamic Effects of Local ART on Adult Female Weight in Kilograms

Dependent variable:	weight (kg)		
	(1)	(2)	(3)
Panel A: Continuous measure of HIV prevalence			
ART ever within 10km X Year 2007 X HIV +	1.753	7.089	7.497
	(5.782)	(4.928)	(4.856)
ART ever within 10km at least 24 months X Year 2007 X HIV +	4.745	2.523	1.716
	(4.749)	(3.924)	(3.895)
Observations	13,684	13,684	13,681
Panel B: Binary measure of HIV prevalence			
ART ever within 10km X Year 2007 X HIV +	0.838	1.198	1.210
	(1.127)	(0.977)	(0.946)
ART ever within 10km at least 24 months X Year 2007 X HIV +	2.078*	0.948	0.758
	(1.103)	(0.952)	(0.929)
Observations	13,684	13,684	13,681

Notes: Data come from the 2001 and 2007 Zambia Demographic Health Surveys All dependent variables are indicator variables. "ART within 10km" is an indicator variable equal to one if a health clinic with 10 kilometers of the respondent offered ART at least twelve months prior to the survey date. "ART within 20km" is defined analogously. Continuous measure of HIV is prevalence in respondent's demographic group. Binary measure of HIV is an indicator variable equal to one if respondent is in a demographic group with HIV prevalence above median. All specifications include the standard lower-level triple-difference interactions. Controls in column (1): interview month times interview year indicator variables, urban indicator variable, and province indicator variables. Additional controls in column (2): indicator variables for primary and secondary school completion, indicator variables for five-year age group, and a marital status indicator variable. Additional controls in column (3): indicator variables for PMTCT availaibility, VCT availability, household access to piped water, and bednet ownership. Parameters estimated using ordinary least squares (OLS) regression. Standard errors are in parentheses and are clustered by Standard Enumeration Area (SEA).

*** Significant at the 1 percent level, ** Significant at the 5 percent level, * Significant at the 10 percent level.