Title: Unequal returns: the impact of antiretroviral Treatment on AIDS mortality in Addis Ababa, Ethiopia.

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Extended Abstract:

1. Background

The provision of anti-retroviral treatment (ART) will be one of the most important public health interventions in eastern and southeastern Africa in the decade to come. An unintended consequence of the widespread introduction of ART could be an increase in health inequality: as there is inequality in the contraction of HIV/AIDS, ART could lead to a compounding of the issue as those more likely to get the virus would also be less likely to have access to treatment. Empirical evidence to support arguments that ART has increased inequality in health is sparse as data is poor or non-existent in many locations where ART has been introduced (Diaz et al., 2005). The few studies on inequity in the impact of ART in developed countries as well as Brazil, have reached mixed conclusions (McNaghten et al. 2003; Antunes, Waldman, and Borrell 2005; Gebo et al. 2005). Reports from sub-Saharan Africa do not exist, or have not yet been published.

2. Hypotheses

This paper tests two separate but related hypotheses. First, is AIDS mortality correlated with socioeconomic status? Second, are areas with greater resources in terms of wealth and education associated with a more favorable[1] change in the proportion of AIDS attributable mortality after the introduction of ART?

3. The Setting

Addis Ababa has an estimated population of close to 3 million and is one of the largest urban centers in East-Africa. At the time of our study it was administratively classified into 28 Woreda's and 328 Kebele's. A *Kebele*, the unit of analysis in this study, is the smallest administrative unit in Ethiopia with a population size in the 1994 census that ranged from 500 to 21,000

As is the case for many urban areas in the region, Addis Ababa is severely affected by the HIV/AIDS epidemic. For 2003, urban HIV prevalence is estimated at 12.6% (MOH 2004), and this has obvious repercussions for the distribution of causes of death. For 2001, between 60-70 % of adult deaths (aged 20-54) are attributed to AIDS (Araya et al. 2004; Reniers et al. 2006b). Since 1999, a limited number of AIDS patients have been receiving antiretroviral medication through the informal market and usually at a very high cost. In July 2003, the Ethiopian government adopted a policy for the provision of antiretrovirals through a co-pay scheme ranging from 30US$ to 80US$ per month. For most Ethiopians this is a substantial amount, considering that the monthly salary of an entry-level administrative government

[1] The vocabulary "more favorable" is used because AIDS mortality can in fact go up. The hypothesis thus posits that administrative units where households and individuals are on average wealthier and better educated are characterized by less of an increase or more of a decrease in AIDS mortality compared to units that are poorer or not as well educated..

employee is less than 50US$. Nonetheless, well over 10,000 patients were receiving antiretroviral drugs in Ethiopia by the end of 2004. In February 2005, the government launched a free ART program in which new patients are enrolled as well as transferred from the fee based schemes. Exhaustive and detailed data on the number of patients on ART's are not easy to come by, but in 13 governmental and private hospitals in the capital for which data are available, a combined number of 6,605 patients have been receiving ART between July 2003 and December 2004[2].

4. Data and methods

Mortality data come from a surveillance of burials that was initiated at all cemeteries of Addis Ababa in February 2001. The surveillance records information for over 20,000 deaths a year and has an estimated coverage between 80 and 90 percent (Reniers et al., 2006). The surveillance is assisted by cemetery clerks who were trained in a two-day workshop. Twelve supervisors closely monitor the work of the clerks and report to the project office on a weekly basis. The cemetery clerks collect information on the date of burial, age, name, sex, address, and presumed cause of death (i.e., the lay report of the cause of death) from relatives or close friends while they are making arrangements for burial.

The main outcome of interest is the AIDS attributable mortality fraction (AAMF) at the kebele level. The AAMF is estimated based on lay reports of causes of death following a methodology that has been developed in Araya et al (2004) & Reniers et al. (2006). In brief, lay reports of causes of death are used as a diagnostic test for identifying AIDS deaths whereby the physician review of verbal autopsy interviews – carried out in 2004- are used as the 'gold' or reference standard. The diagnostic indicators obtained from that analysis are subsequently used to obtain estimates of the AAMF for the period covering February 2001- February 2006. These are broken down into an estimate of the AAMF prior to the introduction of ART (2001-2003) and one for the period after the introduction of a governmental ART program (2004-2006). The change in the fraction of mortality due to AIDS since the introduction of ART is captured by differencing the two.

Summary measures for socio-economic status, educational attainment and other background characteristics are taken from the 1994 census and also aggregated to the kebele level (CSA 1999). The two main explanatory variables of interest in this paper are a measure of wealth and a measure of educational attainment. The wealth measure, labeled MWI, is a simple assets-based summation scale that combines questions about the size of the dwelling, the construction materials used in the house (roof material and wall material), the source of water used in the household, the type of kitchen and the availability of a toilet and radio. These indices are averaged at the kebele level to obtain a continuous measure with values

[2] Data provided by the Addis Ababa Regional Health Bureau. This list of hospitals is thought to comprise most important providers of ART, but it is not exhaustive.

ranging from 0.74 to 6.18 – the higher its value, the greater the average household wealth of a given kebele. The second explanatory variable of interest is educational attainment. This is a dichotomous variable whereby 'low education' characterizes kebeles with a median number of years of schooling less than or equal to 6 years. High education typifies those kebeles with a median number of years of schooling greater than 6 years. No kebele records a median number of years of schooling greater than 8 years.

These data allow us to explore the relationship between socioeconomic background characteristics and AIDS mortality, while accounting for the spatial structure inherent in the data. The analysis (not yet finalized) will consist of two parts. In a first step, we estimate the strength and direction of the association between the AAMF and the socio-economic indices at the kebele level before the introduction ART, thereby controlling for population density, urban/rural status, and religious composition of the kebeles. In a second step, we explore the relationship between the same predictors and change in the share of AIDS attributable mortality since the introduction of ART. An additional control for the pre-ART proportion of mortality attributable to HIV/AIDS will be included along with those mentioned above. To address the presence of spatial autocorrelation, two separate spatial models are employed at each step. The spatial autoregressive model (SAR) corrects for dependence in the residual term by explicitly partitioning residual into a segment that is attributable to the defined spatial relationship of neighboring kebeles and that which varies normally with a mean of 0. The second model, the spatial lag (SP-lag), considers the spatial dependence to be a component of the outcome of interest not the residuals. To test for the sensitivity of the results to different assumptions about the spatial structure multiple weight matrixes are used, labeled boundary share and symmetrical NN in table 1.

5. Preliminary Results

The spatial distribution of the indices for wealth and education illustrate that both resources are unequally distributed over Addis Ababa (figure 1). The rural areas at the eastern, southeastern and southwestern fringe of the city are clearly the least privileged in terms of our wealth indices, but also within the urban core of the city there are clear differences in terms of the distribution of wealth and educational attainment. The swath of kebeles that extends towards the south with relatively low, but still higher values on the wealth index that the neighboring rural areas, includes districts that border the main road towards the southern region of Ethiopia. The districts with relatively high values for the socio-economic status measures at the southeastern edge of the urban core of the city are those that comprise and border the *Bole area*; the richest and most expensive residential area located near the capital's international airport. AIDS mortality is not equally distributed over the different districts either (figure 2). In terms of the pre-ART level of AIDS attributable mortality, most rural areas stand out with low values. This is also the case for the Bole area, whereas the stretch of districts around the main road towards the south seems to be characterized by relatively high values. The pattern in terms of the change in the AIDS attributable mortality fraction since the introduction of ART is not obvious, but clearly deviates from the pre-ART trend.

Figure 1: The spatial distribution of wealth and education, Addis Ababa 1994

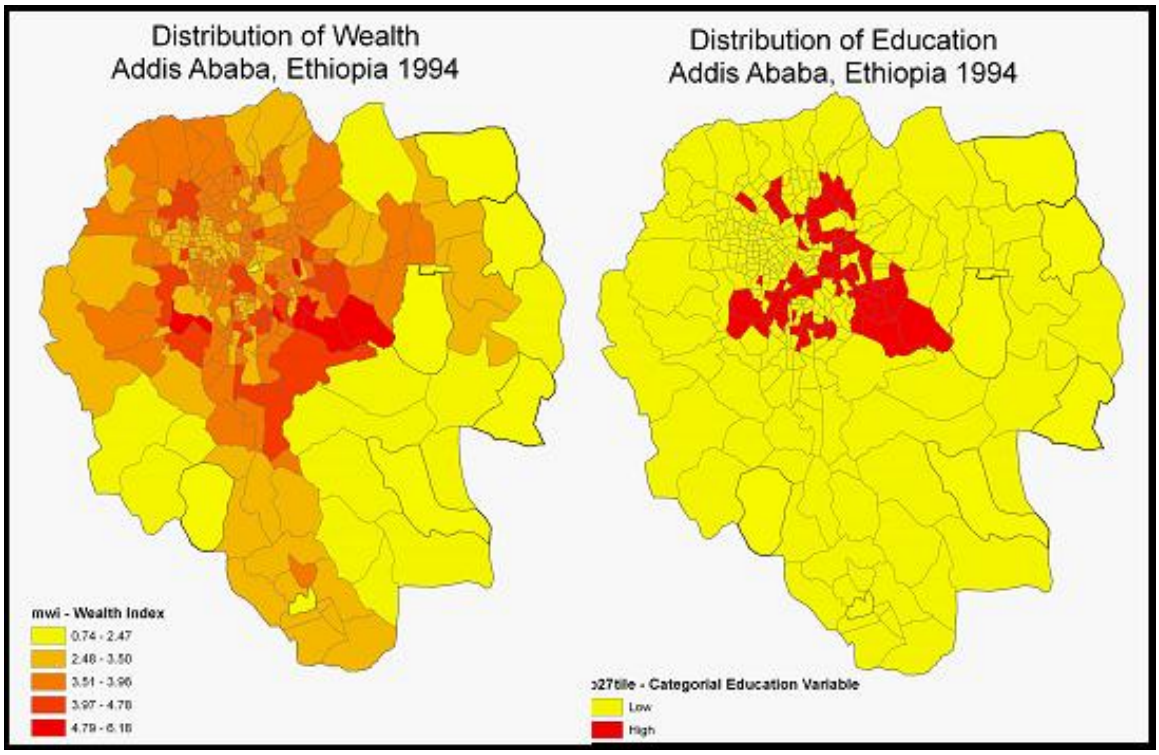
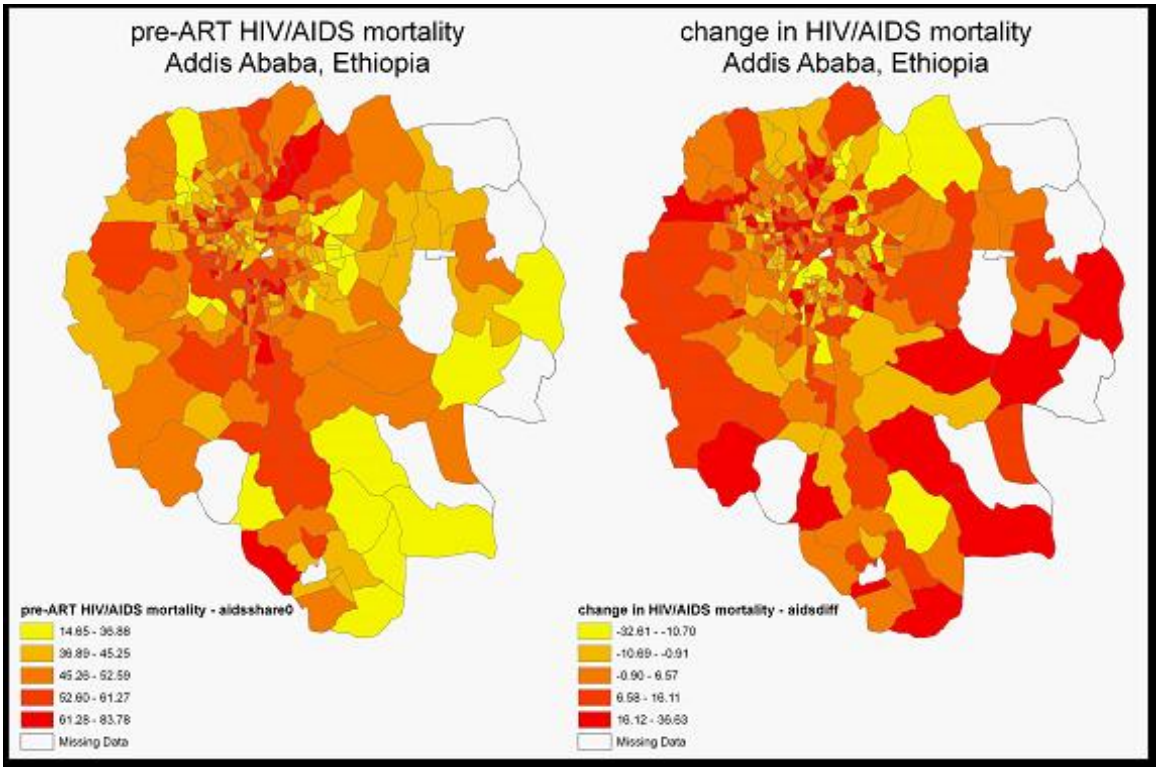


Figure 2: The spatial distribution of the AIDS mortality fraction and changes therein since the introduction of ART in Addis Ababa, Ethiopia (2001-2005)



First spatial regression results suggest that the AIDS attributable mortality fraction at the Kebele level is positively correlated with low socio-economic status, orthodox religion and urban character of the district (not shown). Following the introduction of ART, the citywide share of AIDS attributable mortality stagnated or declined slightly: in 2001, TB/AIDS deaths accounted for about 58.6% of all deaths in the age range 20-64. The comparable estimate for 2005 is 56.3%. The change in the AIDS mortality following the introduction of ART did not occur evenly throughout the city. This is illustrated in table 1, which presents the coefficient estimates and tests of significance for the regression of the change in the share of AIDS attributable mortality on a number of background characteristics. Across a variety of model specifications and after controlling for the initial level of AIDS mortality, the most favorable changes in the AIDS mortality fraction are recorded in those districts with score higher on our measures of wealth and education attainment. This does not mean, however, that a wealthy Kebele could be expected to experience a net decline in HIV/AIDS mortality, which depends on the level of HIV/AIDS mortality recorded before the distribution of ART as well as other factors.

Table 1: The effect of SES on the change in the proportion of mortality attributable to HIV/AIDS before and after the introduction of ART – Addis Ababa, Ethiopia

	Ordinary Least Squares Model			Spatial Autoregressive Model (Boundary Share)			Spatial Autoregressive Model (Symmetrical NN)			Spatial Lag Model (Boundary Share)			Spatial Lag Model (Symmetrical NN)		
		(t)			(z)			(z)			(z)			(z)	
Wealth Index	-3.25	(-2.62)	**	-3.16	(-2.54)	*	-3.36	(-2.70)	**	-3.18	(-2.59)	***	-3.24	(-2.64)	***
Orthodox (%)	-0.79	(-0.15)		1.37	(0.23)		-0.81	(-0.15)		-0.06	(-0.01)		-0.57	(-0.11)	
Urban/Rural (1=rural)	-0.87	(-0.27)		-0.30	(-0.09)		-1.88	(-0.58)		-1.07	(-0.34)		-1.17	(-0.37)	
Pop. Dens. (1,000 per km.2)	0.06	(1.73)	+	0.06	(1.51)		0.06	(1.59)		0.06	(1.69)	+	0.06	(1.73)	+
Education (1=6+ years)	-2.89	(-2.08)	*	-3.19	(-2.24)	*	-2.95	(-2.12)	*	-2.83	(-2.06)	*	-2.86	(-2.09)	*
pre-ART HIV/AIDS mortality (%)	-0.53	(-8.76)	***	-0.60	(-9.65)	***	-0.55	(-9.08)	***	-0.53	(-8.68)	***	-0.53	(-8.80)	***
Intercept	45.55			44.19			44.22			41.41			42.28		
rho / lamda				0.24	(3.23)	**	0.08	(1.82)	+	0.16	(3.56)	***	0.03	(0.69)	
log likelihood				-1160			-1162			-1186			-1164		
adjusted (psuedo) R^2	0.248			0.262			0.249			0.244			0.245		
n	319			319			319			319			319		

$+p \leq .10, *p \leq .05, **p \leq .01, ***p \leq .001$

6. Preliminary conclusions:

The analyses in this paper are not perfect and should come with a number of reservations that relate to the definition and measurement of the dependent variable, as well as the relatively long lag between the measurement of the dependent and independent variables. However, these are the data limitations that we are confronted with and there are very few, if any, alternatives. The unfortunate reality is that most countries or settings that are severely affected by the HIV/AIDS epidemic are also those that are characterized by a dearth of data suitable for the systematic monitoring of interventions. This paper is an

attempt to circumvent this problem using an unconventional data source (burial surveillance data) and an unconventional estimation method (AIDS mortality fraction estimated from lay reports of causes of death). The accuracy of the estimation procedure should therefore not be considered the strength of our approach; instead we aim to shed light on an issue that would otherwise have not been addressed at all.

Consistent with concerns that have been expressed in editorials of public health journals, we not only find that AIDS mortality correlates with low socio-economic status, but more importantly perhaps, that the interventions tend to reinforce a health inequity (e.g. Loewenson and McCoy, 2004 ; Egger et al., 2005 {McCoy et al., 2005 ; Rosen et al. 2005). We cannot exclude, however, that the observed pattern in the data is also consistent with a model whereby HIV first emerged among the rich and only later extended into poorer segments of the population. Nonetheless, these results corroborate an earlier finding that ART, due to greater control over economic resources necessary to pay for the drug, primarily benefited men (Reniers et al., 2006). These inequities may fade out as the Ethiopian government has launched a free ART program in February 2005 and simplified the eligibility criteria in October 2005 following improved supply of drugs, but that conclusion remains conditional on future evidence from the burial surveillance.

7. References

Antunes, Jose L. F., Eliseu A. Waldman, and Carme Borrell. 2005. "Is It Possible to Reduce AIDS Deaths Without Reinforcing Socioeconomic Inequalities in Health?," *International Journal of Epidemiology* 34: 586-92.

Araya, Tekebash, Georges Reniers, Ab Schaap, Derege Kebede, Abera Kumie, Nico Nagelkerke, Roel A. Coutinho, and Eduard J. Sanders. 2004. "Lay Diagnosis of Causes of Death for Monitoring AIDS Mortality in Addis Ababa, Ethiopia," *Tropical Medicine and International Health* 9(1): 178-86.

CSA. 1999. *The 1994 Population and Housing Census of Ethiopia. Results for Addis Ababa. Volume II: Analytical Report*. Addis Ababa: Central Statistical Authority (CSA), Office of Population and Housing Census Commission.

Diaz, Theresa, Georges Loth, James Whitworth, and Donald Sutherland. 2005. "Surveillance Methods to Monitor the Impact of HIV Therapy Programmes in Resource-Constrained Countries," *AIDS* 19(S2): S31-S37.

Egger, Matthias, Andrew Boulle, Mauro Schechter, and Paolo Miotti. 2005. "Antiretroviral Therapy in Resource-Poor Settings: Scaling Up Inequalities?" *International Journal of Epidemiology* 34(3): 509-12.

Gebo, K. A., J. A. Fleishman, R. Conviser, E. D. Reilly, P. T. Korthuis, R. D. Moore, J. Hellinger, P. Keiser, H. R. Rubin, L. Crane, F. J. Hellinger, and W. C. Mathews. 2005. "Racial and Gender Disparities in Receipt of Highly Active Antiretroviral Therapy Persist in a Multistate Sample of HIV Patients in 2001," *J Acquir Immune Defic Syndr* 38(1): 96-103.

Loewenson, R. and D. McCoy. 2004. "Access to Antiretroviral Treatment in Africa," *BMJ* 328(7434): 241-2.

McCoy, D., M. Chopra, R. Loewenson, J. M. Aitken, T. Ngulube, A. Muula, S. Ray, T. Kureyi, P. Ijumba, and M. Rowson. 2005. "Expanding Access to Antiretroviral Therapy in Sub-Saharan Africa: Avoiding the Pitfalls and Dangers, Capitalizing on the Opportunities," *Am J Public Health* 95(1): 18-22.

McNaghten, A. D., D. L. Hanson, M. S. Dworkin, and J. L. Jones. 2003. "Differences in Prescription of Antiretroviral Therapy in a Large Cohort of HIV-Infected Patients," *J Acquir Immune Defic Syndr* 32(5): 499-505 .

MOH. 2004. *AIDS in Ethiopia. Technical Document for the Fifth Edition.* Addis Ababa, Ethiopia: Ministry of Health, Disease Prevention and Control Department.

Reniers G, Araya T, Berhane Y, Davey G, Sanders EJ. 2006. *Gender differences in AIDS mortality following the introduction of antiretroviral therapy in Ethiopia*. Annual Meeting of the Population Association of America, Los Angeles, March 30 – April 1.

Reniers G, Araya T & Sanders EJ. 2006b. Life table estimates of adult HIV/AIDS mortality in Addis Ababa. *Ethiopian Journal of Health Development*, 20 (1): 3-9.

Rosen, S., I. Sanne, A. Collier, and J. L. Simon. 2005. "Hard Choices: Rationing Antiretroviral Therapy for HIV/AIDS in Africa," *Lancet* 365(9456): 354-6.