Assessing the economic impact of HIV/AIDS on Nigerian households: a propensity score matching approach

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Objectives: We used a novel approach to assess the impact of HIV/AIDS on individuals' healthcare utilization and spending in the Oyo and Plateau states of Nigeria and income foregone from work time lost.

Methods: Data from a 2004 random survey of over 6400 individuals were compared with a sample of 482 individuals living with HIV/AIDS. Estimating the effect of HIV is complicated by the fact that our sample of HIV-positive individuals was non-random; there are selection effects, both in acquiring HIV and being in our sample of HIV-positive people, which was based on contacts through non-governmental organizations. To overcome these, we compared HIV-positive people with a control group with similar observed characteristics, using propensity score matching. The matched HIV-negative individuals had worse health and greater health spending than the full HIV-negative group. This suggests that our HIV sample would not have had 'average' outcomes even if they had not acquired HIV.

Results: Compared with our matched control group, HIV is associated with significantly increased morbidity, healthcare utilization, public health facility use, lost work time and family time devoted to care-giving. Direct private healthcare costs and indirect income loss per HIV-positive individual were 36 065 Naira, approximately 56% of annual income per capita in affected households. Approximately 40% of these costs were income losses associated with sickness and care-giving. 10% of the cost of HIV is accounted for by public subsidies for health. The largest single cost, representing 54% of the total economic burden of HIV, is for out-of-pocket expenses for healthcare.

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Introduction

The economic and social impacts of the HIV/AIDS epidemic in sub-Saharan Africa have attracted much attention [1,2]. Households affected by HIV/AIDS may cut back on non-health-related expenditures, and children's nutritional status and educational attainment may suffer [3–6]; household members may also reallocate their efforts away from income-earning activity to care-giving. When large expenditures go towards treatment and funerals, care-giving responsibilities increase and income is lost as a result of premature mortality and morbidity among younger adult wage earners, households may be unable to cope with the financial shocks [2,7]. These effects are exacerbated if drugs for AIDS treatment are expensive, if public subsidies for care are limited, or if health insurance is unavailable [8,9]. There are also psychic costs associated with the death and illness of family members, or stigma associated with HIV [10,11].

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With more than 5% of Nigeria's adult population infected with HIV, the effects of HIV/AIDS on Nigerian households are of obvious policy relevance, but little is empirically known about them. This paper contributes to filling that gap. We also make a methodological contribution: to estimate the direct and indirect economic costs of HIV/AIDS we need to compare observed health and economic outcomes with the outcomes we would expect in the absence of HIV. Recent work has compared economic outcomes in households with an HIV-positive member with a random sample of households [12]. Being HIV positive is not random, however, and may correlate with confounding characteristics, which would themselves affect health expenditures and economic outcomes. This selection effect will be present in any survey; ours has a further selection effect because our sample of HIV-positive people is based on contacts through non-governmental organizations (NGO) and therefore is not random.

Some studies have attempted to circumvent this selection problem by focusing on the economic impact of adult mortality without reference to HIV status, assuming the economic effect of HIV/AIDS is the same as for other causes of death [2,13,14]. Others have relied on ad hoc matching of households affected by HIV with those that are not [4,15,16]. We used a formal approach to address this selection effect by creating a control group of individuals from our random sample. For each HIV-positive person, we found a control possessing similar observed predetermined characteristics. We could then assess the economic impact of being HIV positive by comparing the outcome for each person with his, or her, matched control. As it is difficult to match on all characteristics that influence selection simultaneously, we used the propensity score matching method, which combines all of the covariates into one number and match on that scalar summary [17].

Our matched control group was quite different from our random sample of people, both in terms of their observed characteristics such as educational level, age and religion, and in terms of their health and economic outcomes. Matching to the control group therefore made a significant difference to our estimates of the economic impact of HIV.

Data and methodology

Data

We focused on households in two Nigerian states, Oyo and the Plateau. Although accounting for only approximately 6.3% of Nigeria's total land area and a roughly similar share of its population, these two states offer insights for Nigeria overall because of their considerable geographical and ethnic variations. Furthermore, official adult HIV prevalence rates based on sentinel surveys, 3.9% for Oyo State and 6.3% for Plateau State, are not far from the national average of 5.6%.

Two types of households were sampled: 'general' households, randomly selected from the population, and households explicitly identified as having HIV-positive members. To ensure adequate rural–urban representation, the sample was stratified into two urban and two rural local government areas in each state. Urban residential areas were stratified by economic status: low, medium and high. Within each stratum, streets were randomly chosen, followed by a systematic selection of houses on the basis of the number of buildings in each street. When more than one household lived in a building, a single household was selected by ballot. We used a similar procedure for rural households, except we did not stratify residential areas by living standards, given the more economically homogeneous nature of the population. This sampling approach was adopted after unsuccessful attempts to use enumeration area maps of the National Population Commission, which were based on the census of 1991 and were out of date. The survey was administered by introducing the study to heads of households and obtaining their verbal consent. A trained field worker then proceeded to carry out a structured questionnaire.

We used a different sampling strategy for households with HIV-positive members. These households were sampled purposively because a probability sampling approach was unlikely to identify a sufficiently large sample when infected persons are unwilling to 'self-identify'. The study was introduced to hospitals and NGO working with people with HIV, and their staff initially obtained the verbal consent of eligible respondents. Subsequently, trained field workers were introduced to persons living with HIV/AIDS; the prospective respondents were re-introduced to the study's objectives and their consent was obtained in writing. Because NGO activity in rural areas is limited, most HIV-positive sample households were identified from urban locations. Hospitals were the main entry point for rural locations.

All sampling took place in May 2004. Overall, 1481 households were sampled, 999 'general' households and 482 with an adult member explicitly identified with HIV. The survey collected data on a variety of household and individual-level characteristics. Apart from demographic information on each household member, such as age, sex, marital status, etc., socioeconomic information, such as individuals' education, literacy and work status, ethnicity, earnings, income from sources other than labor earnings, household expenditures, assets and other indicators of living conditions was collected. We also collected data on illness in the 4 weeks preceding the survey; hospitalizations and illness exceeding 3 months in the preceding year; the type of health facility where treatment was sought; out-of-pocket health expenditures; transportation expenses linked to care; funeral expenses; the length of time during which an individual was unable to perform normal activities; time spent in care-giving by non-ill members of the household; and on health financing.

Methodology

We compared morbidity rates, hospitalization rates, inpatient stays, amounts spent out-of-pocket for health-care, work time forgone by sick persons, and time spent by other household members in caring for sick individuals (also comparing care-giving for individuals who were HIV positive with care-giving for those who were not).

Our sampling framework gives rise to a number of problems. Due to the sensitivity around reporting HIV status, our random survey of households, who we labelled 'HIV negative' may in fact have been HIV positive. This will lead to an underestimate of the gap in outcomes between HIV-positive and negative individuals. Given an HIV prevalence rate of approximately 5% in Nigeria, our estimate will be 95% of the true gap, which suggests this bias is not large.

The major worry is that the status of being HIV positive and counted in our sample is itself non-random and may correlate with an individual's other confounding characteristics. To address this concern, we used propensity score matching methods to generate a set of controls (self-reported HIV-negative individuals) corresponding to treatment cases (self-reported HIV-positive individuals). In particular, individuals who were HIV positive were matched to HIV-negative individuals with similar predicted probabilities (propensity score) of being HIV positive, conditional on a set of observable characteristics.

The key assumption in this approach is that conditional on the propensity score, assignment to the treatment (HIV-positive) and control (HIV-negative) groups can be taken to be random [17]. If this is the case, then the difference in outcomes between treatment and control groups can be directly compared to give the effect of 'treatment'. One test of this assumption is that, conditional on the propensity score, the observable predetermined characteristics of the two groups have similar distributions. Even if this 'balancing' property is satisfied, we still have to assume that selection to the treatment group is not based on unobservable characteristics that also affect our outcome variables. A better approach would be to match on characteristics measured before infection, since these should not be influenced by HIV status. Unfortunately we only have cross-sectional data measured after infection for the HIV positive and are restricted to match on characteristics that are not affected by HIV status.

We used four procedures, which all use propensity scores, to assess 'nearness' between control and treated cases: the stratification method, nearest-neighbor method, radius method and the kernel method [18]. Matching is carried out with replacement so that one individual can potentially serve as the control for several HIV-positive individuals. These methods all yielded very similar estimates of the impact of HIV/AIDS on outcomes. Treatment cases and control cases were further restricted to a common support, thereby eliminating cases in which the treatment and nearest control may be quite far apart. The 'propensity score' on which these individuals were matched was constructed by a logit regression of treatment status (1 if HIV positive, 0 if not) on observables that included age, sex, age-squared and rural origin; indicators of primary, secondary and higher levels of education; state of residence, and indicators of religion and ethnicity. The list of explanatory variables used for this matching exercise includes individual characteristics, and does not include household incomes, household size, marital status, health expenditures, or asset holdings, because these variables are all likely to be influenced by HIV status. Including endogenous household level variables in the matching would have severely biased our results.

Results

Table 1 presents the logit regression used to generate propensity scores for matching controls to treated cases. The propensity score is the predicted probability of reporting HIV-positive status, conditional on a full set of predetermined variables, reported in Table 1, for each individual. Each explanatory variable was interacted with a dummy for male or female; this allows each explanatory variable to affect mens' and womens' likelihood of being HIV positive differently. We report two columns of coefficients in Table 1, one for men and one for women, though there is in fact only one propensity score regression.

Results from the propensity score regression suggest that, for the sample in question, HIV prevalence rises with age at first and then declines. The peak age at which women are most likely to report themselves HIV positive is approximately 39 years, whereas the peak for men is approximately 45 years of age. For women, primary and secondary school education appears to increase the risk of HIV, relative to the baseline of those who have not completed primary education, whereas for men primary schooling increases the risk but postsecondary education appears to lower it. Muslim men in our sample appear to be more likely to be HIV positive, whereas membership of the dominant ethnic group lowers risk.

We used our estimated propensity score from the regression in Table 1 to match each HIV-positive individual with a control individual. We used nearest-neighbor matching (random assignment if equidistant and with replacement). Table 2 summarizes sample means for three groups: individuals with HIV (the treatment group); individuals from the random sample who are matched to the treatment

Table 1. Propensity score regressions.

Variables	Men	Women
Constant	−10.838[a] (0.802)	−10.439[a] (0.870)
Age (in years)	0.448[a] (0.040)	0.456[a] (0.049)
Age-squared	−0.005[a] (0.0005)	−0.006[a] (0.0007)
Rural dummy (rural 1, 0 otherwise)	−0.222 (0.150)	−0.407[a] (0.160)
State dummy (Oyo 1, 0 otherwise)	−1.153[a] (0.185)	−0.612[a] (0.184)
Dummy for primary schooling	0.537[a] (0.216)	0.490[a] (0.227)
Dummy for secondary schooling	0.042 (0.200)	0.680[a] (0.189)
Dummy for higher education	−0.509[a] (0.192)	−0.209 (0.214)
Dummy for religion (Muslim 1, 0 otherwise)	0.749[a] (0.177)	−0.005 (0.200)
Dummy for dominant ethnic groups (Yes 1, 0 otherwise)	−0.562[a] (0.169)	−0.317[b] (0.179)
Logit regression chi-square (d.f. 21)	689.41	
Number of observations	6937	

Source: Authors' estimates.
[a]Statistically significant at the 5% level.
[b]statistically significant at the 10% level.
d.f, degrees of freedom.

group under the nearest-neighbor rule (the HIV-negative control group); and the full set of HIV-negative individuals in the random sample. Notice that for our predetermined variables: age, sex, religion, and ethnicity, there are considerable differences in the sample means between the treatment group (column 1 in Table 2) and the unmatched group (column 3). For example, the HIV-positive individuals are older, better educated, and more likely to be male than individuals from the random sample. Once the nearest-neighbor criterion is used to generate a matched set of controls, however, the sample means of the predetermined variables of the matched control group, shown in column 2 of Table 2, are considerably closer to those of the HIV-positive group.

Note that an alternative to the full propensity score matching exercise described above would be to match men only with men and women with women, but use propensity scores for matching within each group. This produced results very similar to full propensity score matching (results available upon request).

The propensity score matching approach mimics an experimental design with a treatment and control group. The control group is, however, only truly valid if being HIV positive is random after conditioning on the controls we used. If being HIV positive is correlated with unobserved confounders we may be measuring the effect not of being HIV positive but of these confounders. In the

Table 2. Summary statistics for households reporting HIV-positive members (treatment) and households without HIV-positive members (control).

Variable	Treatment individuals (HIV positive)	Matched control individuals (HIV negative)	All HIV-negative individuals
Explanatory variables in propensity score regression			
Average age (in years)	39.28	38.90	28.19
Share of men (%)	54.29	52.39	50.62
Rural residence (%)	38.16	36.46	39.29
From Oyo State (%)	33.54	35.64	48.08
Completed primary only (%)	18.24	20.34	10.20
Completed secondary only (%)	28.51	30.81	22.94
Completed high school or higher (%)	24.11	23.91	21.59
Proportion belonging to dominant ethnic groups	67.92	65.22	80.17
Share of Muslims (%)	25.16	21.76	23.99
Outcome variables			
Illness in past 4 weeks (%)	44.23	14.33	10.46
Hospitalization in past 1 year (%)	27.04	7.44	4.44
Major illness in past 1 year (%)	42.55	12.65	7.31
Hospital expenses in last one year (in Naira)	10729	2185	1329
Healthcare expenses in past 4 weeks (Naira)	2629	1812	536
Work/usual activity sacrificed in past year (in days)	18.70	2.61	1.30
Work/usual activity sacrificed in past 4 weeks (in days)	2.41	0.74	0.38
Household asset index	−0.16	−0.24	−0.08
Household size	5.49	6.98	7.23
Number of individuals	477	900	6460

Source: Authors' calculations, using household survey data for Nigeria. Asset index was derived on the basis of principal component methodology. Dominant ethnic groups referred to four groups that comprised 78% of the sample households – Yoruba, Birom, Ngas and Igbo. A matched control group for the treatment group was generated by identifying the individual with the closest propensity score under the nearest-neighbor (random matching) methodology. See Becker and Ichino [18] for more details.

absence of real experimental data, estimating the effect of being HIV positive adjusting for observable confounders, as we did, seems better than not adjusting at all, even if it falls short of adjusting for all possible confounding effects.

Note from Table 2 that when we compared the outcomes of interest of the treatment with the matched control group: morbidity rates, hospitalization rates, health expenditures and work time lost, the differences in sample means, with few exceptions, were large (in contrast to the set of predetermined variables). These differences are caused by the presence of HIV. Moreover, the outcome variables can be very different between the matched control group and the sample of all HIV-negative individuals. This indicates that individuals with the same predetermined characteristics as HIV-positive individuals differ in their outcomes from the average of the random sample.

Table 3 presents our findings on the effect that HIV has on health outcomes, spending, work time loss and time spent on care-giving. For each variable we compared the outcome for the HIV-positive individuals with that for a set of matched controls. All healthcare utilization and spending was measured for the individual (most surveys look at household utilization and expenditure – we have individual level data). Column 1 of Table 3 reports the differences in outcomes using nearest-neighbor matching in which each HIV-positive person is matched with the individual in the random sample with the closest propensity score. In cases in which two or more individuals are equally close we chose between them randomly to make the match. In column 2 of Table 3 we repeated the nearest-neighbor matching but put equal weight (the weights sum to one) on each possible match when two or more were equidistant. In column 3, we used radius matching, using as controls every observation that is within 0.01 of the HIV-positive person's propensity score. In column 4 we used kernel matching using all observations in the random sample of controls but weighting those that were close to the HIV-positive individual's propensity score. Finally, in column 5 we split the HIV-positive individuals into strata, based on their propensity scores, and matched them with all the individuals from the random sample that fell into the same stratum. We report the size of the average difference between the outcome for the HIV-positive individuals and the matched control group, and a *t*-statistic for the statistical significance of this difference based on bootstrapping the standard error of our estimate.

The results of the different matching methods are quite similar. We found that individuals with HIV report a greater incidence of morbidity and a greater use of health services, out-of-pocket health expenses and care-giving hours than their matched HIV-negative counterparts. HIV-positive individuals were approximately 20 percentage points more likely to report hospitalization in the past year than the matched controls. They were approximately 35 percentage points more likely to report a major illness and had approximately 3 more days of inpatient care over the same period. HIV-positive persons also reported greater out-of-pocket expenses, by approximately 9000 Naira, approximately 16 additional work days lost, and over one hour more of care time per day, than matched controls.

HIV-positive individuals also used more of both public and private healthcare services, but their utilization of

Table 3. Effect of HIV-positive status on morbidity, hospitalization, health spending, loss of usual activity and care-giving among matched individuals: estimates from five different matching methods.

Indicator	Nearest-neighbor (random)	Nearest-neighbor (equal weights)	Radius	Kernel	Stratification
Last 4 weeks					
Morbidity rate (%)	29.90 (10.67)	29.40 (10.48)	30.50 (12.99)	31.30 (13.39)	30.30 (12.81)
Inpatient stays (%)	6.10 (3.91)	5.80 (3.71)	5.70 (4.23)	5.70 (3.76)	5.50 (3.99)
Inpatient days (in days)	0.62 (3.78)	0.62 (3.79)	0.61 (3.83)	0.58 (3.40)	0.58 (3.59)
OOP health expenses (in Naira)	817 (0.73)	503 (0.45)	1846 (3.73)	1807 (3.08)	1727 (3.26)
Lost work time/usual activity	1.67 (5.66)	1.62 (5.50)	1.87 (6.83)	1.87 (6.57)	1.81 (6.49)
Used a public health facility (%)	14.10 (6.51)	14.00 (6.45)	15.20 (8.01)	15.40 (7.14)	15.00 (7.76)
Used a private health facility (%)	16.60 (7.45)	16.40 (7.37)	15.90 (8.08)	16.10 (9.09)	15.80 (7.95)
Last 1 year					
Inpatient stays (%)	19.60 (8.36)	20.00 (8.53)	21.10 (10.14)	20.70 (10.50)	20.30 (9.71)
Inpatient days (days)	3.03 (5.16)	3.03 (5.15)	2.90 (5.04)	2.90 (4.85)	2.91 (5.03)
Incidence of major illness (%)	35.60 (13.12)	36.10 (13.28)	39.30 (16.76)	37.80 (16.24)	37.10 (15.91)
OOP health expenses (Naira)	8544 (4.18)	8260 (4.04)	9415 (5.28)	9340 (5.47)	9317 (5.24)
Lost work time/usual activity for sick (in days)	16.09 (6.86)	15.96 (6.81)	16.88 (7.40)	16.62 (7.80)	16.59 (7.30)
Daily hours of care-giving for sick (when ill)	1.14 (9.65)	1.17 (9.91)	1.31 (12.53)	1.25 (12.57)	1.22 (11.42)
Public facilities used? (%)	21.00 (9.25)	21.20 (9.32)	22.30 (10.83)	21.50 (10.78)	21.10 (8.059)
Private facilities used? (%)	8.80 (4.67)	9.30 (4.91)	11.00 (6.65)	10.70 (6.45)	10.50 (6.29)
Observations (treatment)	477	477	474	477	474
Observations (control)	900	900	5281	5285	5288

OOP, Out-of-pocket. Estimates are of the average treatment effect, under each matching method; the radius was taken to be 0.01 under the 'radius method'; *t*-statistics are reported in parentheses below estimates of the average treatment effect.

Table 4. Annual direct and indirect income losses from ill health (in 2004 Naira).

Individual type	Out-of-pocket expenses	Public subsidies	Lost income from work (ill person)	Lost income (care-giver)	Total loss (direct + indirect)	Household annual income per capita
HIV positive	21 589	3890	12 030	2446	39 955	49 623
Matched controls	4621	742	4694	242	10 298	79 723
All HIV negative	3853	575	2578	56	7062	93 375

These estimates are for matched treated and control cases, as well for the entire HIV-negative population. Out-of-pocket expenses are primarily payments made for receiving care. These are estimated by adding annual hospitalization expenses to 12 times the out-of-pocket spending on outpatient care in the past 4 weeks. A small portion (in per capita terms) of these expenses is accounted for by funeral expenses. Public subsidies are calculated by multiplying utilization of (inpatient days and outpatient visits) public sector of matched HIV-positive and HIV-negative individuals by the cost of a single inpatient day and outpatient visit in the public sector (because user fees are negligible). To obtain unit costs, we divided annual total public sector expenditures for curative care (as reported for Oyo State) by a weighted sum of estimated inpatient days and outpatient visits (assuming each outpatient visit costs approximately one-seventh of an inpatient day), using per capita utilization estimates from our household survey and population estimates from the National Population Commission of Nigeria. Our estimated unit subsidies are Naira 139 per outpatient visit and Naira 976 per inpatient day; lost income/usual from work for ill person was estimated by multiplying days lost from the survey by a daily wage imputed (those for whom wage data were unavailable) by regressing the log of daily wage on a collection of explanatory variables such as educational status (primary, secondary or higher education), experience and experience-squared, sex, ethnicity, state of residence and religion; lost income from care-giving was estimated similarly.

public services was disproportionately larger. This is not surprising in light of the expense of treating conditions associated with HIV/AIDS, and particularly for antiretroviral treatment.

These findings translate into significant losses to households (and government) in terms of direct medical care costs as well as incomes foregone by sick household members and their caregivers. Table 4 presents our estimates of medical care expenses and income losses associated with illness in the treatment group, the matched control group and the unmatched set of HIV-negative individuals, based on the results in column 1 of Table 3. Our estimates focus on incomes lost in a given year and do not include future incomes likely to be lost as a result of premature morbidity and mortality. The direct and indirect costs of morbidity associated with HIV/AIDS turned out to be remarkably large. Out-of-pocket expenses on healthcare by HIV-positive individuals were nearly five times those of matched HIV-negative individuals and nearly 40% of the per capita income of the affected households (note that this household income is significantly lower for the HIV-positive than the control group, and is probably endogenous).

Our analysis also confirms the relatively large burden on household caregivers, and the considerable reliance on public subsidies. Because our calculations do not fully account for differences in the intensity of care received by HIV-negative and HIV-positive individuals at public facilities, the estimates in Table 4 probably underestimate the reliance on public subsidies.

Discussion

Some of these lost incomes and health expenditures may be recouped by allowances for sick leave, health insurance and reimbursements for health expenses by employers, or financial support from the extended family or community. Our survey data suggest, however, that health insurance coverage is rare, and community support is limited in Nigeria, particularly for people with HIV. Elsewhere, we report survey findings that Nigerian employers discriminate against employees with HIV when it comes to benefits associated with illness [19]. The financial burden is thus most likely to fall squarely upon individuals with HIV and their families. Our survey information on asset sales in response to illness further confirmed the nature of this burden: for 13% of the treatment group, household members sold assets to pay for illness-related expenses in the preceding year, compared with 2.5% for the control group.

Our results are consistent with other studies. Using an unmatched sample of HIV-negative individuals in India, Pradhan *et al.* [15] found that health expenditures of households with an HIV-infected member amounted to approximately 19% of their non-food spending, three times the share of households with no HIV-positive members. A study in South Africa that compared households with HIV-positive members with their HIV-negative neighbors found that HIV-affected households reported greater morbidity and utilization of public sector health providers [20]. Booysen *et al.* [4] found that direct and indirect income losses from HIV/AIDS exceeded three times the average monthly income per capita of a household. Studies in Kenya, Tanzania and Uganda have also found a strong association between adult mortality, asset sales and income losses to households [2,13,21].

In conclusion, HIV-affected households in Nigeria face serious economic challenges compared with their HIV-negative counterparts. These include substantial income losses and an increased burden of care-giving and out-of-pocket healthcare spending. Community and other sources of formal or informal insurance are scarce, so Nigerian households must rely on their own resources to meet healthcare expenses and deal with income losses.

The significance of these findings is tempered by our relatively small-sized and geographically limited household sample; we focused on only two of the 36 Nigerian states (excluding Abuja). Our survey was undertaken over a period of one month during May 2004, and this timeframe may not capture seasonal biases. The lack of longitudinal analysis is another serious issue of concern. If unobservable characteristics influenced the risk of HIV infection or healthcare utilization, such as high rates of discounting the future, or higher pre-infection incomes leading to greater use of sex worker services, or if health facilities were in close proximity in the past (enabling sexually transmitted infection treatment), matching on currently observable characteristics will not yield reliable estimates of the economic impact of HIV infection. In these circumstances, information on pre-infection socioeconomic characteristics is useful, which we do not possess.

These limitations notwithstanding, we believe our strong and consistent findings provide a valid basis for policy conclusions. Increased access to public facilities and financing is obviously important, given the limited access to other sources of financing among people with HIV. These may include subsidized access to antiretroviral drugs. When patients with HIV are unaware of services available at public and mission facilities, increased coordination with traditional healers and others who often treat people with HIV may lead to more referrals to public facilities. The private sector could also be engaged with by tax incentives to provide treatment for their HIV-positive employees and families.

Because of significant income losses associated with HIV/AIDS, increasing access to income-generating schemes for HIV-positive people is crucial. Much can be learnt from the experience of successful microfinance institutions that have helped address the financial needs of poor entrepreneurs [22,23]. Protecting the financial assets of people with HIV is also important. Nigeria could also promote HIV prevention programmes, because they are more cost-effective than treatment [24].

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References

1. Over M. *The macroeconomic impact of AIDS in sub-Saharan Africa*. Technical working paper no. 3. Washington, DC: The World Bank, Africa Technical Department; 2004.
2. Yamano T, Jayne TS. **Measuring the impacts of working-age adult mortality on small-scale farm households in Kenya.** *World Dev* 2004; **32**:91–119.
3. Bechu N. **The impact of AIDS on the economy of families in Cote d'Ivoire: changes in consumption among AIDS affected households.** In: *Confronting AIDS: evidence from the developing world.* Edited by Ainsworth M, Fransen L, Over M. Washington, DC: The World Bank; 1998. pp. 341–348.
4. Booysen F, van Rensburg D, Bachmann M, Engelbrecht M, Steyn F. **The socioeconomic impact of HIV/AIDS on households in South Africa.** *AIDS Bull* 2002. Available at www.mrc.ac.za/aids/march2002/economic.htm. Accessed: July 2005.
5. Donovan C, Bailey L, Mpyisi E, Weber M. Prime age adult morbidity and mortality in rural Rwanda: Effects on household income, agricultural production and food security strategies. Kigali, Rwanda: Ministry of Agriculture, Livestock and Forestry; 2003.
6. Nampanya-Serpell N. **Social and economic risk factors for HIV/AIDS affected families in Zambia.** Presented at the *AIDS and Economics Symposium*. Durban, South Africa, 7–8 July 2002.
7. Barnett A, Blaikie P. *AIDS in Africa: its present and future impact.* New York: The Guilford Press; 1992.
8. Bloom DE, Glied S. **Who is bearing the burden of the AIDS epidemic in Asia?** In: Bloom, D., Lyons, J., editors. *Economic implications of AIDS in Asia.* New Delhi: Oxford University Press; 1993.
9. Guinness L, Alban A. *The economic impact of AIDS in Africa: a review of the literature*. UNAIDS background paper for the Africa Development Forum (ADF). Geneva: UNAIDS; 2000.
10. Bolton P, Ndogoni L. Cross-cultural assessment of trauma-related mental illness. A report of research conducted by World Vision Uganda and The Johns Hopkins University. Baltimore, MD: Johns Hopkins University; 2001. Available at: http://www.certi.org/publications/policy/ugandafinahreport.htm. Accessed: May 2007.
11. Germann S. **Psychosocial impact of HIV/AIDS on children**. *AIDS Bull* 2004. Available at www.mrc.ac.za/aids/june2004/impact.htm. Accessed: July 2005.
12. Canning D, Mahal A, Odumosu K, Okonkwo P. **The impacts of HIV/AIDS on Nigerian households.** In: *AIDS in Nigeria: a nation on the threshold.* Edited by Adeyi O, Idoko J, Kanki PJ, Odutolu O. Cambridge: Harvard University Press; 2006. pp. 193–212.
13. Menon R, Wawer M, Konde-Lule J, Sewankambo N, Junli C. **The economic impact of adult mortality on households in Rakai district, Uganda.** In: *Confronting AIDS: evidence from the developing world.* Edited by Ainsworth M, Fransen L, Over M. Washington, DC: The World Bank; 1998. pp. 325–339.
14. Lundberg M, Over M, Mujinja P. *Source of finance assistance for households suffering an adult death*. Working paper no. 2508. Washington, DC: The World Bank; 2000. Available at: http://econ.worldbank.org/files/1320_wps2508.pdf). Accessed: May 2007.
15. Pradhan B, Sundar R, Singh S. *Socioeconomic impacts of HIV/AIDS in India.* New Delhi, India: National Council of Applied Economic Research; 2006.
16. Das S, Mukhopadhyaya A, Ray T. *Long run economic costs of HIV/AIDS in India*. New Delhi, India: Indian Statistical Institute, Planning Unit; 2006.
17. Rosenbaum P, Rubin D. **The central role of the propensity score in observational studies for causal effects.** *Biometrika* 1983; **70**:41–55.
18. Becker S, Ichino A. **Estimation of average treatment effects based on propensity scores.** *Stata J* 2002; **2**:358–377.
19. Canning D, Mahal A, Odumosu K, Okonkwe P. **The economic impact of HIV/AIDS on Nigerian firms.** In: *AIDS in Nigeria: a nation on the threshold.* Edited by Oadeyi O, Kanki P, Odutolu O, Idoko J. Cambridge, MA: Harvard Center for Population and Development Studies; 2006. pp. 175–191.
20. Bachmann M, Booysen F. **Health and economic impact of HIV/AIDS on South African households: a cohort study**. *BMC Public Health* 2003. Available at www.biomedcentral.com/1471-2458/3/14. Accessed: May 2008.
21. Mujinja P, Over M. **The impact of AIDS on health care utilization and expenditure by the fatally ill in northwest Tanzania**. In: *International Conference on AIDS.* Berlin, Germany. 6–11 June 1993 [Abstract no. WS-D123–1].
22. Basu A, Blavy R, Yulek M. *Microfinance in Africa: experience and lessons from selected African countries*. Working paper no. WP/04/174. Washington, DC: The World Bank; 2004.
23. Claudio Gonzalez-Vega C, Schreiner M, Meyer R, Rodriguez-Meza J, Navajas S. **BancoSol: the challenge of growth for microfinance institutions.** In: *Microfinance for the poor.* Edited by Schneider H. Paris: Organization for Economic Cooperation and Development; 1997. pp. 129–170.
24. Canning D. **The economics of HIV/AIDS in low-income countries: the case for prevention.** *J Econ Perspect* 2006; **20**:121–142.