The impact of the food crisis on adherence to antiretroviral treatment and on treatment success among HIV/AIDS patients in Mozambique[1]

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Abstract

People living with HIV/AIDS in Africa are among the most vulnerable because of the debilitating effect of the illness, which prevents them from having an income-generating activity. As highly active anti-retroviral treatments are developed, and access to this therapy scaled-up, they are able to improve their health to a point of living a normal life. The treatment, however, requires to be taken in certain conditions, such as after a nutritious meal, and can be costly in terms of travel to the health facility, even if the drug regimen is subsidized. In this context, the impact of a food crisis on welfare, and in particular, on food consumption, can have a very negative impact of adherence to treatment and health outcomes. To test this hypothesis, we use data from a longitudinal survey carried out in Mozambique in 2007 and 2008, which was designed to include households with HIV positive individuals as well as comparison households with no identified HIV positive members. Food grain prices have risen by 150% between January 2006 and June 2008, with about 40% of that rise that occurred in just the first half of 2008. We find that, as a likely effect of the food crisis, there has been a real deterioration of welfare in terms of income, food consumption and nutritional status in Mozambique between 2007 and 2008, among both HIV and comparison households. However, HIV households have not suffered more from the crisis than others. We conjecture that initiation of treatment and better services in the health facilities have counter-balanced the effect of the crisis by improving the health of patients and their labor force participation.

1. Introduction

HIV/AIDS is the leading cause of adult mortality in Africa. In Mozambique, 12.5% of adults were HIV positive in 2008 (UNAIDS/WHO, 2008). The proportion of HIV positive patients with an advanced infection receiving HAART (Highly Active Antiretroviral Treatment) in Mozambique was 24% in 2007 (UNAIDS/WHO, 2008). Adherence to treatment is a key determinant of treatment success and is crucial in avoiding the development of resistances. Antiretroviral therapies need to be taken at least once a day and need to be taken after a meal to avoid side effects. Good nutrition is therefore an essential element in ensuring adherence and treatment success among HIV/AIDS patients. The food crisis that culminated in 2008 constitutes a major risk by reducing access to food for HIV/AIDS patients who generally are already among the most vulnerable groups in the communities. In addition, even if the antiretroviral medicines are generally subsidized, access to treatment is costly in terms of travel to the health facility and opportunity costs for patients and their households.

This context brings up two questions that we try to answer in this paper. First, what is the impact of the food crisis on adherence to antiretroviral treatment? And next, what is the impact of the crisis on treatment outcomes and the health status of HIV/AIDS patients? Prior to these analyses, we need to assess whether there has been an impact of the food crisis on the economic status of households, in particular those households that include a person living with HIV/AIDS. We use data from a longitudinal survey carried out in Mozambique in 2007 and 2008, which was designed to include households with HIV positive individuals as well as comparison households with no identified HIV positive members.

At the global level, food grain prices have risen by 150% between January 2006 and June 2008, with about 40% of that rise that occurred in just the first half of 2008 (World Bank, 2008). Ivanic and Martin (2008) have estimated that, as a consequence of higher global food prices, worldwide, the 2.3 billion people living with less then 2$ a day will become poorer, while 100 million will fall into poverty. There are multiple channels by which a food (and fuel) crisis can negatively impact human development, such as reducing the utilization of education and health services, depleting the

productive assets of the poor and, in particular, worsening nutrition, as food prices are higher (World Bank, 2008).

The welfare impact of a rise in food prices depends on the distribution of net sellers and net buyers of food in an economy, and can be represented by the concept of Net Benefit Ratio (NBR) of a food price shock, introduced by Deaton (1989). The NBR is the difference between the ratio of food sales over total income and the ratio of food purchases over total expenditures for a household. If the NBR of a household is positive, a rise in food prices will increase the NBR and thus have a positive impact on its welfare. On the contrary, a net consumer (NBR < 0) will suffer from such a shock. In urban areas, where most households are net consumers, a rise in food prices is likely to have a negative impact on welfare, whereas it is more contrasted in rural areas. Poor rural households are often unable to produce a marketable surplus that exceeds their food expenditures, and if such is the case their welfare will worsen as a result of the food crisis.[2] Arndt et al. (2008) assess the impact of higher fuel and food prices in Mozambique at the households and macroeconomic level. As this country is a net importer of food and imports all its fuel, the crisis is a negative terms-of-trade shock. Rice and maize prices increased by 68.8% and 57.3% in Maputo respectively, which is slower than international prices, but wheat prices increased faster (107.6%). While rural Mozambican households are fairly well insulated from a variation in market prices because of the large part of food consumption that is home produced, poor households living in Maputo city will suffer the most, because consumption of own-produced food is non-existent. Arndt et al. (2008) predict that the poorest households in Maputo lose the most while middle-income groups in the rural north and center gain the most. While a rural/urban HIV prevalence breakdown is unavailable for Mozambique, data from other African countries show that most people living with HIV/AIDS in Africa live in urban areas (Measure DHS, 2008). Moreover, the province breakdown shows that the southern (where Maputo city is situated) and central provinces have the highest rates of prevalence of HIV/AIDS in Mozambique (Republic of Mozambique National AIDS Council, 2008). People living with HIV/AIDS are already a vulnerable group because of the

[2] The NBR does not allow for behavioral changes on the part of producers or consumers and measures only first order impact. As households and firms modify the structure of their consumption and production, second order adjustments should dampen any negative first-order impacts.

negative impact of the illness on labor force participation or the cost and difficulty of accessing treatment. A negative impact of the crisis on their welfare and nutritional status is thus to be expected.

Medical research has established that a minimum level of adherence to ARV treatment of 95% is necessary to achieve significantly better health outcomes as assessed by the viral load, immune system and occurrence of opportunistic infections (Paterson et al., 2000). Non adherence predicts disease progressions and survival rates, and increases the risk of transmission of drug resistant viruses (Bangsberg et al., 2001, De Olalla et al., 2002, Falagas et al., 2008). Failure to achieve proper adherence to treatment is thus both an individual and collective risk. Determinants of adherence depends on several factors such as the treatment regimen (which can be quite complex and include food restrictions, specific schedules, etc.), disease characteristics, the quality of the patient-provider relationship, or the clinical setting. Sociodemographic factors do not consistently predict adherence behavior (Ickovics & Meade, 2002). The meta-analysis by Falagas et al. (2008) on socioeconomic status as a determinant of adherence finds that while the relationship is unclear, there is a positive trend of association between income, education or employment status and adherence. It is worth noting that adherence is not found to be consistently lower in developing countries, and largely depends on access to treatment and financial barriers (Orrel et al., 2003b). When therapy is fully subsidized, it can be at least as good as in developed countries (Orrel et al., 2003a). Even when treatment is free, transportation costs to the health facility to get a prescription refilled are found to be a powerful barrier to adherence. Moreover, patients have to make "impossible choices" between competing claims: transport costs and good nutrition of the patients compete with schooling fees or medical costs for children, food for the rest of the family, etc. (Ware et al., 2009). As already mentioned, malnutrition can be an obstacle to adherence (Weiser, 2003). A negative shock on income or food access that may occur in the event of a food crisis, and more generally, of a global economic crisis, can therefore be a strong determinant of non-adherence to treatment.

The paper is organized as follows. In the next section, we present the dataset. In section III, we look at the impact of the food crisis on the welfare of households in the sample, differentiating by their HIV status. Section IV studies changes in adherence to treatment between 2007 and 2008, while

section V looks at the evolution of treatment outcomes, defined by the variation of the CD4 count of HIV patients. Section VI concludes.

2. The data

We use data collected in 2007 and 2008 in 4 provinces of Mozambique (Maputo City, Maputo Province, Sofala, Manica).The survey was designed to collect data in order to assess the impact of the Treatment Acceleration Project (TAP). The TAP is a World Bank project carried out in three countries of Africa: Mozambique, Burkina Faso and Ghana, which scaled-up access to HAART. The project began in 2004 and had a 4-year duration.

The HIV/AIDS patients of the survey were identified at the health facility where they received treatment and were interviewed at home along with the rest of the household. The questionnaire includes information on consumption, time use, labor force participation and earnings of not only the patient, but of all members of the household. It also included questions on adherence to treatment, health of adults and children, anthropometric measurements, and quality of life. We will refer to these households in which there is one HIV/AIDS patient identified as "HIV households" in the rest of the paper.

A group of comparison households was included in the sample, in which there was no identified HIV/AIDS patients, to control for general trends in socio-economic circumstances. The comparison households were randomly selected in the neighborhood of the HIV households of the sample.

The first wave of the survey, conducted between August and December of 2007, included 658 HIV households and 341 comparison households. In the second wave, one year later, HIV households that could not be found and interviewed were not replaced, but comparison households were. The panel consists of 896 households interviewed in both waves: 616 HIV households and 280 comparison households. At the individual level, there are 616 identified HIV positive patients, 2579 individuals living in HIV households but not identified as HIV positive, and 1431 individuals belonging to comparison households.

In addition to the living standards and health questionnaire, we collect biomedical records for HIV positive individuals at the health facility, allowing an objective measure of the health and treatment status of patients. These biomedical records include the date of treatment initiation as well as the dates, weights and CD4 counts at the last visits (up to 7) by the patient at the health facility. There are 498 observations in this biomedical record dataset, out of the 616 potential patients identified in the living standards and health survey.

3. Is there an impact of the food crisis on the welfare of households in Mozambique?

The first step of our analysis is to assess whether the food crisis had an impact on the welfare of households in Mozambique, and, in particular, on their nutritional status. Indeed, if the crisis lowers the income of households, then access to food could be restricted which will have a negative impact on adherence to treatment or health outcomes.

As mentioned in the introduction, a food crisis, namely, the drastic increase in the price of food products, affects different types of households differently. An urban household is mainly a net consumer of food and is therefore affected negatively by a price increase, whereas a rural household can be affected positively if he is a net seller of food. In the data, health facilities in which HIV patients are found for the survey are identified as rural or urban. Using this definition of urban or rural, we find that only 5% of the sample is rural, which is consistent with the fact that most HIV positive adults live in urban areas, where, in addition, access to antiretroviral treatment is easier. We can thus assume that their food consumption and nutritional status will be affected negatively by the food crisis. Although there is no way, with our data, to measure the direct impact of the food crisis on the overall welfare of households, we can use the change in income, food consumption and nutritional status between 2007 and 2008 as proxies for that impact. The food crisis indeed reached its peak between January and June 2008 and can be considered a systemic shock.

Income and consumption are measured on a monthly per adult equivalent basis, in meticais[3]. Income is the sum, over all members of the household, of labor income (wage, household business or

[3] 100 mts = $4.32 (November 2008)

farm), non labor income (insurance, pension, etc.), private and institutional transfers, and home produced food. Consumption is the sum of food consumption (purchased and home produced), non food items purchased, education, housing (water, electricity, etc.), health, ceremony and special events expenditures. Both income and consumption were deflated in 2008 using the consumer price index provided by the IMF, namely 6.2% (IMF, 2009). With the figures about the food crisis in mind, this number seems somewhat unrealistic, therefore we also calculated a specific food deflator, used to deflate a third measure of welfare: food consumption, which includes only purchased and home produced food. To compute this food inflation index, we used the survey data on purchased food products to calculate unit prices for each food product and shares in the consumption basket. On this basis, we calculated a Fisher price index, which is equal to 43.2% (see Appendix for more details on the construction of the food price index). Because food expenditures represent almost half of total expenditures in Mozambique, the inflation figure of 6.2% provided by the IMF is questionably low (INE, 2004). In this context, we decided to deflate income and consumption by our calculated food price index too.

The anthropometric measures used to proxy for households' nutritional status are the weight-for-age z-scores for children aged 1 to 10 years old, the body-mass-index and the height-for-age z-scores for children aged 5 to 19 years. These were computed using the WHO growth standard (De Onis et al., 2007). A household nutritional status measure was obtained by averaging each z-score over all the children in the household. Alternatively, we use the minimum z-score in the household.

Figure 1 shows the change in some of these measures for all households of the sample between 2007 and 2008. In this graph, income and consumption are deflated using the IMF figure (6.2%)[4]. One can see that the household mean weight-for-age z-score, the household mean bmi-for-age z-score and monthly income have strongly decreased, while food consumption weakly decreased and global consumption seems unchanged[5].

[4] As explained below, table 1 has another measure of consumption and income that uses another deflator, which we did not put in the graph for clarity reasons.

[5] One must keep in mind that anthropometric measures in settings where malnutrition is prevalent necessarily worsen over time as anthropometric failure is a cumulative process: if two children are born healthy but one is malnourished, the difference between the two will grow in time.

Table 1 shows the mean values of the welfare and nutritional measures in 2007 and 2008 and the p-value of the mean comparison Student tests. As in figure 1, income significantly decreased whatever the deflator used. There is some indication of consumption smoothing, as consumption did not decrease using the IMF deflator. It however diminished significantly when the 2008 value was deflated using the food price index. The two measures of income and consumption obtained using the different deflators probably provide an upper and lower bound for the change between 2007 and 2008. The real value of the change is thus situated somewhere between these two measures. The weight-for-age and bmi-for-age household mean and minimum z-score too have worsened between 2007 and 2008, while the height-for-age measure does not change.

We use a difference-in-difference specification to assess whether there was a specific impact of the crisis on HIV households. The equation estimated is:

$$y_{it} = \alpha_0 + \beta_1 X_{it} + \beta_2 HIV_i + \beta_3 d2008 + \delta HIV_i * d2008 + \varepsilon_{it},$$

where y_{it} is a measure of welfare or nutritional status, X_{it} is a set of controls that include characteristics of the head of household (age, age squared, education, sex), the number of children aged 0 to 14 in the household, the mean age of children over which the z-scores are computed for the anthropometric specifications, and province dummies (Maputo city province is the reference), HIV_i is a dummy that equals 1 if household *i* is HIV, 0 otherwise, $d2008$ is a dummy that equals 1 if year *t* is 2008, 0 otherwise.

In this equation, coefficient β_2 indicates whether HIV households are worse off or better off in general, whatever the year and β_3, capturing the trend, signals whether the economic or nutritional situation of all households improved or worsened between 2007 and 2008. Coefficient δ is the difference-in-difference estimator: it shows whether, once initial characteristics and the trend are controlled for, HIV households did better or worse than comparison households between the two waves.

Results in table 2 show that HIV households are generally worse off in terms of consumption, income and height-for-age of children. There is a general worsening of economic conditions between

2007 and 2008 seen in 8 of the 11 specifications. For income and consumption, we present in columns (1), (2) and (1a), (2a) respectively, measures using the two different deflators already mentioned, but we favor (1a) and (2a), as they show a negative impact of 2008 which is more consistent with columns (6) to (9) showing a deterioration of nutritional outcomes. The coefficient for 2008 in the height-for-age regressions is not significant, which is consistent with the fact that height-for-age is a measure of long-term nutrition while weight-for-age and bmi-for-age measure short-term nutritional status (WHO, 1995). Children belonging to HIV household have a growth deficit that is characteristic of long-term undernutrition or malnutrition, and this does not change in the short period of a year between the 2 waves of the survey. However, children belonging to all households have a worsened weight-for-age z-score between 2007 and 2008, which is consistent with a negative impact of the food crisis.

The interaction term $HIV_i * d2008$ has a positive and significant coefficient in two specifications and is not significant in all other cases. This shows that, even if HIV households suffer from the crisis between 2007 and 2008, they do not suffer more than the comparison households of the sample. One possible explanation for this is that there could be two opposite shocks on the welfare of HIV households simultaneously. The first one is of course the negative shock of the food crisis between 2007 that 2008. The second, positive shock could possibly be the initiation and the continuation of antiretroviral therapy. As ARVs become more available by being scaled-up, patients who were too ill to work started a treatment and could work again and increase their income.

Endogeneity issues are a limitation of this analysis. For example the negative coefficients on being HIV positive in either year (β_2) could be driven by some unobservable heterogeneity among households which explains both the level of welfare and the probability of being HIV positive. One must be cautious when interpreting the coefficient on HIV status in table 2. The effect is not necessarily causal because there could be some reverse causality that biases (probably overestimates) the coefficient.

4. Is there an impact of the food crisis on adherence to treatment of HIV patients?

Results in the previous section show that HIV households, like comparison households, have suffered a deterioration of their income, food consumption and nutritional status. As explained earlier, nutrition can be a determinant of adherence of treatment, as well as income (because of transportation costs for example). In this section we try to assess whether the evolution of adherence is linked to the change in welfare, and therefore if it has worsened.

Measuring adherence to a treatment is difficult. In our sample, adherence is not observed, as in other studies where pill counts and other methods allow for an objective measure[6]. We have to rely on the report of the patient himself or of the female head of households. Indeed, the questionnaire has two "health services and utilization" sections. The first is answered by the female responsible for the health of the members of the household. She gives information for every member of household. In the second section, the respondents are the individuals themselves. They answer the section if they declare that they were ill in the last 6 months (all illnesses, not only HIV/AIDS). An individual will be declared non-adherent to his treatment if any of the following conditions is satisfied: he forgot to take his medication at least once in the last 4 weeks, he did not take all the medication exactly as prescribed at least once in the last 7 days or he did not take his medication appropriately at any time. In most cases we only have the female head's report or the self-report. When we have both, an individual is considered non-adherent if he did not adhere by at least one of the two reports. A binary measure of adherence is thus obtained, equal to 0 if non adherent. This measure is defined for all individuals, whatever the type of treatment, but can be restricted only to HIV patients, and thus represent a measure of adherence to ARVs.

There is an alternative measure of adherence that is available from the specific HIV/AIDS section of the questionnaire. From this section, we define a patient as non-adherent if he has initiated anti-retroviral treatment and has stopped or interrupted it at any time or is not currently taking it. This measure is self-reported and defined for HIV patients only. A shortfall of this measure is that if the patient is non-adherent in 2007, he is theoretically, non-adherent once and for all, because he has

[6] See Liu et al. (2001) for a comparison of the difference measurement methods.

interrupted treatment at some point. It is thus not possible to "become adherent" between the 2 waves of survey.

Both measures of adherence have the drawback of being binary. This means that there can be no distinction between a patient who forgets his pill once and one that never takes his treatment appropriately. Medical research has defined a threshold of adherence of 95% to insure efficacy of HAART, and our measures are therefore a little too strict, medically speaking (Paterson, 2000). Unfortunately, the data on hand do not allow us to define a continuous measure of adherence.

Table 3 shows rates of adherence and non adherence in 2007 and 2008 for all individuals, HIV patients only and the alternative measure. HIV patients are less adherent to treatment than the average in 2007, with rate of non adherence of 18.4% against 13.5% for the whole sample (all sick individuals who took some treatment in the past 6 months). In 2008 adherence among HIV patients improves while total adherence worsens. The alternative measure of non adherence is much lower, namely, 7.2% in 2007 and 5% in 2008. One possible reason for that is that this measure is only self-reported, whereas the other measure is partly reported by the female head of household. Self-report has a high probability of underestimating non adherence because of memory and disclosure issues.

If adherence seems to improve among HIV patients between 2007 and 2008, this can be misleading because the statistics are only cross-sectional, which means that it is not necessarily the same sub-sample in the two cross-sections. Stigma and secrecy associated with being infected with HIV can lead to under-declaration of being infected or taking ARV treatment. Moreover, the survey design does not force disclosure of the HIV/AIDS status in the health module of the questionnaire. Individuals are asked about illness in the past 6 months, but a HIV-positive individual under ARV therapy can feel perfectly healthy and thus not declare any recent illness[7]. In that case, he is not asked about any kind of treatment nor adherence to it. For the HIV patients-only measure of adherence, this leads to a number of 67 observations for which adherence is observed both years, out of a potential 616 patients. Besides, only 17 of these observations are changes in adherence between the two waves. Unfortunately, such a small number of observations and minimal variability in the dependant variable

[7] For ethical reasons, the survey was conducted so that the interviewer did not know whether the patient was HIV positive.

do not allow us to analyze the evolution of adherence in a multivariate, panel setting and we are limited to bivariate analyses.

Table 4 shows the change in the 3 measures of adherence (whole sample, HIV patients only, alternative measure of adherence) between 2007 and 2008. The second column shows that 71% of HIV patients stayed adherent, while 18% were not adherent in 2007 and became so in 2008. A limited number of patients were adherent previously and became non adherent in the second wave. Although sample sizes are too small to definitely conclude, there has been no visible deterioration of adherence to treatment between the two waves of the survey.

The descriptive analysis of the change in adherence shows that there does not seem to be an effect of the food crisis on adherence: the vast majority of individuals stayed adherent between 2007 and 2008. Besides, there are more individuals who became adherent between 2007 and 2008 than individuals who became non-adherent. However, scaling-up of treatment and HIV related services in health facilities could have triggered a general trend towards better adherence. In addition, as patients become familiar with their treatment regiment, which can be very complex, and as treatment shows its efficacy by improving their health, they become more adherent. Therefore, we cannot conclude definitely as to the impact of the crisis on adherence between these two years, as we do not have a good counterfactual, that is, we do not know how adherence would have evolved without the crisis.

The small size of the sample leads us to consider the issue of panel attrition. 42 HIV households were lost between the 2 waves. If the loss of HIV patients after 2007 is non random with respect to adherence, because of deaths or loss to follow-up at the health facility, non-adherence could be significantly higher in 2008 than what the data shows us. Tables 5a, 5b and 5c show the proportion of adherent and non-adherent patients in 2007 by follow-up status. The independence test yields non significant results: non adherence is not significantly associated with attrition. However non-adherence of HIV patients is (non-significantly) higher among those lost between the 2 waves (table 5b). Small sample sizes could explain the non significance of the independence test, and it should be treated with caution.

5. Is there an impact of the food crisis on antiretroviral treatment outcomes?

The second issue we consider is whether the food crisis had an impact of the health outcomes of antiretroviral treatments. Health outcomes, measured by the CD4 count, can proxy for adherence to treatment and will thus complete the analysis from the previous section (Paterson et al., 2000). Furthermore, health outcomes are a subject of interest by themselves: has the crisis, by lowering the access to food, decreased the effectiveness of the treatment?

We use OLS regressions where the dependant variable is the variation of the CD4 count, measured as the difference between the most recent CD4 count and the lowest CD4 count. CD4 are cells that are part of the immune system and their count is a measure of the severity of the HIV/AIDS infection. A healthy adult has a CD4 count between 500 and 1500 cells per cubic millimeter of blood, while ARV treatment is initiated when they fall below 200 (350 in high resource settings). The CD4 count data are found in the biomedical records, which collected health related data on 498 HIV positive patients of the survey. We merged these records with the living standards survey and regressed the change in CD4 count on welfare and nutritional status measures, to assess the impact of the food crisis on health outcomes. The equation estimated is:

$$\Delta CD4_i = \alpha + \beta_1 X_i + \beta_2 B_i + \delta \Delta y_{it,t-1} + \varepsilon_i ,$$

where X_i includes individual characteristics in 2007 (age, gender, marital status, education, health facility dummies, province dummies, welfare or nutritional status in 2007),

B_i represents biological controls, which we detail in the next paragraph,

$\Delta y_{it,t-1}$ is the change in the welfare or nutritional status measure between 2007 and 2008.

To control for heterogeneity in each patient's illness and treatment, we include the number of months between the two CD4 counts (lowest and most recent) and the level of the lowest CD4 count. The former is expected to have a positive coefficient because a longer period of time allows for a more important improvement in health status, while the latter should be negative: the lower the initial CD4 count, the larger scope there is for an improvement through treatment. We also include the duration of treatment at the time of the most recent CD4 count and a dummy indicating whether the patient is

under antiretroviral therapy at all: there are indeed patients in the sample who are monitored at a health facility but not treated with antiretrovirals because they have not yet reached the threshold at which treatment is initiated. Health facility dummies should control for differences in the quality of treatment, monitoring and care. For example a health facility that has better counseling on adherence to treatment will help a patient take his treatment properly and make it more efficient.

The results are presented in table 6. We have included in the regression the initial level of welfare, for example income, as well as the change between the 2 waves. This specification controls for the initial situation of the household, since variations in income might be differently felt depending on whether it was initially poor or rich. Once again, income and consumption are introduced using 2 different deflators, yielding a lower bound with the IMF figure of 6.2%, and an upper bound with the calculated food price index of 43.3%.Columns (1) and (2) of table 6 show that using the income measure, those who are initially wealthier have better treatment outcomes. Meanwhile, the coefficient on the change in income is positive and significant at the 5% level. In the context of the crisis, this means that those whose income has been affected negatively by the food crisis have seen their health outcome deteriorate more or progress slower than others. However, in table 6, we do not find similar results when looking at consumption and nutritional status measures.

6. Conclusion

People living with HIV/AIDS in Africa are among the most vulnerable because of the debilitating effect of the illness, which prevents them from having an income-generating activity. As highly active anti-retroviral treatments are developed, and access to this therapy scaled-up, they are able to improve their health to a point of living a normal life. The treatment, however, requires to be taken in certain conditions, such as after a nutritious meal, and can by costly in terms of travel to the health facility, even if it is entirely subsidized. In this context, the impact of a food crisis on welfare, and in particular,

on food consumption, can have a very negative impact of adherence to treatment and health outcomes. This is a particularly crucial issue, as it affects both the health of the patient and public health, by the development of resistant forms of the virus that occur when adherence is sub-optimal.

Our analyses have found that, as a likely effect of the food crisis, there has been a real deterioration of welfare in terms of income, food consumption and nutritional status in Mozambique between 2007 and 2008, among both HIV and comparison households. However, HIV households have not suffered more from the crisis than others. We hypothesize that initiation of treatment and better services in the health facilities have counter-balanced the effect of the crisis by improving the health of patients and their labor force participation. This issue will be explored in further research.

Keeping in mind that sample sizes are very small and adherence is only reported and not observed, the data shows that adherence to antiretroviral treatment has not significantly decreased, as the vast majority of those for which it is measured stayed adherent between the two waves of the survey. This result tends to confirm other (medical) studies of adherence, which find no consistent link between it and the socio-economic status, in particular income. However, those whose income was negatively affected by the crisis have seen a less rapid progression or a deterioration of their CD4 count, compared to those whose income did not change.

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Figure 1: Change in welfare indicators between 2007 and 2008

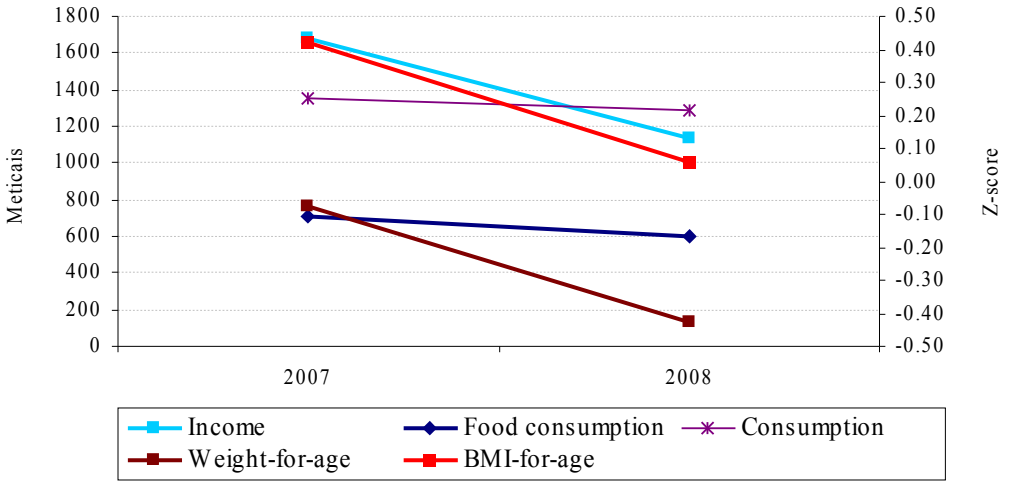

Table 1: Change in household welfare indicators between 2007 and 2008 in Mozambique. Sample means

	2007	N	2008	N	Difference	p-value
Income[1]	1675.91	896	1135.54	896	-540.38	**0.04**
Consumption[1]	1350.56	861	1291.53	872	-59.03	0.44
Income[1,5]	1675.91	896	793.14	896	-882.77	**0.00**
Consumption[1,5]	1350.56	861	902.10	872	-448.47	**0.00**
Food consumption[1,5]	712.92	861	594.64	872	-118.28	**0.01**
Weight-for-age z-score[2]	-0.07	494	-0.43	546	-0.35	**0.00**
Height-for-age z-score[3]	-1.33	604	-1.22	662	0.11	0.21
Body Mass Index-for-age z-score[3]	0.42	601	0.06	656	-0.37	**0.00**
Lowest weight-for-age z-score[4]	-0.46	494	-0.85	546	-0.39	**0.00**
Lowest height-for-age z-score[4]	-1.96	604	-1.85	662	0.12	0.22
Lowest BMI-for-age z-score[4]	-0.15	601	-0.51	656	-0.36	**0.00**

[1] *Monthly, per adult equivalent, in meticais (100mt = $3.7)*
[2] *Household mean, children 1-10 years*
[3] *Household mean, children 5-19 years*
[4] *Household lowest z-score*
[5] *Specific food deflator used*

Table 2: HIV status, the 2008 food crisis and household welfare indicators in Mozambique. Ordinary Least Square Regressions.

	(1)	(2)	(1a)	(2a)	(3)
VARIABLES	**Consumption**	**Income**	**Consumption[1]**	**Income[1]**	**Food consumption**
HIV household	**-0.323*** **	**-0.376*** **	**-0.323*** **	**-0.376*** **	**-0.307*** **
	(0.0595)	(0.113)	(0.0595)	(0.113)	(0.0649)
Year 2008	-0.0807	**-0.378*** **	**-0.440*** **	**-0.737*** **	**-0.169** **
	(0.0694)	(0.128)	(0.0694)	(0.128)	(0.0757)
HIV household*year 2008	**0.183** **	0.0380	**0.183** **	0.0380	**0.162***
	(0.0835)	(0.155)	(0.0835)	(0.155)	(0.0911)
Household characteristics					
Age of head	-0.00570	0.00200	-0.00570	0.00200	-0.0145**
	(0.00629)	(0.0121)	(0.00629)	(0.0121)	(0.00686)
Age of head squares	-9.29e-06	-5.51e-05	-9.29e-06	-5.51e-05	9.16e-05
	(7.44e-05)	(0.000141)	(7.44e-05)	(0.000141)	(8.11e-05)
Head has primary education	-0.0523	0.124	-0.0523	0.124	-0.0856
	(0.0543)	(0.104)	(0.0543)	(0.104)	(0.0593)
Head has secondary education	0.374***	0.898***	0.374***	0.898***	0.240***
	(0.0630)	(0.119)	(0.0630)	(0.119)	(0.0688)
Head is male	0.000901	0.226***	0.000901	0.226***	0.0529
	(0.0411)	(0.0779)	(0.0411)	(0.0779)	(0.0448)
Number of children 0-14	-0.166***	-0.180***	-0.166***	-0.180***	-0.153***
	(0.0124)	(0.0235)	(0.0124)	(0.0235)	(0.0136)
Maputo province	-0.301***	-0.331***	-0.301***	-0.331***	-0.241***
	(0.0633)	(0.118)	(0.0633)	(0.118)	(0.0691)
Beira province	-0.418***	-0.417***	-0.418***	-0.417***	-0.199***
	(0.0495)	(0.0944)	(0.0495)	(0.0944)	(0.0540)
Manica province	-0.807***	-0.913***	-0.807***	-0.913***	-0.565***
	(0.0645)	(0.126)	(0.0645)	(0.126)	(0.0704)
Constant	7.667***	6.926***	7.667***	6.926***	7.067***
	(0.141)	(0.275)	(0.141)	(0.275)	(0.154)
Observations	1733	1480	1733	1480	1733
R^2	0.263	0.196	0.285	0.231	0.168

[1]Specific food deflator used

Table 2 (cont.):

	(4)	(5)	(6)	(7)	(8)	(9)
VARIABLES	**Weight-for-age**	**Height-for-age**	**BMI-for-age**	**Lowest weight-for-age**	**Lowest height-for-age**	**Lowest BMI-for-age**
HIV household	0.0489	-0.156	0.180	-0.0374	**-0.244***	0.00412
	(0.145)	(0.132)	(0.122)	(0.158)	(0.142)	(0.139)
Year 2008	**-0.270***	0.0909	**-0.352****	**-0.368****	0.00870	**-0.539*****
	(0.163)	(0.152)	(0.140)	(0.178)	(0.163)	(0.160)
HIV household*year 2008	-0.139	0.0176	-0.0544	-0.0795	0.0990	0.190
	(0.199)	(0.183)	(0.169)	(0.217)	(0.196)	(0.192)
Household characteristics						
Age of head	-0.0333**	-0.0332**	-0.00386	-0.0353**	-0.0372**	-0.00812
	(0.0145)	(0.0135)	(0.0124)	(0.0159)	(0.0145)	(0.0141)
Age of head squares	0.000548***	0.000510***	6.33e-05	0.000577***	0.000539***	0.000118
	(0.000171)	(0.000158)	(0.000145)	(0.000187)	(0.000169)	(0.000165)
Head has primary education	0.207	0.248**	-0.000895	0.243*	0.253**	-0.00577
	(0.132)	(0.119)	(0.109)	(0.144)	(0.128)	(0.124)
Head has secondary education	0.636***	0.647***	0.142	0.625***	0.647***	0.170
	(0.154)	(0.141)	(0.130)	(0.169)	(0.152)	(0.148)
Head is male	-0.0811	-0.0933	-0.0314	-0.0620	-0.0972	-0.00247
	(0.101)	(0.0902)	(0.0831)	(0.111)	(0.0967)	(0.0946)
Number of children 0-14	-0.0666*	-0.0468	-0.0144	-0.285***	-0.288***	-0.206***
	(0.0347)	(0.0303)	(0.0278)	(0.0379)	(0.0325)	(0.0316)
Mean age of children[2]	0.00265	-0.000713	-0.00579***	0.00589***	-0.00357***	-0.00808***
	(0.00185)	(0.00115)	(0.00106)	(0.00203)	(0.00123)	(0.00121)
Maputo province	0.275*	0.0694	0.312**	0.248	0.149	0.350**
	(0.152)	(0.142)	(0.132)	(0.166)	(0.152)	(0.150)
Beira province	-0.0965	-0.390***	-0.0748	-0.0407	-0.387***	-0.144
	(0.121)	(0.110)	(0.101)	(0.132)	(0.118)	(0.115)
Manica province	-0.439***	-0.387***	-0.298**	-0.260	-0.306**	-0.248*
	(0.152)	(0.142)	(0.130)	(0.166)	(0.152)	(0.148)
Constant	0.0744	-0.714**	1.228***	0.101	-0.179	1.647***
	(0.359)	(0.355)	(0.326)	(0.393)	(0.380)	(0.372)
Observations	1040	1266	1257	1040	1266	1257
R^2	0.068	0.052	0.055	0.105	0.108	0.081

[2]Mean age of children for which z-score is available (1-10 years for weight-for-age, 5-19 for bmi and height-for-age)

Table 3: Adherence to treatment in 2007 and 2008

	All	Only HIV+	Alternative	All	Only HIV+	Alternative
	2007			2008		
Non adherent	46	23	41	81	61	32
%	*13.5*	*18.4*	*7.2*	*16.4*	*16.3*	*5*
Adherent	294	102	528	413	314	609
%	*86.5*	*81.6*	*92.8*	*83.6*	*83.7*	*95*
Total	340	125	569	494	375	641
%	*100*	*100*	*100*	*100*	*100*	*100*

Table 4: Evolution of adherence between 2007 and 2008

	All	HIV+ only	Alternative measure
Became adherent	14	12	26
%	*17.1*	*17.9*	*5.6*
Became non adherent	7	5	10
%	*8.5*	*7.5*	*2.2*
Stayed adherent	59	48	418
%	*72*	*71.6*	*90.7*
Stayed non adherent	2	2	7
%	*2.4*	*3*	*1.5*
Total	82	67	461
%	*100*	*100*	*100*

Adherence and follow-up status

Table 5a: all individuals

Adherence in 2007	Lost	In wave II	Total
Non adherent	3	43	46
%	*10.3*	*13.8*	*13.5*
Adherent	26	268	294
%	*89.7*	*86.2*	*86.5*
Total	29	311	340

Pearson chi2(1) = 0.2748 Pr = 0.600

Table 5b: only HIV+ patients

Adherence in 2007	Lost	In wave II	Total
Non adherent	3	20	23
%	*25*	*17.7*	*18.4*
Adherent	9	93	102
%	*75*	*82.3*	*81.6*
Total	12	113	125

Pearson chi2(1) = 0.3851 Pr = 0.535

Table 5c: alternative measure of adherence (only HI

Adherence in 2007	Lost	In wave II	Total
Non adherent	3	38	41
%	*7.7*	*7.2*	*7.2*
Adherent	36	492	528
%	*92.3*	*92.8*	*92.8*
Total	39	530	569

Pearson chi2(1) = 0.0148 Pr = 0.903

Table 6: Impact of household welfare indicators and their variation during the 2008 food crisis on the evolution. of the CD4 counts of HIV/AIDS patients in Mozambique. Ordinary Least Square Regressions.

VARIABLES	(1) Variation of cd4	(2) Variation of cd4	(2) Variation of cd4	(3) Variation of cd4	(3) Variation of cd4	(4) Variation of cd4
Income variation	**0.0124****					
	(0.00606)					
Income level in 2007	**0.0237****					
	(0.0107)					
Income variation[1]		**0.0178****				
		(0.00868)				
Income level in 2007[1]		**0.0291****				
		(0.0124)				
Consumption variation			-0.00697			
			(0.0123)			
Consumption level in 2007			0.0144			
			(0.0184)			
Consumption variation[1]				-0.00997		
				(0.0176)		
Consumption level in 2007[1]				0.0114		
				(0.0216)		
Food consumption variation[1]					-0.0599	
					(0.0398)	
Food consumption level in 2007[1]					-0.00998	
					(0.0415)	
Weight-for-age z-score variation						7.678
						(22.35)
Weight-for-age z-score in 2007						12.17
						(27.23)
Constant	104.2	-348.4	107.3	-327.0	-406.7	211.0
	(245.5)	(356.9)	(266.2)	(343.9)	(336.3)	(410.3)
Observations	210	186	202	172	172	90
R-squared	0.277	0.304	0.253	0.278	0.309	0.328

[1] *Specific food deflator used*

Appendix: Construction of a food price index

To calculate the food consumption in 2008 in real terms, we have computed a specific food price index using the survey data. This was done in 3 steps:

1) Computing the unit price of each product for each year:

The food consumption module includes information on amounts and quantities purchased by each household for 51 food products (perishables and non-perishables). We can thus calculate the unit price of each product for each year as the total amount of a product purchased by the whole sample divided by the total quantity purchased. The formula is:

$$p_j = \frac{\sum_{i=1}^{n} a_{ij}}{\sum_{i=1}^{n} q_{ij}},$$

where p_j is the unit price of product j, a_{ij} and q_{ij} are respectively the amounts and quantities of product j purchased by household i over the last 7 days and n is the number of households in the sample.

We only included the food products that were purchased by a significant number of households (around 100), which brought the number of products included in the food index down to 25. Because of conversion problems between the different units used in the survey (kilograms, "groups of 4", bags), we only used the data in the most common unit.

2) Calculating the shares of each product in the food consumption for each year:

The share s_{ij} of product j in the total food consumption of household i is:

$$s_{ij} = \frac{a_{ij}}{\sum_{j=1}^{m} a_{ij}},$$

where m is the number of food products included. We average the shares over the whole sample to get the average weight s_j of food product j in the price index:

$$s_j = \frac{\sum_{i=1}^{n} s_{ij}}{n}.$$

3) Computing a Fisher food price index:

We use a Fisher price index, which is defined as:

$$P_{Fisher} = \sqrt{P_{Laspeyres} * P_{Paasche}}$$

Where $P_{Laspeyres}$ is the Laspeyres index, which uses the baseline shares for each year:

$$P_{Laspeyres\,07/08} = \frac{\sum_{j=1}^{m} s_{j07} p_{j08}}{\sum_{j=1}^{m} s_{j07} p_{j07}},$$

and $P_{Paasche}$ is the Paasche index, which uses the final shares for each year: $P_{Paasche\,07/08} = \frac{\sum_{j=1}^{m} s_{j08} p_{j08}}{\sum_{j=1}^{m} s_{j08} p_{j07}}$.