FOOD SECURITY RESEARCH PROJECT

IMPACT OF HIV/AIDS-RELATED DEATHS ON RURAL FARM HOUSEHOLDS' WELFARE IN ZAMBIA: IMPLICATIONS FOR POVERTY REDUCTION STRATEGIES

BY

ANTONY CHAPOTO AND T.S. JAYNE

WORKING PAPER No. 15
FOOD SECURITY RESEARCH PROJECT
LUSAKA, ZAMBIA
December 2005
(Downloadable at: http://www.aec.msu.edu/fs2/zambia/index.htm)

ACKNOWLEDGMENTS

We wish to acknowledge the financial support from the American people via USAID, and substantive support by the USAID/Zambia mission to the Food Security Research Project/Zambia, a joint collaboration between the Ministry of Agriculture and Cooperatives, Government of Zambia, the Agricultural Consultative Forum, and Michigan State University's Department of Agricultural Economics. Supplemental support was also provided to the Food Security III Cooperative Agreement (GDG-A-00-02-00021-00) by the United States Agency for International Development/Bureau for Economic Growth, Agriculture and Trade's Office, Washington, D.C. This paper draws from Chapoto's Ph.D. dissertation (see Chapoto 2006).

Comments and questions should be directed to the In-Country Coordinator, Food Security Research Project, 86 Provident Street, Fairview, Lusaka: tel 234539; fax 234559; email: fsrp@coppernet.zm

FOOD SECURITY RESEARCH PROJECT TEAM MEMBERS

The Zambia FSRP field research team is comprised of Jones Govereh, Steven Haggblade, Anthony Mwanaumo, Billy Mwiinga, Jan Nijhoff, and Ballard Zulu. MSU-based researchers in the Food Security Research Project are Antony Chapoto, Cynthia Donovan, Thomas Jayne, David Tschirley, and Michael Weber.

EXECUTIVE SUMMARY

This study uses nationally-representative panel data on 5,420 rural households in Zambia, surveyed in 2001 and 2004, to measure the impacts of HIV/AIDS-related prime-age mortality on livelihoods. The availability of a nationally representative longitudinal data allowed us to analyze the impacts of disease-related prime-age death across two time periods and between households that experienced mortality of adults aged 15 to 59 compared to households not experiencing mortality or chronic illness. A comparison of the changes in household outcomes (e.g., household composition, farm and crop production, value of livestock, and off-farm income) over time between the treatment (households with prime-age death and/or chronic illness) and control group (household without prime-age chronic illness and death) provides an estimate of the impact of prime-age mortality. However, rural households are heterogeneous in many variables that change and evolve differently for different households and one would expect the effects of prime-age death to differ between households depending on their initial conditions in terms of assets, income and dependency ratios. To control for these heterogeneous factors we take into account the household initial conditions enumerated in 2001, in particular value of assets, land holding size and effective dependency ratio.

The study highlights several findings.

First, irrespective of gender and/or position in the household of the deceased person, rural farm households in Zambia attempt to cope with the death of PA adults through changes in household composition. In all cases household size declined by a factor less than one member, suggesting that afflicted households are partially successful in replenishing their family size to restore their supply of labor. However, in response to the death of a male household head, poorer households are much less able to attract new members than non-poor households, which are almost fully able to restore household size to former pre-death levels. These results imply that the widespread view that death of productive members of the family results into labor shortages needs to be more carefully nuanced, taking into account the position of the deceased person and the initial conditions of the household. Nevertheless, the loss of adult members, especially heads and spouses, may have longer run impacts not measured in the relatively short three-year period of this analysis, such as the loss of inter-generational knowledge in terms of farming skills and knowledge.

Second, the effects of PA death on farm production were sensitive to the gender and position in the household of the deceased. The death of a PA male and female resulted in a 13% and 5% decline in cultivated land, while the death of male household heads resulted in a 21% reduction in land cultivated. Mortality of younger adults resulted in statistically insignificant declines in land cultivation.

One might find it puzzling that the impacts of mortality appear to be larger in the case of male mortality, given that women provide most of the labor input into agricultural production. However, in about 33% of the cases among households experiencing male head of household mortality, the widow ended up cultivating substantially less land in 2004 compared to pre-death levels in 2001. This could be due to loss of land, capital and livestock assets to other relatives after the death of their husband. We also find that relatively wealthy widow-headed households are particularly vulnerable, as they have more land and assets that can be claimed by relatives than afflicted households that are poor to begin with. Household that were relatively wealthy in 2001 and then lost their household head faced more severe

declines in land cultivation and cattle assets. The implication of this finding implies that the responses to mitigating the social and economic impacts of HIV/AIDS in Zambia may not be successful if they ignore the gender inequalities that exist in terms of land access and other productive assets important for rural livelihood. Therefore, efforts to safeguard widows' rights to land and productive assets through changes to traditional inheritance institutions through educational programs involving local community authorities may be an important component of social protection and poverty alleviation strategies in this era of HIV/AIDS.

Third, in contrast to the widespread view that households experiencing prime-age mortality cope with the reduction in family size by switching to labor-saving crops such as roots and tubers, the results show positive but statistically insignificant effects on the cultivation of these crops except among households experiencing the death of non-head/spouse females. The death of other adult women in the household results in a 5% decline in area under roots and tubers. Afflicted and non-afflicted households had virtually identical effective dependency ratios (the ratio of children, elderly and chronically ill adults divided by the number of healthy PA adults) in the 2004 survey. These findings indicate that afflicted households are not necessarily more labor-constrained or more likely to increase cultivation of labor-saving crops than non-afflicted households. While some studies have identified HIV/AIDS as a contributing factor in the rise of labor-saving root and tuber cultivation in Zambia as well as other parts of southern Africa, it is important to take into account other exogenous factors contributing to changes in crop mix. Recent agricultural policy changes in the region associated with structural adjustment and food market reform have affected the relative output/input price ratios for grain crops relative to roots and tubers, reducing the profitability in some areas of grains as compared to roots and tubers (Jayne et al. 2005). This example highlights the importance of properly controlling for other factors when assessing the impact of HIV/AIDS on rural livelihoods to avoid spurious conclusions. These results suggest that for afflicted households as a group, the loss of family labor due to a death in the household may not necessarily mean that agricultural labor becomes the limiting input in agricultural production (any more so than capital assets, for example, which are likely to be drawn down due to foregone income, medical treatment, and funeral expenses among afflicted households).

Fourth, the macro-level picture emerging from recent demographic population projections, which include the impact of AIDS-related deaths, demonstrates that although the epidemic will reduce life expectancy and population growth considerably in the hardest-hit countries, the epidemic has not caused a decline either in the aggregate labor supply or in the labor-to-available- land ratios in agriculture. In fact, between 1990 and 2000, the rural population of Zambia has grown at a considerably faster rate than the overall population–43.6% vs. 33.9% according to the 1990 and 2000 national population censes. Therefore, prioritization of public sector investment in the development and dissemination of technologies aimed at mitigating the effects of prime-age adult mortality ideally requires in-depth evaluation of household- and community-specific constraints and opportunities, as well as consideration of the need for balance between investments in long-term rural economic productivity growth and targeted assistance to both afflicted and non-afflicted households. Assessing which labor-saving technologies to prioritize should involve investigation of the characteristics of affected households, whose labor time is most constrained, the productivity impacts of these technologies, and the overall payoffs from alternative allocations of public resources across sectors.

Fifth, in terms of value of crop output and gross output per hectare, the results do not strongly support the contention that households incurring prime-age death suffer large declines in crop output–except among initially poor households experiencing the death of a male household head. Among this group of afflicted households, the gross value of crop production per hectare declined by 19% relative to non-afflicted households. There is evidence to suggest that wealthier households incurring male head-of-household death attract boys and other males to join the household, while initially poor households have greater difficulty in doing so. This finding supports the need for creating or and/or strengthening community-based networks to assist poorer households experiencing mortality of household heads and spouses. Government and interested donor agencies may also assist with agricultural extension programs to reach afflicted poor households in order to strengthen their capacity to cope with the loss of prime-age core members.

Sixth, the value of cattle assets appear to suffer greatly from the death of a PA male head of household whilst the impacts of death of other prime-age members are negative but not statistically significant. Afflicted households appear to liquidate small animals as the first line of defense to mitigate the impact of PA death. The sale or liquidation of cattle is a more extreme coping mechanism, as it may compromise the household's future livelihood (Stokes 2003). Cattle assets are not only a stock of wealth but are also an input into agricultural production (through draft power for land preparation). Fortunately, adult mortality is not associated with significant declines in cattle assets except in the case of male household head mortality, which indicates the relative severity of impacts in this case. Another reason why households experiencing male head-of-household death show a significant decline in cattle assets is that property of the deceased man (including cattle) is often redistributed to the man's relatives.

Seventh, in contrast to the general assumption that HIV-related mortality is typically associated with household heads/spouses, the survey findings show that only 36.6% of households with PA death incurred household heads/spouse death. About 30% of all the disease-related PA mortality reported in this nationally-representative rural longitudinal survey involved chronically ill persons who joined the household after the first survey–presumably to receive terminal care. While all adults are likely to make important contributions to their families, both materially, in their roles as nurturers and teachers, and in less tangible ways, it appears that the most severe economic effects occur when the death is the household head or spouse. The fact that less than 40% of the prime-age deaths observed in Zambia's rural areas involved a household head or spouse suggests that the potential magnitude of rural PA mortality on rural household agricultural and off-farm incomes and orphaning rates–while still very serious–may be somewhat less severe for many households than often suggested in the conceptual literature on this topic.

Key words: HIV/AIDS, prime-age mortality, endogeneity, rural livelihoods

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1.0 INTRODUCTION

Fully two decades since the HIV/AIDS epidemic in Africa has been characterized as a major economic development crisis, there remains a dearth of micro-level information on the impacts of the disease on rural African households and their responses, although this is fortunately beginning to change. Most micro-level HIV/AIDS impact studies in the literature hypothesize about the impacts of the epidemic but rarely quantify them (for example see Drinkwater 1993; Barnett et al. 1995; Kwaramba 1997; SAFAIDS 1998; UNAIDS 1999; Topouzis 2000; Stokes 2003; FAO 2003; FAO 2004). These studies are constrained by the absence of micro-level information on how households respond to HIV/AIDS and the subsequent impacts on agricultural production, productive assets, non-farm (off-farm) income and any other key indicators of household welfare.

There are a growing number of studies in Africa attempting to provide micro-level information on the impacts of HIV/AIDS on rural households and their responses but there is still modest quantitative information on the effects of HIV/AIDS-related mortality. Most of these studies are faced with four major limitations.

First, the few available micro-level studies of the effects of HIV/AIDS on rural households are almost always drawn from specific geographic sites purposively chosen because they were known to have high HIV infection rates, such as Rakai in Uganda and Kagera in Tanzania (Barnett and Blaikie 1992; Barnett et al. 1995; Tibaijuka 1997; World Bank 1999; Lundberg, Over, and Mujinja 2000). While providing valuable insights into how afflicted households respond to the disease, such studies are limited in their ability to extrapolate to understand national-level impacts. The paucity of nationally representative micro-level information remains a critical limitation on the generation of more reliable macro-level projections on the effects of HIV/AIDS.

Second, only a few studies examine the effects of disease-related mortality on afflicted households using longitudinal data. Cross-sectional surveys cannot adequately measure the dynamic effects of mortality or control for unobserved heterogeneity, which are undoubtedly important in this context. Cross-sectional studies are generally unable to provide insights on impacts, since they cannot compare household characteristics before and after incurring mortality shocks; such studies only allow us to compare *ex post* conditions of afflicted versus non-afflicted households. Furthermore, for studies with no controls, it is unclear if any observed changes in household welfare for the period before and after death can be attributed to morbidity and mortality apart from other shocks or initial conditions affecting afflicted and non-afflicted households alike.

Third, a major difficulty in measuring the impact of adult mortality, especially mortality attributable to AIDS, is that it is influenced by behavioral choices rather than by random events. The few longitudinal empirical studies measuring the impact of adult mortality from AIDS on agriculture and rural farm households' welfare acknowledge that the death of prime-age adults, especially mortality attributable to AIDS, may be endogenous to outcomes but nevertheless treat mortality as exogenous (e.g., Ainsworth and Dayton 2000; Beegle 2005; Booysen 2003; Yamano and Jayne 2004). However, with longitudinal data, the endogeneity issue, while still important, is not as critical as with cross-sectional data because fixed effects and/or difference-in difference models can be estimated to control for time-invariant individual and household characteristics. Nevertheless, time-varying unobserved heterogeneity remains a major problem even with longitudinal data, which may influence both the dependent variables of interest as well as the probability of mortality in the household. Thus, there is the need to test for endogeneity and, if present, explore other methods that may control for endogeneity of PA mortality due to illness.

Fourth, almost all of the quantitative micro-level studies to date have measured the effects of mortality *in afflicted households* compared to non-afflicted households. Yet, especially in hard-hit areas, if non-afflicted households are likely to be indirectly affected by the mortality occurring around them, non-afflicted households may not be a valid control group. This situation, in which a minority of households incurs a shock, but the shock is spread across households in a community presents methodological challenges for estimating the full effects of the shock using household survey data.

1.1 Objectives

Using comprehensive rural farm household longitudinal data from Zambia, this paper measures the impacts of prime-age (PA) adult morbidity and mortality on crop production and cropping patterns, household size, livestock and non-farm income. The paper adopts and extends the counterfactual (difference-in-difference) approach used by Yamano and Jayne (2004) by controlling for initial (pre-death) household conditions that may influence the severity of the impacts of adult mortality. In particular, the study controls for initial poverty status, landholding size, effective dependency ratios, and the gender and position of the deceased person. Moreover, the possibility that PA death in the household is endogenous is taken into account by conceptualizing the measurement of effects of prime-age adult death on rural agricultural households' welfare as a two stage process: *first,* by examining the characteristics of afflicted households; and *second*, conditional on being afflicted, determining the effects of morbidity and mortality on indicators of household welfare both prior to and after mortality. The findings from this study provide important information that may assist governments, donors, and development planners in developing specific policies or interventions to mitigate the impacts of the disease on vulnerable households.

The remainder of the paper is organized as follows: Section 2 describes the data and methods used in this paper. Results and conclusions are presented in Sections 3 and 4, respectively.

2.0 DATA AND METHODS

2.1 Data

The data comes from nationally representative longitudinal data on 5,420 households in 393 standard enumeration areas (SEAs)[1] in Zambia surveyed in May 2001 and May 2004. The survey was carried out by the Central Statistical Office (CSO) in conjunction with the Ministry of Agriculture and Cooperatives (MACO) and Michigan State University's Food Security Research Project. The 1999/2000 nationally representative Post Harvest Survey (PHS), which surveyed about 7,500 households, was the base for the Supplemental Survey (SS) of May/June 2001. The SS covered the same reference period as the PHS of 1999/00 crop and marketing year, but collected additional information on non-farm income, adult and child mortality information including retrospective questions on mortality in the household over the previous five years, and basic socio-economic information on all individuals listed in the 1999/00 PHS demographic roster. Because of missing information on some households, the valid sample was reduced to 6,922 households. A follow-up survey of the same 6,922 households surveyed in SS 2001 was revisited in May/June 2004 and a total of 5,420 households were re-interviewed. Enumerators revisiting these households asked for the whereabouts of the members included in the demographic roster of the initial survey, and recorded cases of death and illness, departure, and new arrival of individual members.

The 1999/00 PHS sampling frame was based on information and cartographic data from the 1990 Zambia Census of Population and Households. The census questionnaire included a question on whether the household engaged in agricultural activities (crop growing, livestock and poultry raising, and fish farming), as well as check items to identify the specific crops grown and animals raised by the household. Households were included in the sample only if they were found to cultivate crops or raise livestock. The reason for excluding the non-agricultural households was to improve the efficiency of the sampling frame for crop and livestock production and other agricultural characteristics.[2]

Zambia is divided into nine provinces, which are further divided into 70 districts For the Census enumeration, a cartographic operation was conducted to define census supervisory areas (CSAs), which were further divided into standard enumeration areas (SEAs).[3] A stratified three-stage sample design was used. The CSAs were primary sampling units selected with probability proportional to size (PPS) at the first stage, where the measure of size was based on the total number of households in the CSA. At the second sampling stage, one SEA was selected with PPS within each sample CSA. This resulted in a similar dispersion of the sample and probabilities of selection as if the SEAs had been selected directly at the first sampling stage. Within each selected SEA, all households were listed and stratified by size for selecting the sample households at the last sampling stage.

Households were classified into small- and medium-scale farming households, defined as those cultivating areas less than 5 hectares and between 5 and 20 hectares, respectively. Households cultivating more than 20 hectares were classified as large-scale farmers and were

[1] "Standard enumeration areas" (SEAs) are the lowest geographic sampling unit in the Central Statistical Office's sampling framework for its annual Post Harvest Surveys. Each SEA contains roughly 15 to 20 rural households.

[2] Although the rural households of landless farm laborers and those engaged in other economic activities are of analytical interest, they are best studied through other surveys, such as the Living Conditions Monitoring Survey (Megill 2004).

[3] The SEA is the smallest area with well defined boundaries identified on census sketch maps and each SEA was covered by an individual enumerator for the census data collection.

not included in this survey. Initial village listings of all households were generated to prepare the sample frames. The percentage of households who engaged in neither crop nor animal production on their land was found to be low, less than 4%. Landlessness is somewhat higher in areas closer to towns, where a higher proportion of households are engaged exclusively in non-farm activities. Since smaller households vastly outnumber the larger ones, the survey over-sampled the medium-scale farming households in order to ensure adequate inclusion of the larger households in the survey. A weighting procedure was formulated in order for the sample estimates from the PHS and SS surveys to be representative of the population of small to medium scale farmers. These sampling weights were multiplied with sample descriptive estimates. For more details about survey design and sampling procedures see Megill (2004).

2.2 Sample Size and Attrition

Table 1 presents basic information on the households surveyed, re-interview rates, and prevalence of disease-related mortality over the 2001-2004 period. Of the 5,420 households successfully re-interviewed, 571 households had at least one prime-age death in the sample, of which 547 of these households had at least one disease-related prime-age (PA) death over the three-year period, 30 households had prime-age deaths due to accidents or homicide, and 6 households had deaths due to both causes. Of the 5,420 households that were re-interviewed in 2004, 78 households did not appear to be the same households interviewed in 2001 so are excluded from this analysis. Of the remaining 5,342 households, 542 households incurred at least one prime-age disease-related death, 52 (9.6%) of them suffered multiple prime-age deaths, with 44 households experiencing 2 deaths, 6 households experiencing 3 deaths and 2 households experiencing 4 prime-age deaths. Of those households experiencing multiple prime-age deaths, 15 households experienced more than one male death and 16 households had more than one female death. Out of a total of 571 prime-age deaths, 211 (37.0%) prime-age individuals joined the household after the 2001 survey and died between 2001 and 2004. This is evidence that a high proportion of HIV-positive individuals returned to their rural families to receive terminal care after becoming ill.[4]

In a study such as this, which addresses the impacts of mortality using longitudinal data, treatment of attrition is particularly important. Adult mortality may contribute to household dissolution, which contributes to attrition and may lead to under-reporting of mortality rates and biased measurement of the socio-economic impacts of mortality (Hosegood et al. 2004). The impacts of adult mortality would most likely be different for households that dissolve as opposed to those that remain intact.

Of the 6,922 households interviewed in 2001, 5,420 (78.3%) were re-interviewed in May 2004. If attrition caused by enumerators not re-visiting several SEAs in 2004 that were included in the 2001 survey is excluded, the re-interview rate rises to 88.7%. And if attrition caused by adult household members being away from home during the enumeration period

[4] Other studies have found that a high proportion of HIV-positive individuals returned to their rural families to receive terminal care after becoming ill (e.g., Kitange, Machibya, and Black 1996).

Table 1. Prevalence of prime-age (PA) mortality[a] by province, rural Zambia between 2001 and 2004

Province	Households interviewed in 2001	Households re-interviewed[b]	Descriptive results in 5342 valid re-interviewed households					
			Household with at least one prime-age deaths due to illness		Cause of death		Predicted AIDS-related deaths[d]	
			Male	Female	Disease	Other[c]	by WHO classification[e]	One major sign and at lease one minor sign
	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)
	Number	number(%)	number	number	number	number	number (%)	number (%)
Central	714	573 (80.3)	34	34	68	4	13 (19.1)	16 (23.5)
Copperbelt	393	312 (79.4)	12	16	28	3	9 (32.1)	12 42.9)
Eastern	1331	1126 (84.6)	68	71	139	7	33 (23.7)	55 (39.6)
Luapula	777	619 (79.7)	24	29	53	4	15 (28.3)	26 (49.1)
Lusaka	214	161 (75.2)	8	19	27	1	7 (25.9)	14 (51.9)
Northern	1363	1027 (75.3)	42	46	88	4	31 (35.2)	37 (42.0)
Northwestern	472	324 (68.6)	15	7	22	-	3 (13.6)	6 (27.3)
Southern	872	690 (79.1)	33	51	84	6	28 (33.3)	43 (51.2)
Western	786	588 (74.8)	18	44	62	1	23 (37.1)	31 (50.0)
Total	6922	5420 (78.3)	254	317	571	30	162 (28.4)	240(42.0)

Source: CSO/MACO/FSRP Post Harvest Survey 1999/2000 and Supplemental Survey, 2001 and 2004

Notes: [a]Prime-age is defined as ages 15-59 for both men and women. [b]Of the 21.7% not re-interviewed, 0.2% were refusals, 10.2% moved out of SEA, 5.7% recorded as dissolved and 5.2% non-contact. [c]AMR (adult mortality rate)=Prime-age deaths/1000 prime-age person years. Figures in parentheses are AMR including individuals who joined the household and died between 2001 and 2004 but were not in the first survey. [d] Cause of death is defined as HIV/AIDS using lay diagnosis data of the deceased (see section 2.2). [e] WHO classification: 2 major signs (weight loss greater than 10% of body weight in a short period of time, chronic diarrhea for more than a month) and at least one minor sign (persistent cough for more than one month, itching skin rash, fungal infection of mouth and/or throat, history of herpes zoster, generalized herpes simplex infection and enlarged lymph nodes (World Health Organization 2004) and those refusing to be interviewed is excluded, the re-interview rate rises to 94.5%. Because 5.5% of the sample in 2001 was not re-interviewed due to households moving away or dissolving, this study measures the effects of mortality on households that remained intact over the three-year survey interval.

An examination of the relationship between household attrition, dissolution, and household size in 2001 show that the percentage of households "attriting" is inversely related to household size (Table 2). While 8.4% of the households sampled in 2001 contained either one or two members, these households accounted for over 12% of the cases of attrition and 18% of the cases of household dissolution. Dissolution was a more important cause of household attrition among smaller households than among larger households, possibly because households with one or two members tend to be more mobile and move frequently. By contrast, larger households were more likely to incur a prime-age adult death. This is because the probability that a household will incur a prime-age adult death is positively correlated with the number of adult members in the household.

2.3 Relationship between Adult Mortality and HIV/AIDS

Of the 5,420 households successfully re-interviewed, 362 of these households (6.3%) had at least one disease-related prime-age (PA) death over the three-year period (see Table 1).[5] An investigation of the correlation between prime-age mortality rates from our panel survey data and district HIV prevalence rates from antenatal clinics as reported in Zambia's Demographic Health Survey (CSO, MoH and Macro International 2003) shows a strong relationship between prime-age mortality and HIV prevalence rates (Figure 1).[6] The Pearson correlation coefficient of 0.84 suggests that the adult mortality rates observed in our survey data is closely associated with HIV-prevalence. The strength of these correlations is notable, especially considering that the provincial HIV prevalence rate is not disaggregated by urban/rural classification. This is evidence that a large proportion of prime-age mortality observed in our household data is indeed due to AIDS-related causes. However, our analysis is not able to identify cause of death (except in cases of violent death) and is hence confined to the impact of prime-age mortality due to disease in general.

2.4 Model and Estimation Strategies

2.4.1 Econometric model

To measure the impacts of PA mortality and morbidity on outcome Y_i, we consider the estimation of a panel model that contains a binary variable for PA death as an explanatory variable. The following base model is formulated:

$$Y_{it} = \gamma_t + t * D_i\delta + \alpha_i + \varepsilon_{it} \quad i = 1,..., N \quad t = 1,..., T \qquad [1]$$

---

[5] This only includes households with individuals in both the first and second surveys. A small number of recorded deaths were due to violence or accidents; these were excluded from the analysis.

[6] National estimates of HIV prevalence in sub-Saharan Africa are almost exclusively based upon surveys of antenatal clinics, the majority of which are located in urban areas. The Zambia Demographic Health Survey figures are derived from blood sample testing of a randomly selected national sample of PA adults.

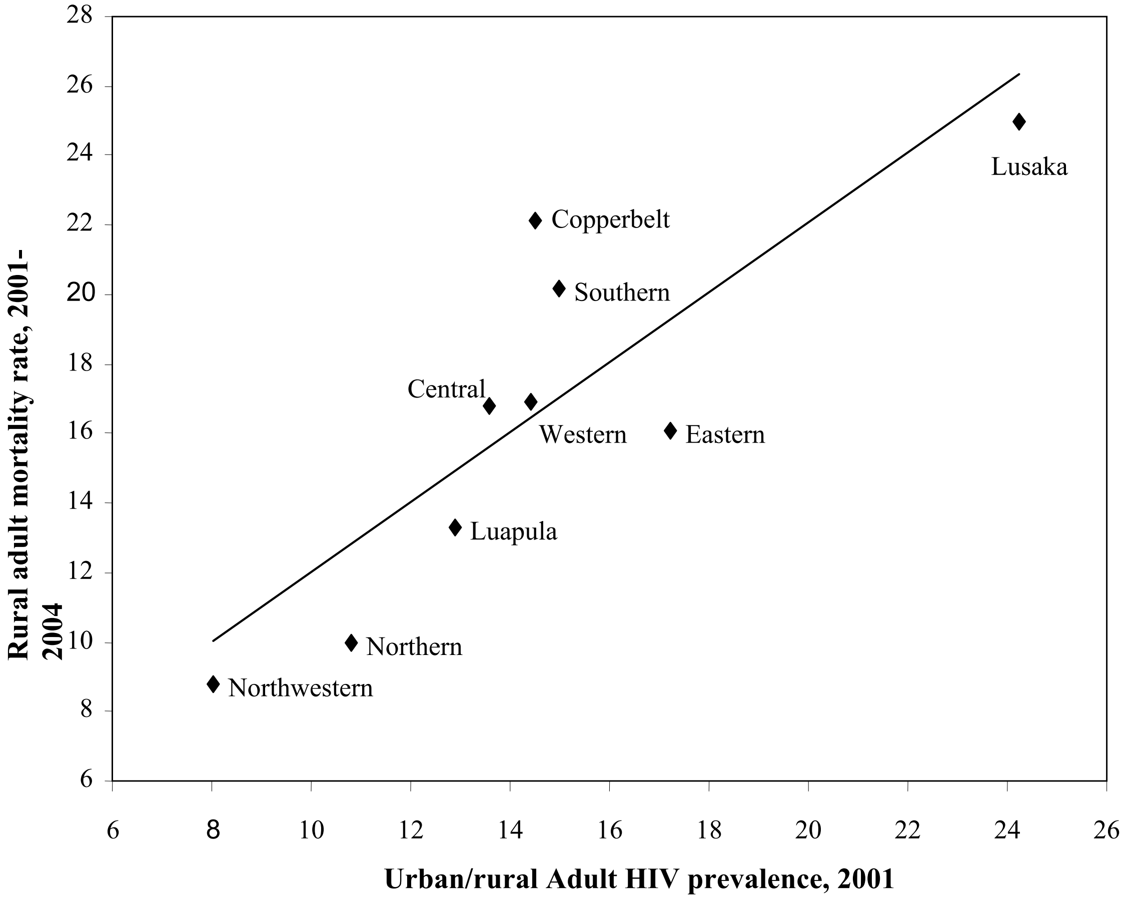
Table 2. Relationship between household size, attrition, dissolution, and prime-age mortality in 2001-2004

Household Size	Households in 2001 sample	Households attriting in 2001-2004	Households attriting due to dissolution	Households dissolving as % of 2001 sample	Households dissolving as % of households attriting	Households incurring PA mortality	Households incurring PA mortality as % of reinterviewed household
(A)	(B)	(C)	(D)	(E)[a]	(F)[b]	(G)[c]	(H)[d]
Number	number	number	number	(%)	(%)	number	(%)
1	199	68	30	15.1	44.1	1	0.8
2	385	118	43	11.2	36.4	12	4.5
3	781	196	57	7.3	29.1	27	4.6
4	1021	263	76	7.4	28.9	36	4.7
5	1041	224	48	4.6	21.4	55	6.7
6	924	211	46	5	21.8	46	6.5
7	730	126	32	4.4	25.4	40	6.6
8	606	108	24	4	22.2	44	8.8
9	387	70	11	2.8	15.7	25	7.9
≥10	848	119	23	2.7	19.3	76	10.4
Total	6922	1503	390			362	

Source: CSO/MACO/FSRP Post Harvest Survey 1999/2000 and Supplemental Survey, 2001 and 2004

Notes:
[a]Column E =Column D /Column B
[b]Column F=Column D/Column C
[c]36 households incurred more than one prime-age death
[d]Column H=Column G/(Columns B-C)

Figure 1. Correlation between Provincial adult mortality rates from CSO 2001 and 2004 household survey data and 2001 HIV + prevalence rates, Zambia



Notes: Pearson correlation coefficient is 0.84.

Sources: Adult mortality rates (age 15-49) derived from the 2001 and 2004 household surveys. HIV+ prevalence rates are from 2001 Sentinel Surveillance Site information published by the Ministry of Health and ZDHS respectively.

where Y_{it} denotes an outcome, such as household composition, area under cultivation, value of farm output, and non-farm income for household *i* at time *t*; $D_{it} = 1$ if a household experienced prime-age death between 2001 and 2004 and 0 otherwise; the parameter γ_t denotes a time-varying intercept (Wooldridge 2002); α_i captures the household-level fixed effects (assumed constant over time); and ε_{it} is an error term.

A comparison of the changes in outcomes (Y) over time between the treatment group (households incurring a prime-age death and/or chronic illness) and the control group (households not incurring prime-age chronic illness or death) provides an estimate of the impact of prime-age mortality. Differencing the time 1 and time 0, equation 1 yields:

$$\Delta Y_i = \gamma + D_i\delta + \Delta\varepsilon_i \quad i = 1,..., N \qquad [2]$$

where ΔY_i is the 2004 - 2001 difference for a given outcome measure for each household i, D_i is the treatment indicator, δ is the treatment effect, γ is a constant, and $\Delta\varepsilon_i$ is the difference between errors at time 1 and time 0.

Estimation of equation 2 by OLS gives the average treatment (δ) which is essentially the impact of prime-age death on outcome Y. Assuming that neither initial household conditions nor attributes of the deceased person affect δ, and nothing else changes between afflicted and non-afflicted households, one could use this simple difference-in-difference estimator to evaluate the impact of death.[7]

However, rural households are heterogeneous in their initial conditions. There is growing evidence that the effects of prime-age death differ between households depending on their initial conditions in terms of assets, incomes, and stock of education (see Yamano and Jayne 2004; Ainsworth and Dayton 2000; Beegle 2005; Yamano and Jayne 2005). To control for these heterogeneous factors, a vector of exogenous household initial covariates (X_i) are introduced into equation 1 as follows:

$$Y_{it} = \gamma_t + t * D_i\delta + t * X_i^o\varphi + \alpha_i + \varepsilon_{it} \quad i = 1,.., N \;\; t = 1,..., T \qquad [3]$$

Differencing the time 1 and time 0, equation 3 yields:

$$\Delta Y_i = \gamma + D_i\delta + X_i^o\varphi + \Delta\varepsilon_i \quad i = 1,..., N \qquad [4]$$

To analyze the differential impacts of PA mortality, these initial (pre-death) characteristics were interacted with the treatment (D). The estimated treatment effect remains δ but it is now interpretable as a *ceteris paribus* effect. The model in equation 4 could then be re-expressed as:

[7] This paper follows the taxonomy convention proposed by Barnett and Whiteside (2002): "Afflicted" households are those that have incurred a prime-age death in their households; households that have not directly suffered a death but are nevertheless affected by the impacts of death in the broader community are referred to in this study as "affected." Households not directly suffering a death may be non-afflicted, but it is doubtful that there are any non-affected households in hard-hit communities of Eastern and Southern Africa.

$$\Delta Y_i = \gamma + D_i\delta + X_i^o\varphi + X_i^o * D_i\eta + \Delta\varepsilon_i \qquad [5]$$

2.4.2 Empirical model and estimation strategy

Very little is known about the dynamics of household behavioral response to premature PA adult mortality in Africa and evidence to date shows great heterogeneity. We adopt and extend the model and estimation methods of Yamano and Jayne (2004). As an extension of their study, we estimate the impacts of mortality on various household outcomes taking into account initial (pre-death) household variables as well as tests for the likely endogeneity of death variables before choosing the estimation method. Using equation 5 and adding provincial dummy variables (P), and interaction terms of deaths between 2001 and 2004 and pre-death household characteristics (X^o*D) the following model is estimated:

$$\Delta Y_i = \gamma + D_i\delta + X_i^o\varphi + X_i^o * D_i\eta + P\varsigma + \Delta\varepsilon_i \qquad [6]$$

Outcome variables (ΔY_i) : The changes in outcome household level variables were grouped into three categories: household composition, agricultural production and cropping patterns; value of livestock assets; and non-farm income. Household composition variables included changes in household size and composition of men, women, boys and girls aged 11 and under.[8] Agricultural production and cropping patterns variables included the change in total land cultivated, land cultivated by crop category (cereals, roots and tubers crops, high value crops), and the gross value of crop production per hectare. The value of livestock assets and non-farm income variables included the change in value of small and large animals, and off-farm income.

Death variables (D_i): D_i is a vector of deaths occurring in households between 2001 and 2004. Because the impact of prime-age mortality may differ depending on the gender of the deceased member, D_i was specified as two categorical variables, one for households suffering the death of a prime-age male (D^M) and one for households incurring the death of a prime-age female (D^F). We further differentiate the impacts of mortality according to the position of the deceased in the household by introducing categorical variables for the death of a male household head (D^{MH}), female head or spouse (D^{FH}), other prime-age males (D^{MO}), and other PA females (D^{FO}). This specification enables us to test for the possible status-differentiated effects of mortality.

Household pre-death conditions (X^0)*:* This vector of initial household conditions includes asset poverty status, land holding size, and households' effective dependency ratio in 2000. Effective dependency ratios, following de Waal (2003), are defined as the number of children, elderly, and chronically ill prime-aged adults divided by the number of healthy prime-aged adults. These variables were interacted with mortality variables to test whether the impacts of PA mortality are sensitive to households' initial (2000) poverty levels, landholding size, and effective dependency ratios. Ideally, these initial conditions should be measured prior to the onset of chronic illness, but data was not available to precisely determine the timing of onset of illness.

---

[8] Due to data limitations the number of children could not be disaggregate into boys and girls age 6 to 11 and children under the age of 5. There is evidence in the literature that suggests that households cope with the loss of prime-age adults by either pulling young boys and girls out of school to replenish the pool of physical labor or sending children away to live with relatives to ease the burden on food security.

The model specified in equation 6 is static in the sense that it measures a snapshot of afflicted households' changes in welfare outcomes in 2003/04 compared to pre-mortality conditions in 2000/01. Household responses to a death are unlikely to be fully reflected over this relatively short time period. Moreover, in the case of HIV/AIDS, if illness occurred before the 2001 survey, it is likely that household adjustments may already be reflected in the first survey. We considered the inclusion of a dummy variable to controls for current prime-age chronic illness in the household but decided against this because current chronic illness is likely to be endogenous given that individuals to some extent may select which households to die in. As mentioned earlier, many individuals return to the homes of their parents to receive terminal care (Kitange, Machibya, and Black 1996). Moreover, chronic illness is believed to be measured with considerable error because of its subjective and self-reported nature (see Strauss et. al. 1993, Beegle 2005).

It must also be noted that the control group may be tainted by the fact that in areas where the epidemic is widespread, no household in the community may remain unaffected. A high incidence of illness and death due to HIV/AIDS may result in a breakdown of social capital and local institutions that affect the whole community (afflicted and non-afflicted). We included lagged district HIV/AIDS prevalence in the models to control for the extent of HIV in an area.

2.4.3 Econometric issues

Estimation of (6) is faced with two major econometric challenges: the likely endogeneity of death variables and attrition bias. Ignoring these issues may result in inconsistent and biased results. We address these issues in the following manner.

Attrition bias

As mentioned earlier, the longitudinal data used in this study suffers from an attrition rate of approximately 19%. If this attrition occurs randomly, then there is no reason to worry about selection bias due to attrition, although efficiency will be lost because of a reduced sample. It is possible that the incidence of prime-age mortality is higher among households that attrited but there is no way to determine this. If attrition bias is non-random then it is imperative to control for such attrition bias.[9]

Comparing the mean levels of household characteristics in May 2001 for households that were re-interviewed versus those that attrited, we find some notable differences (Table 3). For example, households not re-interviewed had slightly younger household heads (43 years vs. 45 years), smaller household sizes with fewer children age 5 and below, fewer boys and girls age 6 to 14, fewer prime-age male and female and elderly males, slightly smaller landholdings, less farm equipment and animals, and slightly higher rates of chronically ill adults in 2001. This is not surprising given the fact that attriting households were smaller to start with in 2001.

[9] For an overview of sample selection see Fitzgerald, Gottschalk, and Moffitt (1998), and Alderman et al. (2001).

Table 3. Household characteristics stratified by attrition status

Household attributes in 2000	Re-interviewed N=5420		Not re-interviewed N=1502		Difference	
	Mean	Std. dev	Mean	Std. dev	Mean	t-stat
Age of household head (years)	44.71	15.04	42.50	15.04	2.21**	5.72
Mean education of head and spouse(years)	5.78	3.22	5.86	3.68	-0.07	-0.27
Household size (number)	5.91	3.01	5.17	2.63	0.73**	9.58
Children 5 and under (number)	0.93	0.93	0.83	0.91	0.09**	4.08
Boys 6 to 14 (number)	1.47	1.34	1.30	1.21	0.17**	5.31
Girls 6 to 14 (number)	1.57	1.35	1.39	1.22	0.18**	6.08
Prime-age male 15 to 59 (number)	1.26	0.99	1.07	0.87	0.19**	6.71
Prime-age female 15 to 59 (number)	1.33	0.88	1.20	0.78	0.14**	6.52
Elderly Males age 60 and above (number)	0.14	0.35	0.10	0.31	0.04**	4.06
Elderly Females age 60 and above (number)	0.11	0.33	0.10	0.30	0.02+	1.84
Households with chronically ill adult (number)	1.27	0.46	1.31	0.50	-0.04	-0.58
Prime-age death between 1996-2000(=1)	0.10	0.30	0.10	0.30	0.00	-[a]
Landholding size (ha)	2.80	2.82	2.45	2.69	0.35**	5.44
Land cultivated (ha)	1.49	1.38	1.25	1.20	0.24**	7.19
Total household income ('000 Zkw)	1843	3962	1819	3571	23.91	1.10
Value of assets ('000 Zkw)	901	2793	550	1751	351.26**	5.76
Productive assets ('000 Zkw)[b]	108	399	53	238	55.02**	6.23
Distance to nearest tarmac/main road (km)	25.32	35.49	24.93	33.39	0.39	0.58
Distance to nearest district town (km)	34.48	22.57	36.00	23.77	-1.52	-1.78

Source: CSO/MACO/FSRP Post Harvest Survey 1999/00 and Supplemental Surveys, 2001 and 2004

Notes:
** indicates 1% significance level; *indicates 5% significance level; + indicates 10% significance level.
[a] t cannot be computed because the standard deviations of both groups are 0.
[b]Productive assets are the sum of the value of farm equipment (scotch carts, harrows and ploughs) and livestock.

To deal with potential attrition bias, the inverse probability weighting (IPW) method is adopted, which assumes that the probability of being re-interviewed as a function of observables information is the same as the probability of being re-interviewed as a function of observables, plus unobservables that are only observable for non-attrited observations (see Wooldridge 2002). In general, the IPW works well if the observations on observed variables are strong predictors of non-attrition and if the observations on unobserved variables are not strong predictors of non-attrition. We use enumerator quality variables (59 enumeration team categorical variables) to predict re-interview. Each enumeration team was headed by a supervisor who was authorized to decide when enumerators give up trying to contact designated households. The re-interview model is specified as follows:

$$\text{Prob}(R_{it} = 1) = f(HIV_{t-j}, X_{i,2000}, E_{it}) \qquad (7)$$

R_{it} is one if a household (i) is re-interviewed at time t, conditional on being interviewed in the previous survey, and zero otherwise; HIV_{t-j} is the district HIV-prevalence rate at the nearest surveillance site in 1995; X_{i2000} is a set of household characteristics in the 2001 survey including landholding, productive assets, demographic characteristics (number of children ages 5 and under, number of prime age males and females), and ownership of various assets and E_{it} is a set of 59 enumeration teams. All of the variables in (7) are observable even for households that were not re-interviewed in 2004. Equation (7) is estimated with Probit for attrition between the 2001 and 2004 surveys, obtaining predicted probabilities (Pr_{2001}). Then, the inverse probability ($1/Pr_{2001}$) is computed, and then applied to all impact models estimated.

Table 4 shows that single or previously married individuals were less likely to be re-interviewed than married individuals. However, other factors constant, the results also show that prime-age male members were 4.7% more likely to remain in the households between the first and second survey compared to females. This may be because in most parts of Zambia which are patrilineal, females are more likely to leave their parents' home when they marry compared to men who may marry and still live with their parents. Older individuals (age 30 and above) were more likely to be contained in the panel compared to younger members (age 29 and below) who are more likely to relocate. Generally, there exists a stronger positive association with reinterview as age increases. Also, individuals with salary and wage income, and who spend more time away from home in 2000 were less likely to be contained in both surveys. This is an indication that individuals with these characteristics are more mobile and less likely to be in households re-interviewed.

In contrast, individuals who had formal or informal business income were more likely to be contained in both surveys. Although the coefficients on years of education are not significant even at the 10% level of significance, it would appear that the marginal probability of remaining in the sample decreases as an individual's years of education increases. This suggests that individuals with more years of education are more likely to be contained only in the first survey and may have moved elsewhere for better prospects.

Turning to household characteristics, results in Table 4 show that individuals in households experiencing adult death between 1996 and 2000 were less likely to be re-interviewed compared to individuals in households experiencing no death during the same period.

Table 4. Individual-level re-interview model (Probit[a])

Attributes	1=Individuals contained in 2001 and 2001 surveys, 0=individuals contained only in 2001			
	dy/dx		z	P>z
Individual characteristics in 2000				
Gender(1=male, 0=female)	0.047		6.69	0.000
Never married (=1)	-0.172		-14.28	0.000
Previously married (=1)	-0.139		-9.13	0.000
Age group (=1)				
Age 20-24	-0.076		-5.92	0.000
Age 25-29	-0.021		-1.42	0.155
Age 30-34	0.021		1.36	0.173
Age 35-39	0.037		2.02	0.043
Age 40-44	0.090		4.70	0.000
Age 45-49	0.103		4.56	0.000
Age 50-54	0.134		6.64	0.000
Age 55-59	0.124		5.38	0.000
Years of education (=1)				
1-3 years	0.023		1.48	0.139
4-6 years	0.020		1.53	0.125
7 years	0.000		-0.02	0.985
8 years and above	-0.007		-0.42	0.673
Salary wage income (=1)	-0.044		-3.15	0.002
Formal/Informal business activity (=1)	0.033		2.50	0.012
Months away from home (number)	-0.013		-4.51	0.000
Household characteristics in 2000				
Children 5 years and under (number)	0.010		1.77	0.077
Children ages 6 to 11 (number)	0.002		0.81	0.420
Prior PA death from diseases in 1996-2000 (=1)	-0.038		-2.25	0.024
Landholding size (Ha)	0.002		1.01	0.312
Draft animals and farm equipment (Zkw)	0.002		2.31	0.021
Community characteristics				
District HIV prevalence rate in 1999	-0.003		-1.73	0.084
District on the line of rail (=1 , 0 otherwise)	-0.030		-1.16	0.244
Distance to the nearest tarmac road (km)	-0.000		-0.09	0.927
Distance to the district Town/Boma (km)	-0.000		-0.82	0.410
Enumeration team dummies included[b]	Yes			
Joint test for individual characteristics (X^2)[c]	1477.83	[0.000]		
Joint test for household characteristics (X^2)[c]	20.38	[0.002]		
Joint test for community variables (X^2)	4.99	[0.288]		
Joint test for team effects (X^2)[c]	1074.45	[0.000]		
Predicted probability of positive outcomes at $\bar{x}$	0.81			
Number of prime-age adults	18817			

Source: CSO/MACO/FSRP Post Harvest Survey 1999/2000 and Supplemental Survey, 2001 and 2004

Notes: Absolute z-scores, calculated using heteroskedasticity robust standard errors clustered for individuals. [a]Estimated coefficients are marginal changes in probability. [b]Enumeration teams are included but not reported in the table. [c]Joint test for individual and household characteristics, and enumeration team effects are significant at 1% significance level.

Landholding size and productive assets are positively associated with reinterview. Individuals in households with many children were more likely to be re-interviewed.

The lagged HIV prevalence variable is negatively associated with re-interview and statistically significant at the 10% level. This may suggest that AIDS exacerbates attrition in standard household surveys. Households suffering from adult mortality due to AIDS may have moved away or dissolved, although the lagged HIV prevalence rate may be picking up the effects of other spatial factors correlated with district-level attrition rates, such as migration and mobility. Other community characteristics such as distance of household to the nearest tarmac road or to the district town appear to reduce the probability of being re-interviewed although this effect is statistically insignificant at 10%. This is because enumerators may be less likely to attempt to re-visit households in remote or relatively inaccessible locations. The enumeration team dummies are also jointly significant; suggesting that differences in enumeration team effort are a strong predictor of re-interview. In any case, the results in Table 4 suggest the importance of controlling for attrition, as is done in the remainder of the analysis. However, the magnitudes of the results between models corrected for attrition versus not-corrected for attrition do not differ significantly, which suggests that, at least in this particular national sample, attrition bias does not create major problems for statistical inference (see Chapoto 2006 for a complete set of results).

Identification of impact of death

The DID fixed effects estimator of equation 6 is confounded by the possibility that PA death variables are endogenous, hence OLS results may be biased. Beegle (2005) outlines some of the reasons why AIDS-related prime-age death could be viewed as endogenous.

First, AIDS-related mortality is caused by behavioral choices rather than random events. Contraction of HIV/AIDS results from distinct patterns of sexual behavior that appears to be influenced by economic and social conditions. In the early years of the epidemic in Sub-Saharan Africa, evidence suggests that men and women with higher education and income were more likely to contract HIV than others because they were more likely to have numerous sexual partners (Ainsworth and Semali 1998; Gregson, Waddell, and Chandiwana 2001).[10] Using the same data set, Chapoto and Jayne (2005) study the socioeconomic characteristics of individuals who died of disease-related causes between 2001 and 2004 in Zambia. They found that (1) single women and men are 2 to 5 times more likely to die of disease-related causes than women and men who are the heads or spouses of their households; (2) females are more likely to die at an earlier age than their male counterparts; (3) relatively wealthy men (defined according to initial household assets and income) are 1.4 to 1.8 times more likely to die than relatively poor men; and (4) irrespective of income status, prime-aged men and women experiencing a prior death in their household in the past 6 years are 23.0 and 18.1 times more likely to die of disease-related causes than men and women in households with no prime-age deaths in the past 6 years. These findings buttress the presumption that prime-age mortality may indeed be endogenous.

Second, seriously ill individuals often move into a parent's or relative's household to obtain terminal care and often prefer to die and be buried in their home area. Since these individuals

[10] As information about HIV transmission spreads, however, it is believed that educated people are more likely to change their behavior in ways that reduce their vulnerability to the disease compared to less educated people.

are selecting which households to die in, the death variable(s) are not likely to be independent of the disturbance term in the household outcomes of interest. Over one-third (36%) of the people who died between 2001 and 2004 in our sample were persons who moved back into the household and died before the second survey. So there is a possibility that the decision to return to a household for terminal care is related to the economic circumstances of the receiving household or the ill person. This is one of the reasons why we do not use chronic illness as an explanatory variable when measuring the impacts of PA mortality on household welfare.

Several methods have been proposed in the literature to deal with endogenous dummy variables when estimating treatment effects models including: "Heckman-type" selection models (Goldberger 1972, based on Heckman's [1976] sample selection model) in which a selection equation and an outcome equation are jointly estimated, assuming a bivariate normal error term in the two equations; and instrumental variables (IV) estimators and nonparametric matching methods, most prominently propensity score matching (Rosenbaum and Rubin 1983), in which the probability of each unit selecting treatment is first estimated, and control observations are chosen by matching this score to the treatment observations. However, all of these methods are dependent on the availability of instruments to identify the impact of death.

Using the two-step IV method that exploits the binary nature of the endogenous explanatory variable(s), we test for endogeneity of PA mortality variables as follows: First, the two years of data are pooled and tested to determine whether mortality is endogenous.[11] Second, the data are tested again to see if death variables are still endogenous after controlling for time-invariant unobservable effects by differencing the outcome variables. Evidence of endogeneity at this stage would warrant the use of instrumental variable fixed effects; otherwise, OLS on the difference models will be sufficient.

The challenge is finding instruments with some explanatory power in distinguishing between afflicted and non-afflicted households, and not directly correlated with the welfare indicators of interest. Time-invariant variables from *ex ante* survey data (e.g., distance from the household to a main road or distance to health facilities) could potentially be used, but their usefulness in distinguishing between afflicted and non-afflicted households may be limited. On the other hand, a variable such as educational attainment of the most highly educated person in the household may have some explanatory power in distinguishing between afflicted and non-afflicted households. However, education is also likely to be correlated with income, so the direct link between education and income is likely to distort or bias the effect of adult mortality on income if education is indeed correlated with income as one might imagine. Moreover, it is educational attainment *prior* to the onset of illness that would be appropriate; this variable might change after the death of an adult if that adult was the most highly educated person in the household. In other words, education level after the death of a household member is likely to be endogenous. At worst one could have used the non-linearity of the first stage regression to identify the impact of death but our results would be less convincing in the absence of plausible exclusion restrictions.

---

[11] First, the method involves estimating the probit model $P(D=1|\mathbf{x},\mathbf{z})=G(\mathbf{x},\mathbf{z};\gamma)$ and obtaining fitted probabilities. Second, equation 5 is estimated by IV using instruments 1, $\hat{G}_i$ and $\mathbf{x}_i$. The method has a unique robustness property because using $\hat{G}_i$ as an instrument for D_i, the model for $P(D=1|\mathbf{x},\mathbf{z})$, does not have to be correctly specified and identification is achieved off the non-linearity of $P(D=1|\mathbf{x})$. However, $\Phi(\gamma_0+x\,\gamma_1)$ and x are usually highly correlated which may result in imprecise estimators (see Wooldridge 2002).

This study considers the use of rainfall shocks as a proxy for migration in and out of the community, lagged district HIV prevalence rates, and prior death in household as likely instruments. Below is a discussion about the possible pathways in which these instruments are linked to PA death.

Lagged HIV/prevalence: As indicted previously, there is a strong relationship between PA mortality rates from our survey data and provincial HIV prevalence rates. This makes lagged HIV prevalence a possible instrument. However, the use of lagged HIV/AIDS prevalence as an instrument could be problematic in the sense that prevalence rates based on sentinel site data may be biased upward, but this problem would less severe to the extent that the upward bias is uniform across all regions. However, if some differential bias existed, then lagged HIV/AIDS prevalence would not be a good instrument because the variable may also be correlated with the outcome variables. Despite the high correlation between HIV prevalence and prime-age mortality, HIV prevalence failed to pass the overidentification test hence we do not use the variable as an instrument.

Prime-age deaths in 1996-2000: In the 2001 survey, respondents were asked about prior mortality of household members during the 1996-2000 period. Chapoto and Jayne (2005) showed that individuals in households experiencing deaths between 1996 and 2000 were more likely to die of disease-related causes in the 2001-2004 period, making prior PA death a good proxy for future deaths. Thus, the correlation between prior deaths' and current mortality makes prior death during 1996-2000 period a good instrument for PA mortality due to illness in 2001-2004. However, it is also possible that mortality in the 1996-2000 period may be related to the dependent variables in the 2001-2004 period. Therefore, prior PA death is not used as an instrument in pooled models because it is likely to be correlated with the unobserved household characteristics. In contrast, as a robustness check of the endogeneity tests in differenced model, prior PA death is included as an instrument in one of the model (model 1) and excluded in the other (model 2). The results in section 3.1, Table 6 show that we still reach the same conclusion in both cases.

Rainfall shocks: A long history of variation in rainfall may be correlated with earlier migration in and out of the community. Severe drought tends to induce people to leave the rural areas and their families to seek income in the cities and send food home (see Thiam, Perry, and Piché 2003). Once away from the family some may rely on risky livelihood strategies that expose them to HIV infection and on their return to the community may pass the disease to unsuspecting partners. On the other hand, during good years, rural areas may attract traders from towns and cities and farmers may travel to markets and spend some time away from their families and communities. Such activity results in increased interaction with the outside community increasing their susceptibility to the spread of the disease.[12] Also, some studies have suggested that rural people may be infected with AIDS because of the interaction of drought and poverty, thus poor people (especially young girls) with no other survival alternatives may be forced into transactional sex in order to survive thereby exposing themselves to HIV. For example, a study by Bryceson, Deborah, and Fonseca (2005) of smallholder farmers in three rural villages in Malawi's Lilongwe district revealed that hunger was a greater contributing factor to increasing susceptibility to HIV/AIDS, as these communities were engaging in risky sexual practices to survive.

[12] A study in Senegal found that 27% of the men who had previously traveled in other African countries and 11.3% of spouses of men who had migrated were infected with HIV. In neighboring villages where men had not migrated less than 1% of the people were HIV positive (see Thiam, Perry, and Piché 2003).

Because we are predicting mortality occurring between 2001 and 2004, it likely that people dying of HIV/AIDS-related causes during this period contracted the disease six to eight years previously, given the typical asymptomatic period between HIV contraction and the onset of illness and death. Therefore, this study uses annual rainfall shocks in the 1994/95 drought season (crop season rainfall in 1994/95 minus mean rainfall over the 10-year period from 1990/1991 to 1999/2000) as a proxy for migration. This particular year is used because it was a severe drought year in the country and most likely induced significant migration that could affect mortality with a 7-10 year time lag, taking into account the mean period between HIV infection and death. However, not everyone migrates to other areas in search of other opportunities to help out their families in time of such hardship. It is likely that migration is a function of gender and age. To improve the predictive power of the instruments, we compute interaction variables between rainfall shocks and the age group of the deceased. In particular, eight variables are computed to interact with deviations in rainfall from the 1994/95 drought season from the 10-year mean with eight age groups 20-24, 25-29, 30-34, 35-39, 40-44, 45-49, 50-54 and 55-59 years. The results were not sensitive to which drought year was selected, 1991/92 or 1994/95. Due to high multicollinearity between the deviations in rainfall by year only deviations from the 1994/95 drought year are used.

3.0 RESULTS

We begin with a discussion of the results from the first-stage regression models, which test the suitability and strength of the instruments. We then discuss the results from the Hausman Wu Chi-square test for endogeneity of prime-age death variables by gender and position in the household for pooled OLS and DID regression models. Then having determined whether the prime-age death variables are still endogenous or not after purging the time-variant unobservable effects through differencing the data, the remainder of the section presents the results from appropriate models measuring the impacts of prime-age mortality on rural household outcomes.

3.1 First-stage Regression Models

An instrumental variable must satisfy two requirements: it must be correlated with the included endogenous variable(s) and orthogonal to the error process. The former condition is tested by an F-test of the joint significance of the instruments in the first-stage regression (Table 5). In all cases, the joint F-test for prior death and the 1994 drought age-group shocks are highly significant. Surprisingly, prior prime-age death is a significant predictor of other males and females mortality but not male or female head/spouse. In spite of these fairly large F-statistics and high percentage correctly predicted, a good deal of unexplained heterogeneity remains, as indicated by the low pseudo R^2. Also, in the model of changes in area under high-value crops, the null hypothesis that our instruments are not correlated with the error term is rejected. So the test for endogeneity should be interpreted with these shortcomings in mind.

Is prime-age death endogenous?

As discussed earlier there are reasons to believe that PA mortality from disease-related causes is likely to be endogenous and OLS estimates are biased in such instances. Table 6 columns A to F, summarizes the results from the Hausman-Wu test for endogeneity and Sargan N*R-squared test for overidentification of exclusion restrictions.[13] The results in column A show that prime-age mortality is indeed endogenous when OLS and IV results for the pooled sample are compared. In all the cases except two (the models for gross value of crop production and area under roots and tubers), the null hypothesis that all the prime-age gender and position mortality variables are exogenous is rejected at the 5% level of significance or lower. This finding implies that any attempt to measure impacts of prime-age death on rural household welfare with pooled cross-sectional data would yield biased estimates because of the unobserved effects, which are correlated with the error term.

Taking advantage of the availability of panel data the time-invariant unobserved household characteristics are differenced out as shown in equation 6 and further tested for endogeneity of prime-age death variables. Any evidence of endogeneity at this stage would indicate that even after differencing out the time-invariant unobserved characteristics there still remains time-varying unobserved household characteristics correlated with the error term, which would require us to consider the use of instrumental variable DID fixed effects estimation. However, the results in Table 6, column B and C indicate that differencing of the household time-invariant unobservable characteristics adequately addresses the endogeneity problem,

[13] Details about the first and second stage regression models can be found in Chapoto 2006.

Table 5. First-stage F-statistic for significance of identifying instruments, Pseudo R^2 and percent correctly predicted

	F-test for instruments					% correctly predicted and (Pseudo R^2)		
	Pooled Sample	--------------------Differenced Models------------------------------				Pooled Sample	Differenced Sample	
	Rainfall deviations and age group shocks	Rainfall deviations and age group shocks	Prior Death	Rainfall deviations and age group shocks	All Instruments			
		Model 1[a]	--------------------Model 2[b]--------------------------				Model 1[a]	Model 2[b]
Prime-age Mortality	(A)	(B)	(C)	(D)	(E)	(E)	(F)	(G)
Male head death	147.38**	310.10**	0.01	303.0**	328.3**	98.8(11.3)	98.1(44.1)	98.3(44.1)
Female heads/spouses death	237.11**	363.3**	0.34	3.56.7**	357.8**	98.5(15.5)	96.7(46.5)	97.7(46.9)
Other males death	325.19**	468.7**	15.7**	466.8**	464.6**	97.8(16.1)	97.2(42.6)	96.9(43.6)
Other females death	273.53**	481.5**	5.3*	472.1**	465.6**	97.2(16.4)	96.6(50.6)	96.4(50.7)

Source: CSO/MACO/FSRP Post Harvest Survey 1999/2000 and Supplemental Survey, 2001 and 2004

Notes: + significant at 10%; * significant at 5%; ** significant at 1%. [a]F-test results from first stage regression models without prior death as an instrument. [b]F-test results from first stage regression models with both prior death and age group and rainfall shock variables.

Table 6. Summary table of Hausman Wu Chi-square test and Sargan N*R square test for over identification for pooled and differenced samples

	Hausman Wu Chi-square test[a]			Sargan N*R square test of overidentification[b]		
	Pooled Sample	First differenced		Pooled Sample	First differenced	
		Model 1	Model 2		Model 1	Model 2
	(A)	(B)[c]	(C)[d]	(D)	(E)[c]	(F)[d]
Land cultivated						
Total area cultivated	22.26**	0.82	0.38	4.24	2.72	2.85
Area under cereals	18.32**	2.09	1.89	7.26	3.36	3.97
Area under tubers	6.17	2.64	3.06	5.21	6.82	7.25
Area under high value crops	19.41*	5.41	5.51	8.15	9.43+	9.57+
Household demographics						
Household size	29.26**	1.80	0.65	5.01	7.57	3.16
Males	22.69**	7.19	2.37	8.91	5.02	7.67
Females	22.87**	6.04	6.88	5.85	8.15	8.72
Boys	29.26**	1.80	0.65	5.01	7.57	3.16
Girls	14.56**	5.85	6.09	4.76	8.69	8.71
Crop production						
Gross value of output	5.26	1.32	1.23	7.14	3.71	3.96
Gross value of output/ha	9.46+	2.05	5.51	4.28	2.14	3.22
Assets and off-farm income						
Values of cattle	20.11**	1.49	0.77	5.12	6.72	7.85
Values of small animals	10.40*	4.22	2.99	8.90	7.59	8.12
Off-farm income	25.01**	7.53	8.61	6.99	9.01	9.18

Source: CSO/MACO/FSRP Post Harvest Survey 1999/2000 and Supplemental Survey, 2001 and 2004

Notes: [a]Tests of endogeneity of prime-age mortality (male heads, female heads/spouse, other males and other females): H_0: Regressors are exogenous. [b]Tests of overidentifying restrictions: H_0: All instruments are exogenous. + significant at 10%; * significant at 5%; ** significant at 1%. [c]Results from models without prior death as an instrument. [d]Results from models with both prior death and age group and rainfall shock variables.

since the null hypothesis that all prime-age mortality variables are exogenous is not rejected. These findings offer some support for the validity of earlier studies using fixed effects, RE or DID (but which did not explicitly test for endogeneity). Since this is the first study (to our knowledge) that attempts to test for endogeneity of prime-age mortality when measuring household outcomes, there is need for further empirical evidence on this issue. Based on these findings, results from fixed effects models using differenced data are presented in the remaining sections.

3.2 Impact of Prime-age Death on Household Composition

The results in Table 7 (columns A and B) show that irrespective of gender and/or position of the deceased person in the household, a prime age death is associated by less than a one-person decline in household size within one to three years after the death. For example, the death of a prime-age male reduces the size of the household by 0.84 members. The death of a PA woman reduces the size of the household by 0.69 members. Compared to non-afflicted households, the death of the male household head reduces household size by 0.71 person and the death of females who were heads or spouses of their households reduces household size by 0.81 person. The death of another adult female reduces household size by 0.56 persons. These finding indicates that households respond to mortality by partially replenishing their household size. This appears to be a logical attempt to replenish the household's labor supply after incurring a death.

Changes in household size, shown in column A and B, are the sum of changes in men, women, boys and girls as shown in columns C to J. Looking across the row, it can be seen that the reduction of household size due to male head/spouse death is mainly caused by a reduction of 0.55 in the number of adult males. The drop in adult males is less than one, suggesting partial replacement of males. The change in the number of females is positive, suggesting that women relatives may be coming to help out widows after the death of their husbands. Male household head mortality reduces the number of girls and boys in the household, but the estimate is statistically significant only in the case of girls.

In contrast, the death of PA female heads or spouses and other females reduces the size of the household by 0.81 and 0.56, respectively, and this reduction is due to the change in the number of females. Similar to the effect of male heads/spouses death, the reduction in household size is less than unity suggesting some partial replacement of household members. The results are slightly different for other non-core males death. The reduction in household size due to other non-core male death is a result of a decline in the number of adult males by 0.42 as well as a reduction in the number of girls by 0.34. This additional decline in number of girls explains why the reduction in household size is close to unity. This finding seems to suggest that households incurring other non-core male death are coping by sending away small girls to live with other relatives.

In contrast to PA mortality which generally is not anticipated very far in advance, elderly mortality can be anticipated to some extent. Over time, their roles in the household may progressively be absorbed by other household members. Our results show that the death of elderly adult male and female members reduces the household size by 0.81 and 0.57, respectively. Although statistically significant at the 20% level, the death of an elderly man tends to increase the number of boys in the household, suggesting that the tasks performed by elderly males may be assumed by boys absorbed in the household from the extended family.

Table 7. The impact of PA mortality on household composition by gender and position of the deceased

Covariates	Δ Household size		Change in number of :							
			Adult males		Adult females		Boys		Girls	
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)
Prime-age (PA) adult mortality										
Male	-0.84**		-0.55**		0.04		-0.07		-0.26**	
	(3.94)		(6.17)		(0.54)		(0.78)		(2.63)	
Female	-0.69**		0.07		-0.48**		-0.17*		-0.11	
	(3.40)		(0.99)		(6.10)		(2.09)		(1.27)	
Male head/spouse		-0.71**		-0.73**		0.11		0.01		-0.10
		(2.60)		(5.13)		(1.01)		(0.08)		(0.73)
Female head/spouse		-0.81*		0.01		-0.63**		-0.16		-0.04
		(2.32)		(0.11)		(4.79)		(1.19)		(0.24)
Male non-head/spouse		-0.88**		-0.42**		0.00		-0.13		-0.34*
		(3.06)		(3.77)		(0.03)		(1.19)		(2.50)
Female non-head/spouse		-0.56*		0.12		-0.39**		-0.14		-0.15
		(2.36)		(1.33)		(4.22)		(1.43)		(1.37)
Elderly mortality										
Elderly males	-0.81*	-0.81*	-0.71**	-0.72**	-0.02	-0.02	0.15	0.15	-0.23+	-0.22+
	(2.47)	(2.49)	(5.57)	(5.66)	(0.15)	(0.20)	(1.21)	(1.22)	(1.78)	(1.71)
Elderly females	-0.57+	-0.57+	0.14	0.13	-0.42**	-0.42**	-0.08	-0.07	-0.21	-0.20
	(1.65)	(1.66)	(1.16)	(1.09)	(2.83)	(2.85)	(0.51)	(0.49)	(1.37)	(1.32)
Constant	0.09	0.09	0.19**	0.19**	0.23**	0.23**	-0.18**	-0.18**	-0.16**	-0.16**
	(1.01)	(0.99)	(4.89)	(4.94)	(6.69)	(6.71)	(3.78)	(3.81)	(3.29)	(3.37)
Province x time dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
F-test on Mortality	14.98**	7.73**	19.16**	10.37**	18.59**	10.87**	2.58+	1.24	4.60*	2.64*
R-squared	0.11	0.11	0.11	0.11	0.09	0.09	0.10	0.10	0.11	0.11
Number of observations	5308	5308	5308	5308	5308	5308	5308	5308	5308	5308

Source: CSO/MACO/FSRP Post Harvest Survey 1999/2000 and Supplemental Survey, 2001 and 2004

Notes: ** 1% level of significance, * 5% level of significance and + 10% level of significance. Numbers in parentheses are t-ratios calculated with Huber-White-Robust standard errors.

Do these findings support the widespread view that households incurring prime-age death face severe agricultural labor constraints and increase their dependency ratios? Unfortunately, results in Table 7 alone cannot provide definitive answers to this important question. But these results do provide some indications. *First,* there seems to be evidence suggesting that households are coping by partially replacing lost household members. *Second,* a comparison of household size *ex ante* shows that afflicted household had initially larger household sizes compared to non-afflicted households (see Table 8). Afflicted and non-afflicted households had virtually identical effective dependency ratios, *ex post* (i.e., in the 2004 survey). One also has to bear in mind that most agricultural households generally face peak period labor shortages of some kind. Moreover, farming systems differ due to differences in population densities, farm sizes, and agro-ecological conditions, all of which influence the degree of labor shortages faced by individual farm households. Based on these reasons we suggest caution against potentially over-generalized conclusions that the loss of a PA adult will cause the household to face greater labor shortages than non-afflicted households.

3.3 Impact of PA Death on Farm and Crop Production

Farm production: There are at least four pathways in which farm production can be affected by prime-age mortality, through impacts on labor, knowledge, capital, and land. *First*, a reduction in household size may exacerbate labor shortages, forcing households to cut back on land cultivated or switch to labor saving crops. As mentioned earlier, this general assumption has led some development agencies to advocate for greater investment in labor-saving crop technologies. *Second*, the death of an adult may also entail a loss of agricultural husbandry, management, and marketing knowledge, requiring changes in crop mix. Even in households that are able to attract new members, the skills of the new members (whom we found to be primarily older children) may not match the skills of the deceased. *Third*, crop mix and the intensity of input application may change because of cash constraints imposed on the households after incurring the loss of an adult member. Certain crops require greater use of capital (e.g., purchasing farm inputs, chemical sprayers in the case of cotton, rental of animal traction services). Fourth, and especially in cases where the male household head dies, the widow and her dependents may have insecure land tenure rights and thus lose part or all of the land formerly cultivated by the family.

Table 9 (column A) shows that, in general, adult male mortality resulted in a 13% decline in total land cultivated; this effect is significant at the 5% significance level. Female death of any kind resulted in a 5% decline of cultivated land but the impact is not significant at the 10% level. Surprisingly, there is a 30% decline in land cultivated when elderly (>59 years) men died. This finding suggests that men (aged 60 and above) remain productive in their old age and probably devote a greater portion of their time (and capital) to crop cultivation than the younger male heads (who tend to be the primary earners of off-farm income in sampled households).

Table 9 also disaggregates impacts according to the gender and position of the deceased person (column B). Male head/spouse mortality is associated with a 21% reduction in land cultivation. Examining across the row for “male head/spouse death,” it is shown that most of

Table 8. Mean values by year and whether a household is afflicted by gender of deceased or non-afflicted

	99/00	0304	99/00	0304	99/00	0304	99/00	0304
	Non Afflicted HH		HH with PA death		HH with male death		HH with female death	
	----------Mean value----------							
Household composition								
Effective dependency ratio	1.33	0.99	1.27	0.97	1.31	0.97	1.24	0.97
Household size	5.97	5.88	7.17	6.24	7.20	6.14	7.25	6.41
Male	1.57	1.83	2.01	2.06	2.16	1.90	1.93	2.22
Female	1.62	1.86	2.17	2.15	2.03	2.26	2.31	2.09
Boys	1.34	1.08	1.43	1.02	1.40	1.04	1.45	1.01
Girls	1.43	1.10	1.56	1.02	1.60	0.94	1.56	1.08
Farm production								
Land cultivated	1.91	1.75	2.20	1.81	2.22	1.76	2.25	1.90
Cereals	1.38	1.23	1.66	1.34	1.73	1.28	1.66	1.42
Tubers	0.46	0.39	0.43	0.32	0.38	0.34	0.47	0.30
High value crops	0.07	0.13	0.11	0.15	0.11	0.14	0.12	0.18
Gross value of output ('000 Zkw)	1383.4	1445.2	1495.3	1296.9	1523.0	1328.6	1490.9	1354.3
Gross value of output per ha ('000 Zkw)	927.6	850.9	806.4	744.7	800.1	765.0	790.9	728.6
Land cultivated/adult equivalents ratio	0.65	0.64	0.63	0.66	0.59	0.66	0.68	0.68
Assets and off-farm income								
Values of cattle ('000 Zkw)	766.5	1379.2	1278.0	1580.1	1503.3	1441.7	1542.3	1893.8
Values of small animals ('000 Zkw)	127.3	178.5	145.0	171.3	138.0	154.7	155.2	184.4
Off farm income ('000 Zkw)	991.0	1040.3	1334.7	1271.7	1117.9	1053.4	1491.9	1399.0
Percent with off farm	62.8	51.1	64.6	53.3	61.4	51.6	66.6	54.9
Wealth status in 2000 (% non poor)	50.3	-	45.6	-	49.2	-	41.6	-

Source: CSO/MACO/FSRP Post Harvest Survey 1999/2000 and Supplemental Survey, 2001 and 2004

Table 9. The impact of PA mortality on cultivated land by gender and position in household

Covariates	Δ ln(Area cultivated)		Change in natural log of area under (ha):					
			Cereals[a]		Tubers and root crops[b]		High-value crops[c]	
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)
Prime-age (PA) adult mortality								
Male	-0.13*		-0.16*		0.01		-0.02+	
	(2.26)		(2.31)		(0.66)		(1.78)	
Female	-0.05		-0.01		-0.05*		-0.01	
	(0.91)		(0.23)		(2.09)		(0.99)	
Male head/spouse		-0.21**		-0.19*		-0.03		-0.04*
		(2.87)		(2.36)		(1.00)		(2.41)
Female head/spouse		-0.02		-0.08+		-0.01		0.00
		(0.23)		(1.92)		(0.18)		(0.06)
Male non-head/spouse		-0.06		-0.11*		0.03		-0.01
		(0.81)		(2.10)		(1.52)		(0.58)
Female non-head/spouse		-0.07		-0.04		-0.05*		-0.02
		(1.01)		(0.57)		(2.35)		(1.18)
Elderly mortality								
Elderly males	-0.30**	-0.30**	-0.20*	-0.20*	-0.05	-0.05	-0.01	-0.01
	(3.53)	(3.57)	(2.27)	(2.29)	(1.42)	(1.41)	(0.71)	(0.72)
Elderly females	-0.05	-0.05	-0.14	-0.14	0.05	0.05	0.02	0.02
	(0.48)	(0.52)	(1.04)	(1.06)	(1.34)	(1.32)	(0.99)	(0.97)
Constant	0.04	0.04	-0.12+	-0.12+	-0.01	-0.01	0.00	0.00
	(0.91)	(0.95)	(1.78)	(1.78)	(0.75)	(0.75)	(1.55)	(1.56)
Province x time dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
F-test on Mortality	3.18*	2.67*	2.77+	2.06+	2.35+	2.22+	1.97	1.82
R-squared	0.20	0.20	0.19	0.19	0.25	0.25	0.18	0.18
Number of observations	5305 Households							

Source: CSO/MACO/FSRP Post Harvest Survey 1999/2000 and Supplemental Survey, 2001 and 2004

Notes: ** 1% level of significance, * 5% level of significance and + 10% level of significance. Numbers in parentheses are t-ratios calculated with Huber-White-Robust standard errors. [a]Cereals include: maize, millet, wheat, sorghum and all other minor food crops. [b]Root crops include cassava, sweet potatoes. [c]High value crops include cotton, sunflower, coffee, tobacco, Irish potato, vegetables and fruits.

the decline in cultivated area is for cereal crops (-19%) and high-valued cash crops (-4%). column B results also indicate the important impact of elderly male mortality on crop cultivation, particularly cereals. All the other mortality categories are negative but not statistically significant. This finding seems consistent with our earlier findings that households incurring male head/spouse mortality experience a higher decline in net household size, which may partially explain the relatively severe reduction in cultivated land and production associated with male head of household mortality.

By disaggregating area cultivated by area under cereals, root and tuber crops, and high-value cash crops, we examine the impact of mortality on particular crops by (Table 9, columns C to H) and test the hypothesis that households experiencing prime-age mortality switch to less labor-intensive crops Examining the first row of data in Table 9, we see that the 13% decline in land cultivated among households incurring a male death is due to the reduction in area under cereals and, to a lesser extent, high-value crops. The coefficient on changes in roots and tubers is positive but not statistically significant. By contrast (examining the second row of data), PA female mortality is associated with a 5% decline in area under roots and tubers. When distinctions are made between gender and position of the deceased (in the subsequent rows of Table 9), we see that mortality is associated with a subsequent decline in cereal area of 19% in the case of male heads/spouses, 8% in the case of female heads/spouses, 11% when the death was another non-head male, and 20% for men over 59 years of age. These results support the importance of disaggregating mortality by gender and position in the household of the deceased as well as by crop mix. Otherwise, one might have concluded that households incurring male deaths had a statistically significant decline in land cultivated but missed the fact that mortality of older members has the most important impact on crop area cultivated.

Also, the results in Table 9 column H show that among households experiencing male head/spouse death, area under high value crops declined by 4%, suggesting that, to some extent, the death of a male core member of the household adversely affects cash cropping.

Regarding impacts on area under roots and tubers, there is a significant 5% decline among households experiencing the death of women other than the head or spouse. No significant impacts on root and tuber cultivation are found in the case of men in any category or for female head/spouse or elderly women. These findings provide mixed support for the hypothesis that households experiencing prime-age death cope with the reduction in family size by switching to labor saving crops such as roots and tubers. However, the small and generally statistically insignificant declines in root and tuber cultivation are substantially less than the estimated declines in cereal area in response to adult mortality.

Crop production: Table 10, columns A to D presents the regression results from models measuring impact of PA death on the gross value of crop output and gross value of crop output per hectare. Although the coefficients on mortality variables are negative as expected, there is no statistically significant effect on gross value of output for mortality by gender in general or disaggregated by gender and position of the deceased. The results are similarly insignificant for the models measuring the impact of PA mortality on gross output per hectare.

Table 10. The impact of PA mortality on gross value of output, gross output per hectare values of cattle and small animals and off-income by gender and position in household

Covariates	Change in natural log of:									
	---------------Gross value of output------------				--------------------Values of -----------------------				---Off-farm income----	
	-------Total--------		-----Per hectare----		---------Cattle--------		------Small animals---			
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)
Prime-age (PA) adult mortality										
Male	-0.127		-0.008		-0.287+		-0.295+		0.096	
	(1.61)		(0.12)		(1.71)		(1.66)		(0.37)	
Female	-0.116		-0.050		-0.145		-0.415**		0.017	
	(1.13)		(0.77)		(0.91)		(2.71)		(0.08)	
Male head/spouse		-0.211		0.076		-0.299+		-0.653**		0.366
		(1.39)		(0.69)		(1.73)		(2.70)		(0.95)
Female head/spouse		-0.113		-0.089		-0.018		-0.370+		0.290
		(1.13)		(0.88)		(0.07)		(1.81)		(0.89)
Male non-head/spouse		-0.084		-0.051		-0.279		0.002		-0.083
		(0.95)		(0.61)		(1.26)		(0.01)		(0.25)
Female non-head/spouse		-0.104		-0.013		-0.185		-0.443*		-0.159
		(1.19)		(0.16)		(0.89)		(2.46)		(0.58)
Elderly mortality										
Elderly males	-0.165	-0.169	0.113	0.114	-0.328	-0.324	-0.353	-0.368	-0.304	-0.280
	(0.87)	(0.79)	(1.34)	(1.34)	(1.11)	(1.10)	(1.36)	(1.41)	(0.91)	(0.84)
Elderly females	-0.045	-0.048	-0.013	-0.011	-0.096	-0.094	0.060	0.046	0.508	0.525
	(0.43)	(0.46)	(0.12)	(0.11)	(0.31)	(0.30)	(0.22)	(0.17)	(1.31)	(1.35)
Constant	-0.127+	-0.028	-0.008	-0.054	0.030	0.028	0.294**	0.298**	-0.882**	-0.888**
	(1.76)	(0.57)	(0.12)	(1.04)	(1.53)	(1.41)	(2.87)	(2.90)	(6.28)	(6.32)
Province x time dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
F-test on Mortality	14.98**	7.73**	19.16**	10.37**	2.06	1.19	5.33**	3.88**	0.07	0.51
R-squared	0.11	0.11	0.11	0.11	0.13	0.13	0.18	0.18	0.35	0.35
Number of observations	5308									

Source: CSO/MACO/FSRP Post Harvest Survey 1999/2000 and Supplemental Survey, 2001 and 2004

Notes: ** 1% level of significance, * 5% level of significance and + 10% level of significance. Numbers in parentheses are t-ratios calculated with Huber-White-Robust standard errors.

3.4 Impact of PA Mortality Value of Livestock

Liquidation of assets is cited as one of the coping mechanisms to mitigate the impact of mortality and other shocks (see Barnett and Blaikie 1992). Assets depletion may be a response to a severe income shock, but this response is likely to decrease household use of cash inputs and animal traction in crop cultivation, which would tend to result in lower productivity and overall crop production in future years (Mather et al. 2004). Due to data limitations, we could not obtain a comparable measure of the value of most assets between the two surveys, so the focus is limited to value of livestock, which was collected consistently in the two surveys.

The results in Table 10, columns A and B, show that there is a negative impact of PA mortality on value of cattle assets but the impact by both gender and position in the household of the deceased is statistically insignificant except among households experiencing death of a male head of household. Among households experiencing a male head death, values of cattle declined by about 29.9% but this impact is only significant at the 10% level. The results on the impact of mortality on values of cattle are somewhat similar to those found by Yamano and Jayne (2004) in Kenya. Thus, to some extent, households appear to try to hold on to productive cattle and probably sell only as a last resort. However, this coping strategy breaks down among households incurring male head of household mortality, apparently because the impacts on household crop cultivation are most severe in this particular case.

Table 10, columns C and D, show that PA mortality has significant adverse effects on the values of small animals. The value of small animals declines by 29.5% and 41.5% after the death of adult men and women, respectively. When the results are disaggregated by gender and position in household of the deceased, the impact is highest among households with a male head death with a 65.3% decline, followed by mortality of other females with a 44.3% decline, and a 37.0% reduction in values of small animals among households with female head/spouse death. The result on female head or spouse death of a 37.0% decline in value of small animals is only significant at the 10% level. Generally, these results strongly indicate that afflicted households cope with prime-age mortality by selling off small animals.

3.5 Impact of PA Mortality on Off-farm Income

Previous studies have also suggested that off-farm income sources are at risk among households experiencing PA mortality,[14] particularly among those that are asset poor and vulnerable to begin with. The results in Table 10, columns I and J, show mixed results that are not statistically significant in any case of mortality by gender and position in the household of the deceased.

3.6 Does the Impact Differ by Initial Household Conditions?

In order to seek more clarity on the findings discussed above, we examine whether the impacts differ due to the differences in initial pre-death wealth status, landholding size and effective dependency ratios. Also, we test the sensitivity of the findings by stratifying the

[14] See Mather et al. 2004, Yamano and Jayne 2004, and Donovan et al. 2003.

sample into two groups based on the initial pre-death value of household assets in the 2001 survey[15] and then estimate the models in Tables 7, 9, and 10 with gender and position mortality variables. This specification tests whether household's response to death shocks depend on these initial conditions, which were found to be important in previous studies (Drimie 2002; Yamano and Jayne 2004). We find that differences in initial effective dependency ratios are not significant in most of the cases and hence to save space we concentrate only on the results stratified by initial wealth and landholding size.

3.6.1 Does the impact of mortality differ by wealth status in 2000?

Household composition: The results of the interaction terms between mortality and initial wealth status are not statistically significant except in the case of the male heads/spouses death, which is statistically significant at the 10% level (Table 11). The reduction in household size is greater in initially poor households than non-poor households. Non-poor households are more successful in attracting boys and other males (statistically significant at 15%) to replace the labor lost among households incurring male head/spouse death. However, the loss of knowledge and the foregone income of the deceased is likely to be much harder to replace.

To understand the magnitude of these effects, we simulate the impact of male head of household death on household composition for two types of households: (1) those that are initially poor (in the bottom half of the assets distribution), have landholdings equal to the mean level in the entire sample (3.10 hectares) and mean effective dependency ratio (1.33); and (2) non-poor households with mean landholding size and mean dependency ratio (see Table A1 for the descriptive statistics of all the explanatory variables).

The results indicate that household size declines by 0.301 person in non-poor households and by 0.838 in poorer households. Poorer households appear to have substantially greater difficulties in coping with the death of their household head whereas non-poor households are likely to almost fully restore household size to former pre-death levels. These results seem to support earlier findings in Kenya that poor households experiencing a male head death are less able to cope with a death shock due to limited household resources to support additional members (Yamano and Jayne 2004).

Land cultivated and crop mix: Afflicted households' initial wealth level also affects the impact of male mortality on land cultivation (Table 12). The negative coefficients on the interaction terms suggest that mortality leads to a greater reduction in land cultivated among non-poor households compared to poor households. Evaluated at mean land size (3.10 hectares) and mean effective dependency ratio (1.33) we find that land cultivated and area under cereals decline by 75% and 61% among non-poor households experiencing male household head mortality, compared to a 35% and 36.1% decline among initially poor households. By contrast, the impacts are lower in both poor and non-poor households experiencing female heads/spouse mortality. For example, total land cultivated and area

[15] Value of assets in 2001 includes farm equipment including scotch-carts, oxcarts and harrows, value of cattle and small animal stock and non farm assets such as bicycles and motor vehicles.

Table 11. The impact of PA mortality on household composition by initial household pre-death characteristics

	HH size	Change in number of:			
		Adult males	Adults females	Boys	Girls
	(A)	(B)	(C)	(D)	(E)
Prime-age (PA) adult mortality					
Male head/spouse	-0.828**	-0.693**	0.116	-0.065	-0.187
	(2.78)	(4.16)	(1.12)	(0.40)	(1.31)
Female head/spouse	-1.084**	0.017	-0.528**	-0.382*	-0.191
	(2.64)	(0.13)	(3.99)	(2.29)	(1.10)
Male non-head/spouse	-0.752**	-0.398**	0.028	-0.090	-0.292*
	(2.73)	(3.67)	(0.25)	(0.85)	(2.28)
Female non-head/spouse	-0.444+	0.138	-0.387**	-0.105	-0.090
	(1.82)	(1.49)	(4.08)	(1.10)	(0.87)
PA death by poverty status					
Male heads *poverty status	0.960+	0.058	-0.241	0.728*	0.215
	(1.31)	(0.19)	(1.14)	(2.37)	(0.83)
Female H/S * poverty status	-0.234	-0.214	-0.080	0.078	-0.018
	(0.35)	(0.90)	(0.30)	(0.33)	(0.06)
Other males*poverty status	-0.264	-0.284	0.275	0.107	-0.362
	(0.47)	(1.34)	(1.26)	(0.48)	(1.47)
Other females*poverty status	-0.497	-0.355+	-0.100	-0.002	-0.040
	(1.03)	(1.95)	(0.53)	(0.01)	(0.19)
PA death by 2000 land size					
Male heads/spouses*land size	-0.164	-0.017	0.011	-0.102*	-0.057
	(1.50)	(0.36)	(0.25)	(2.24)	(1.11)
Female heads/spouses*land size	0.067	-0.056	0.041	0.039	0.043
	(0.44)	(1.11)	(0.87)	(0.68)	(0.70)
Other adult males*land size	-0.128	-0.052+	-0.073*	-0.023	0.019
	(1.30)	(1.89)	(2.14)	(0.63)	(0.49)
Other adult females*land size	0.016	0.051**	-0.013	0.001	-0.023
	(0.25)	(2.61)	(0.53)	(0.03)	(0.80)
PA mortality by dependency ratio					
Male heads*EDR[f]	0.064	0.050	0.070	-0.071	0.015
	(0.25)	(0.36)	(0.73)	(0.44)	(0.13)
Female heads/spouses* EDR	-0.585	-0.056	0.142	-0.397*	-0.274
	(1.31)	(0.38)	(0.75)	(2.13)	(1.48)
Other adult males* EDR	0.022	0.039	-0.032	0.010	0.006
	(0.09)	(0.39)	(0.40)	(0.08)	(0.05)
Other adult females* EDR	0.514**	0.004	0.154*	0.158*	0.198
	(2.89)	(0.06)	(2.07)	(2.18)	(1.59)
Province x time dummies	Yes	Yes	Yes	Yes	Yes
Constant	1.339**	0.022	0.332**	0.449**	0.535**
	(4.34)	(0.18)	(3.02)	(3.14)	(4.08)
Joint tests					
Asset poverty status*PA mortality	1.68	0.72	0.72	2.34*	2.18*
Land size*prime-age mortality	7.27**	1.34	1.34	5.41**	7.04**
Dependency ratio*PA mortality	27.01**	13.01**	13.01**	60.72**	51.47**
R-squared	0.15	0.11	0.11	0.19	0.17
Number of observations			5306		

Source: CSO/MACO/FSRP Post Harvest Survey 1999/2000 and Supplemental Survey, 2001 and 2004

Notes: ** 1% level of significance, * 5% level of significance and + 10% level of significance. Numbers in parentheses are t-ratios calculated with Huber-White-Robust standard errors.

Table 12. The impact of PA mortality on cultivated land by initial household pre-death characteristics

	Δ in natural log of Land cultivated (ha	Change in natural log of area under(ha):		
		Cereals	Tubers	High value crops
	(F)	(G)	(H)	(I)
Prime-age (PA) adult mortality				
Male head/spouse	-0.351**	-0.361**	-0.027	-0.041*
	(3.56)	(3.18)	(0.84)	(2.07)
Female head/spouse	0.004	0.073	-0.004	0.001
	(0.05)	(0.68)	(0.09)	(0.03)
Male non-head/spouse	-0.044	-0.089	0.044+	-0.007
	(0.61)	(1.05)	(1.75)	(0.47)
Female non-head/spouse	-0.012	0.007	-0.042	-0.017
	(0.17)	(0.10)	(1.58)	(1.21)
PA death by poverty status				
Male heads *poverty status	-0.380*	-0.310*	0.046	-0.000
	(2.03)	(2.32)	(0.76)	(0.01)
Female H/S * poverty status	0.028	-0.002	-0.048	-0.003
	(0.18)	(0.01)	(0.78)	(0.12)
Other males*poverty status	-0.181	-0.303+	0.002	-0.055*
	(1.24)	(1.75)	(0.03)	(2.10)
Other females*poverty status	-0.121	-0.093	-0.122*	-0.007
	(0.87)	(0.61)	(2.25)	(0.26)
PA death by 2000 land size				
Male heads/spouses*land size	0.064*	0.065+	0.014	-0.002
	(1.96)	(1.94)	(1.32)	(0.37)
Female heads/spouses*land size	-0.023	-0.027	-0.004	-0.002
	(1.07)	(1.26)	(0.29)	(0.16)
Other adult males*land size	0.021	0.021	-0.000	0.002
	(1.17)	(0.92)	(0.04)	(0.22)
Other adult females*land size	-0.015	0.007	-0.016+	-0.002
	(0.88)	(0.36)	(1.86)	(0.54)
PA mortality by dependency ratio				
Male heads*EDR[f]	-0.194	-0.104+	-0.007	0.018
	(1.53)	(1.96)	(0.23)	(1.04)
Female heads/spouses* EDR	0.084	0.155	0.010	-0.002
	(0.78)	(1.08)	(0.19)	(0.07)
Other adult males* EDR	0.013	0.035	-0.022	-0.013
	(0.19)	(0.46)	(1.34)	(1.53)
Other adult females* EDR	0.029	0.014	0.032	-0.006
	(0.63)	(0.30)	(1.63)	(0.51)
Province x time dummies	Yes	Yes	Yes	Yes
Constant	0.258*	0.174	0.015	0.049**
	(2.46)	(1.39)	(0.47)	(3.13)
Joint tests				
Asset poverty status*PA mortality	9.63**	7.26**	4.87**	2.01+
Land size*prime-age mortality	8.46**	7.32	2.12+	0.15
Dependency ratio*PA mortality	0.74	1.14	1.02	0.82
R-squared	0.21	0.22	0.26	0.18
Number of observations		5306		

Source: CSO/MACO/FSRP Post Harvest Survey 1999/2000 and Supplemental Survey, 2001 and 2004

Notes: ** 1% level of significance, * 5% level of significance and + 10% level of significance. Numbers in parentheses are t-ratios calculated with Huber-White-Robust standard errors.

under cereals declined by 0.4% and 7.3% among poor households experiencing female head/spouse of household mortality, compared to declines of 6.4% and 4.7% among non-poor households. One could find these results a bit puzzling given that women devote more labor hours to agriculture than men. However, in about 33% of the cases among households experiencing a male head of household death between 2001 and 2004, the widow was cultivating at least 20% less land in 2004. This could be due to a loss of land, capital and livestock assets to other relatives after the death of their husband. We also find that relatively wealthy widow-headed households are particularly vulnerable, as they have more land and assets that can be claimed by relatives than afflicted households that are poor to begin with (Chapoto and Jayne forthcoming).

There is a less severe but similar pattern of results for other (non-head) prime-age males. These results indicate that other prime-age males in the household play an important role in crop production in rural Zambia and that their death adversely affects land cultivation in both poor and non-poor households alike.

Similar to findings in Kenya (Yamano and Jayne 2004), the death of the male household head in poor households is associated with reductions in area under high-value crops. However, there are no other statistically significant impacts of mortality among households in the bottom 50% of the assets distribution except in the case of elderly male mortality. The results reinforce findings reported earlier that men over aged 59 still exert an important contribution to crop cultivation, not necessarily through their own labor input but possibly through their capital resources for renting animal draft power, hiring labor, and other cash inputs in crop production.

Crop production: Table 13 column A shows that the impacts of mortality on the gross value of crop output does not differ by initial poverty status. Yet the impact of male head mortality on gross value of output *per hectare* does appear to be influenced by initial poverty status (column B). The statistically significant positive interaction term on male head death and poverty status implies that the adverse impact of mortality is greater among initially poor households. For example, evaluating the impact of male head death on gross value of output per hectare at mean land size and mean effective dependency ratio, we find that output per hectare rises by 32% in wealthier households experiencing male head death compared to a 19% decline in assets-poor households. Since there was a net decline in land cultivated in both cases due to male head death these results seem to suggest greater intensification in wealthier households experiencing male head death. Also, as discussed earlier, wealthier households incurring male head of household death are more successful in attracting other males into the household to at least partially compensate for the labor shock.

Livestock assets: Results in Table 13, column C, show that the impacts of mortality on the value of cattle assets do not differ according to initial household wealth status. Yet there do appear to be differential impacts of death shocks on the value of small animals according to initial wealth status. The negative interaction between wealth status and male head mortality implies that male head death causes a greater sell-off of small animals among wealthier households than poor households. Holding land size and effective dependency ratios at their mean levels, our results indicate that the value of small animals declines by 76.9% in wealthier households experiencing male head death compared to 54.6% in asset-poor households. The results show that selling off small animals is a major adjustment mechanism by which both poor and non-poor households respond to adult mortality.

Table 13. The impact of PA mortality on gross value of output, gross output per hectare values of cattle and small animals and off-income by initial household pre-death characteristics

Covariates	Change in natural logs of:				
	---Gross value of output----		-------Values of-----		Off-farm
	Total	Per ha	Cattle	Small animals	
	(A)	(B)	(C)	(D)	(E)
Prime-age (PA) adult mortality					
Male head/spouse	-0.270	0.090+	-0.347+	-0.685**	0.220
	(1.21)	(1.84)	(1.10)	(3.28)	(0.53)
Female head/spouse	-0.043	-0.040	0.104	-0.185	0.122
	(0.43)	(0.41)	(0.40)	(0.68)	(0.32)
Male non-head/spouse	-0.053	-0.042	-0.286	-0.009	-0.027
	(0.60)	(0.49)	(1.31)	(0.04)	(0.08)
Female non-head/spouse	-0.068	-0.030	-0.141	-0.350+	-0.130
	(0.72)	(0.33)	(0.75)	(1.84)	(0.47)
PA death by poverty status					
Male heads *poverty status	0.042	0.510**	0.140	-0.233+	-0.502
	(0.18)	(2.63)	(0.28)	(1.87)	(0.63)
Female H/S * poverty status	-0.138	-0.185	0.416	-0.240	-0.072
	(0.69)	(0.91)	(0.82)	(0.46)	(0.11)
Other males*poverty status	-0.278	-0.024	-0.311	-0.718	0.662
	(1.55)	(0.13)	(0.68)	(1.56)	(0.99)
Other females*poverty status	-0.088	0.028	-0.070	0.116	0.186
	(0.46)	(0.15)	(0.18)	(0.30)	(0.34)
PA death by 2000 land size					
Male heads/spouses*land size	-0.054+	-0.139**	-0.007	0.061	-0.053
	(1.77)	(4.14)	(0.10)	(0.90)	(0.40)
Female heads/spouses*land size	0.040	0.071**	-0.147	0.015	0.154*
	(1.52)	(2.69)	(1.62)	(0.18)	(2.01)
Other adult males*land size	0.024	0.008	-0.012	0.024	-0.085
	(1.13)	(0.35)	(0.25)	(0.47)	(0.78)
Other adult females*land size	-0.002	0.009	0.050	0.006	-0.042
	(0.11)	(0.52)	(0.87)	(0.12)	(0.58)
PA mortality by dependency ratio					
Male heads*EDR[f]	-0.049	0.112	-0.091	-0.038	-0.118
	(0.35)	(0.92)	(0.36)	(0.47)	(0.24)
Female heads/spouses* EDR	0.119	0.015	0.361	0.445	-0.205**
	(0.80)	(0.10)	(1.01)	(1.12)	(2.82)
Other adult males* EDR	-0.113	-0.115	0.231	-0.070	0.195
	(1.62)	(1.47)	(1.39)	(0.32)	(0.70)
Other adult females* EDR	0.052	0.012	0.132	-0.062	-0.091
	(0.60)	(0.14)	(0.53)	(0.36)	(0.39)
Province x time dummies	Yes	Yes	Yes	Yes	Yes
Constant	0.340**	0.094	0.728**	0.813**	-0.092
	(2.66)	(0.78)	(3.22)	(2.96)	(0.22)
Joint tests					
Asset poverty status*PA mortality	2.74**	2.80*	10.00**	36.59**	0.26
Land size*prime-age mortality	7.42**	3.72**	1.96*	5.74**	1.69
Dependency ratio*PA mortality	1.47	0.52	1.27	2.00*	0.58
R-squared	0.17	0.21	0.14	0.22	0.35
Number of observations			5306		

Source: CSO/MACO/FSRP Post Harvest Survey 1999/2000 and Supplemental Survey, 2001 and 2004

Notes: ** 1% level of significance, * 5% level of significance and +10% level of significance. Numbers in parentheses are t-ratios calculated with Huber-White-Robust standard errors.

Off-farm income: Results in Table 13, column D, show no evidence of differential impacts of mortality on off-farm income by initial household wealth status.

3.6.2 Does the impact differ by land holding size in 2000?

Land/labor ratios[16] provide a rough measure of households' potential supply of labor per hectare owned. *A priori* one would expect that households with relatively low land/labor ratios in 2000 would be less labor constrained, and hence less likely to need to attract new members if the household experiences a death, than households with high land/labor ratios. Descriptive results in Table 8 show no significant differences in mean land/labor ratio between afflicted and non-afflicted household, either *ex ante* (before incurring mortality) or *ex post*. Since changes in household size are endogenous, we estimated models with interaction of PA mortality between 2001 and 2004 and initial land holding size in 2000 to determine whether there is a differential impact of death on household composition according to initial landholding size. Our premise is that non-poor households are better able to restore their land/labor ratio, at least to some extent, by hiring in extra labor or attracting new PA members compared to their less wealthy counterparts.

The results in Tables 11, 12, and 13 show some interesting differential impacts of PA mortality according to pre-death landholding size. The results in Table 11, for example, show that there is differential impact on household size among households experiencing male head death. Among poor households with small (25^{th} percentile of landholding size, 1.06 hectares) and large land sizes (75^{th} percentile of landholding size, 4.0 hectares), the death of a male household head results in a decline in household size of 0.92 and 0.74, respectively. Among initially wealthier households, household size *rises* by 0.04 and 0.22 persons, respectively. This finding suggests that the effect of male head death on subsequent household size varies greatly between poor and non-poor households. Poor households experience a decline in household size after the male head dies, while non-poor households are able to partially compensate for the loss of a male head, primarily through attracting more boys into the household.

Table 12 shows that interaction terms between mortality variables and landholding size in 2000 are not jointly significant, suggesting that there are no differential impacts of PA death on land cultivated and crop mix according to initial landholding size except in the case of male head mortality. The positive interaction term on landholding size in 2000 and male head/spouse mortality indicates that households with larger landholding sizes incur a smaller decline in land cultivated in response to male head mortality than households with smaller farms. For example, among households with landholdings in the 75^{th} percentile and incurring mortality of male head/spouse, total land size declined by 54% compared to 73% among similar households but with land sizes at the 25^{th} percentile. This unexpected finding implies that remaining household members on smaller farms are more likely to reallocate their labor from farm to non-farm activities after the departure of the male head.

The results in Table 13 on the impacts of adult mortality on off-farm income show generally statistically insignificant results. However, there is one important exception: the case of female spouse mortality. Households with higher effective dependency ratios (the ratio of children, elderly and chronically ill residents over healthy prime-aged adults) incur a

[16] Adult equivalents are used as a proxy of farm labor.

significantly greater drop in off-farm income after the loss of a female head or spouse than households with low dependency ratios. This stands to reason, because the loss of the female spouse, especially in households with initially high dependency ratios, may compel other adult residents to reallocate their time from activities outside the farm to activities on the household premises. We also find that female spouse mortality has less severe impacts on off-farm income in households with initially large landholdings.

3.7 Does the Impact Differ if the Sample Excludes Homecoming Sick Prime-age Household Members Who Died between 2001 and 2004?

The impact of PA mortality on rural welfare may differ between (a) households suffering the death of members who were long-term residents of the household (i.e., enumerated in the first survey), and (b) households incurring the death of a member who was not resident at the time of the first survey but rather returned to the household to receive terminal care between the time of the first and second survey. Other factors constant, one would expect to find more severe impacts of mortality among households in Category (a) than in Category (b). The initial values of assets, crop production and income of Category (a) households reflect the productivity of resident household members in 2000/01, prior to the household incurring a death, and possibly before any members became chronically ill. The effects of having had at least one adult turn ill and die is measured by the change in household behavior and outcomes between the 2001 and 2004 surveys. By contrast, among Category (b) households, none of the members enumerated in 2001 became sick and/or died between 2001 and 2004. Hence the changes in household behavior and outcomes as measured by the differences in the 2001 and 2004 surveys reflect not the effects of mortality of resident members or the productivity of their labor in 2001, but rather the effects of increased care giving and expenses associated with caring for an ill person who has joined the household. While the welfare indictors of households in both categories (a) and (b) are expected to be adversely affected, the magnitude of the death shock may differ.

To analyze these potentially different impacts, one approach would be to include a dummy variable for households taking in a sick member who was not a resident of the household in 2001 and who subsequently died prior to 2004. However, this variables would be endogenous. As discussed earlier, ill persons' decisions about where to seek terminal care may depend on the initial conditions of the receiving household. We approach this problem by comparing the results of the restricted sample (excluding Category (b) households from the sample) and results from the full sample as presented earlier.

Although the sign and statistical significance of the results remain virtually the same in the restricted and unrestricted models, there are noteworthy differences in how mortality affects household size. Table 14, columns A and B, shows that both the death of resident male and female adults reduces household size by greater than one person. The unrestricted results in Table 7 (which includes mortality of both initially resident adults as well as those who joined the household and then died after the 2001 survey) show smaller reductions in household size. Table 14 shows especially large reductions in household size, -2.12 persons, after the death of a PA male other than the head of household. The death of initially resident women other than the spouse or head is associated with a -1.46 reduction in household size. In these cases, besides the reduction in household size resulting from the adult's death, there is also a significant decline in the number of boys and girls remaining in the household. These results indicate that households' ability to attract new members is more difficult in the case of mortality of members who have resided at the household for some time, which further supports the need for future analysis on this subject to take into account the different types of mortality in the household.

Table 14. The impact of PA mortality on household composition by gender and position of the deceased: Restricted sample

Covariates	Δ Household size		Change in number of :							
			Adult males		Adult females		Boys		Girls	
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)
Prime-age (PA) adult mortality										
Male	-1.44**		-0.85**		-0.11		-0.15		-0.33**	
	(5.71)		(8.13)		(1.16)		(1.27)		(2.70)	
Female	-1.20**		-0.03		-0.72**		-0.23**		-0.21*	
	(5.20)		(0.31)		(8.13)		(2.62)		(2.08)	
Male head/spouse		-0.65*		-0.75**		0.12		0.05		-0.08
		(2.31)		(5.19)		(1.11)		(0.34)		(0.55)
Female head/spouse		-0.80*		0.01		-0.64**		-0.12		-0.05
		(2.26)		(0.10)		(4.87)		(0.93)		(0.33)
Male non-head/spouse		-2.12**		-0.89**		-0.32*		-0.36*		-0.55**
		(5.33)		(5.97)		(2.18)		(2.31)		(2.77)
Female non-head/spouse		-1.46**		-0.02		-0.78**		-0.31**		-0.34**
		(5.36)		(0.16)		(7.27)		(2.65)		(2.73)
Elderly mortality										
Elderly males	-0.90**	-0.85**	-0.73**	-0.73**	-0.03	-0.02	0.13	0.14	-0.27*	-0.26+
	(2.71)	(2.59)	(5.60)	(5.58)	(0.20)	(0.12)	(1.05)	(1.15)	(2.06)	(1.95)
Elderly females	-0.67*	-0.64+	0.10	0.11	-0.48**	-0.47**	-0.06	-0.05	-0.24	-0.22
	(1.96)	(1.86)	(0.87)	(0.89)	(3.29)	(3.21)	(0.35)	(0.29)	(1.52)	(1.44)
Constant	0.12	0.10	0.20**	0.20**	0.25**	0.24**	-0.18**	-0.18**	-0.15**	-0.16**
Province x time dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.13	0.13	0.12	0.12	0.09	0.09	0.10	0.10	0.14	0.14
Number of observations	5150	5150	5150	5150	5150	5150	5150	5150	5150	5150

Source: CSO/MACO/FSRP Post Harvest Survey 1999/2000 and Supplemental Survey, 2001 and 2004

Notes: ** 1% level of significance, * 5% level of significance and + 10% level of significance. Numbers in parentheses are t-ratios calculated with Huber-White-Robust standard errors.

4.0 CONCLUSION AND POLICY RECOMMENDATIONS

Fully two decades since the HIV/AIDS epidemic in Africa has been characterized as a major economic development crisis, there remains a dearth of micro-level information on the impacts of the disease on rural African households and their responses, although this is fortunately beginning to change. Using comprehensive rural farm household longitudinal data from Zambia, we measured the impacts of prime-age (PA) adult mortality on crop production and cropping patterns, household size, livestock and non-farm income. The paper adopted and extended the counterfactual (difference-in-difference) approach used by Yamano and Jayne (2004) by controlling for initial (pre-death) household conditions that may influence the severity of the impacts of adult mortality. In particular, we controlled for initial poverty status, landholding size, effective dependency ratio, and the gender and position of the deceased person. Moreover, this study extends previous research on this topic by explicitly taking into account the possibility that prime-age adult death in the household is endogenous.

Using prior death and age group-specific drought shocks as instruments for prime-age deaths' between 2001 and 2004, the Hausman-Wu chi square test for endogeneity shows that indeed death variables are endogenous for pooled OLS models. However, after differencing out the time-invariant unobserved household characteristics, the Hausman-Wu test indicates that the endogeneity problem is addressed and that OLS estimation using household fixed effects is appropriate.

Based on the difference models, the analysis yields a number of noteworthy findings important for AIDS policy and mitigation strategies for rural farm households.

First, in contrast to the general assumption that HIV-related mortality is typically associated with household heads/spouses, the survey findings show that only 36.6% of households with PA death incurred household heads/spouse death. While all adults are likely to make important contributions to their families, both materially, in their roles as nurturers and teachers, and in less tangible ways, it appears that the most severe economic effects occur when the death is the household head or spouse. The fact that less than 36.6% of the prime-age deaths observed in Zambia's rural areas involved a household head or spouse suggests that the potential magnitude of rural PA mortality on rural household agricultural and off-farm incomes and orphaning rates -- while still very serious -- may be somewhat less severe for many households than often suggested in the conceptual literature on this topic.

Second, irrespective of gender and/or position in the household of the deceased person, rural farm households in Zambia attempt to cope with the death of PA adults through changes in household composition. Based on results for the full sample, household size declined by less than one member. This indicates that afflicted households are partially successful in replenishing their family size. However, in response to the death of a male household head, poorer households have substantially greater difficulties in coping than non-poor households, which are likely to almost fully restore household size to former pre-death levels. These results imply that the widespread view that death of productive members of the family causes labor shortages needs to be more carefully nuanced, taking into account the position of the deceased person and the initial conditions of the household. Nevertheless, the loss of adult members, especially heads and spouses, may have longer run impacts not measured in the relatively short three-year period of this analysis, such as the loss of inter-generational knowledge of farming skills and other abilities. The measured impacts are most severe for households that are poor to begin with and experience the death of a male household head. This may require the targeting of assistance and skill training to relatively poor households headed by widows.

Third, the effects of PA death on farm production were sensitive to the gender and position in the household of the deceased. For example, the death of a PA male resulted in a 13% decline in total land cultivated whilst death of a PA female resulted in a 5% decline of cultivated land. The death of male heads/spouses resulted in a 21% reduction in land cultivated. All the other mortality categories are negative but not statistically significant. This finding appears to be consistent with the findings that households experiencing male heads/spouse death tend to incur a higher decline in household size, and thus may experience greater declines in land cultivation associated with household labor shocks. Moreover, the results show that area cultivated and area under cereals in particular decline more in relatively non-poor households than poor households after the death of a male household head.

Fourth, in contrast to the widespread view that households experiencing prime-age death cope with the reduction in family size by switching to labor-saving crops such as roots and tubers, the results show positive but statistically insignificant effects on the cultivation of these crops except among households experiencing the death of non-head/spouse females. The death of other adult women in the household results in a 5% decline in area under roots and tubers. These findings indicate that afflicted households are not more likely to increase cultivation of labor-saving crops than non-afflicted households. While some studies have identified HIV/AIDS as a contributing factor in the rise of labor-saving root and tuber cultivation in Zambia as well as other parts of southern Africa, it is important to take into account other exogenous factors contributing to changes in crop mix. Recent crop and input policy changes in the region associated with structural adjustment and food market reform have affected the relative output/input price ratios for grain crops relative to roots and tubers, reducing the profitability in some areas of grains as compared to roots and tubers (Jayne et al. 2005). This example highlights the importance of properly controlling for other factors when assessing the impact of HIV/AIDS on rural livelihoods to avoid spurious conclusions.
The results of this study also suggest that for afflicted households as a group, the loss of family labor due to a death in the household may not necessarily mean that agricultural labor becomes the limiting input in agricultural production, any more so than capital assets, for example, which are also likely to be drawn down due to foregone income, medical treatment, and funeral expenses among afflicted households. The macro-level picture emerging from recent demographic population projections, which take into account the impact of AIDS-related deaths, demonstrates that although the epidemic will reduce life expectancy and population growth considerably in the hardest-hit countries, the epidemic has not caused a decline either in the aggregate labor supply or in the labor-to-available land ratios in agriculture. In fact, between 1990 and 2000, the rural population of Zambia has grown at a considerably faster rate than the overall population, 43.6% vs. 33.9%, according to the 1990 and 2000 population censes. Therefore, prioritization of public sector investment in the development and dissemination of technologies aimed at mitigating the effects of prime-age adult mortality ideally requires in-depth evaluation of household constraints and opportunities, as well as consideration of the need for balance between investments in long-term rural economic productivity growth and targeted assistance to both afflicted and non-afflicted households. Assessing which labor-saving technologies to prioritize should involve investigation of the characteristics of affected households, whose labor time is most constrained, the productivity impacts of these technologies, and the overall payoffs from alternative allocations of public resources across sectors.

Fifth, the results do not strongly support the contention that households incurring prime-age death suffer large declines in crop output -- except among initially poor households experiencing the death of a male household head. Among this group of afflicted households, the gross value of crop production per hectare declined by 19% relative to non-afflicted households between the 2001 and 2004 surveys. Evidence suggests that wealthier households incurring male head-of-household death attract boys and other males to join the household, while initially poor households have greater difficulty in doing so. This finding supports the need for creating or and/or strengthening community-based networks to assist poorer households experiencing mortality of household heads and spouses. Government and interested donor agencies may also assist with agricultural extension programs to reach afflicted poor households in order to strengthen their capacity to cope with the loss of prime-age core members.

Sixth, the value of cattle assets appear to suffer greatly from the death of a PA male head of household whilst the impacts of death of other prime-age members are negative but not statistically significant. Similar to the findings by Yamano and Jayne (2004), there is strong evidence to suggest that afflicted households liquidate small animals as the first line of defense to mitigate the impact of PA death. The sale or liquidation of cattle is a more extreme coping mechanism, as it may compromise the household's future livelihood (Stokes 2003). Cattle assets are not only a stock of wealth but are also an input into agricultural production (through draft power for land preparation). Fortunately, adult mortality is not associated with significant declines in cattle assets except in the case of male household head mortality, which indicates the relative severity of impacts in this case. Another reason why households experiencing male head-of-household death show a significant decline in cattle assets is that property of the deceased man (including cattle) is often redistributed to the man's relatives. Therefore, in order to support the food security and farm productivity of widow-headed households, the Zambian government and development agencies may consider targeting households whose capital base is affected by AID-related illness and death as well as encourage change in traditional inheritance institutions to better protect widows and their dependents from losing productive assets such as land and animals after their husband's death.

In about 33% of the cases among households experiencing a male head of household death, the widow was cultivating substantially less land in 2004 than in 2001 before the household lost the male head. This could be partially due to widows' loss of land, capital, and livestock assets to other relatives after the death of their husband. These findings imply that the responses to mitigating the social and economic impacts of HIV/AIDS in Zambia may not be successful if they ignore the gender inequalities that exist in terms of land access and other productive assets important for rural livelihood. Therefore, efforts to safeguard widows' rights to land through land tenure innovations involving community authorities may be an important component of social protection and poverty alleviation strategies.

Seventh, the study shows mixed findings in terms of the impact of PA death on off-farm income. Contrary to the hypothesis that off-farm income sources are at risk among households experiencing PA mortality, particularly among those that are asset poor and vulnerable to begin with, the results were statistically insignificant for all cases of mortality by gender and position in the household of the deceased. However, evidence does point to differential impacts by initial household effective dependency ratio and by landholding size among households experiencing female head or spouse death. Households with female head or spouse female death and having higher effective dependency ratios seem to suffer more compared to afflicted households with lower initial dependency ratios.

Eighth, the study indicates need to take into account the different types of mortality in the household, especially the potential differences in households' welfare between households experiencing deaths of resident members versus households with homecoming sick members who joined the household to receive terminal care. The impact of the death of a member who was always resident in the household in terms of the direct the contribution to the labor supply and demand and welfare needs of the household may differ compared to the death of a 'member' who re-joins the household to seek short-term care before they die. In order to seek more clarity to this issue, future studies need to consider collecting more complete information about the homecoming ill, for example, when they joined the household, whether they left any children, as well as information about remittances from the deceased. These questions may help to more accurately measure impacts of the various types of PA mortality that we are unable to address with this data.

Overall, the results of this study question the usefulness of a homogeneous conceptualization of "afflicted households," especially in the context of proposals for targeted assistance, technology development, and other programs/policies. In most cases the gender and household position of the deceased appear to strongly condition the effects on the household. The death of a male household head is associated with larger negative impacts on household size, farm production and livestock assets than any other kind of adult death. In addition, initial asset levels, land cultivated and initial effective dependency ratios also condition the effects of mortality on households. In general, the impact of adult mortality appear to be most severe for households in the bottom half of the distribution of assets, and that households headed by HIV/AIDS widows are in especially precarious positions. This would imply that AIDS mitigation programs should target their scarce resources particularly toward widow-headed households, especially those that were relatively poor to begin with.

Caveats and limitations: It is important to take note that the findings from this study only measured short run effects of prime-age mortality between April 2001 and April 2004 on a few aspects of Zambia rural farm households. Future research studies need to be designed in order to measure longer-run effects of prime-age adult death, which highlights the need for longer-run longitudinal surveys.

APPENDIX

Table A1. Descriptive statistics: right hand variables of impact models

	Full sample				Poor				Non poor			
		Percentile				Percentile				Percentile		
Variables	Mean	25	50	75	Mean	25	50	75	Mean	25	50	75
PA male heads/spouses death (=1)	0.017	-	-	-	0.020	-	-	-	0.0142	-	-	-
PA female heads/spouses death (=1)	0.023	-	-	-	0.023	-	-	-	0.0229	-	-	-
PA other males death (=1)	0.031	-	-	-	0.028	-	-	-	0.0345	-	-	-
PA other females death (=1)	0.038	-	-	-	0.028	-	-	-	0.0472	-	-	-
Elderly males death (=1)	0.024	-	-	-	0.022	-	-	-	0.0255	-	-	-
Elderly females death (=1)	0.017	-	-	-	0.015	-	-	-	0.0184	-	-	-
Asset poverty in 2000 (=non poor)	0.499	-	-	-	0.501	-	-	-	0.4993	-	-	-
Land holding size in 2000 (Ha)	3.10	1.06	2.03	4.00	2.47	0.81	1.51	3.03	3.74	1.42	2.63	4.95
Effective dependency ratio in 2000 (number)	1.33	0.60	1.00	1.80	1.29	0.52	1.00	1.78	1.37	0.67	1.12	1.83
HIV prevalence rates in 1999 (%)	15.90	13.30	15.90	17.20	15.94	13.20	15.90	17.90	15.87	13.80	15.80	17.10

Source: CSO/MACO/FSRP Post Harvest Survey 1999/2000 and Supplemental Survey, 2001 and 2004

REFERENCES

Ainsworth, M., and J. Dayton. 2000. *Is the AIDS Epidemic Having an Impact on the Coping Behavior and Health Status of the Elderly?* Evidence from Northwestern Tanzania. Washington, D.C.: World Bank.

Ainsworth, M., and I. Semali. 1998. Who Is Most Likely to Die of AIDS? Socio- economic Correlates of Adult Deaths in Kagera Region, Tanzania. In *Confronting AIDS: Evidence for Developing World,* eds. M. Ainsworth, L. Fransen, and M. Over. Brussels: European Commission.

Alderman, H., J. Behrman, Hans-Peter Kohler, J. Maluccio, and S. Watkins. 2001. Attrition in Longitudinal Household Survey Data: Some Tests for Three Developing Country Samples. *Demographic Research* 5: 78-124.

Barnett T., and P.M. Blaikie. 1992. *Aids in Africa: Its Present and Future Impact*. London, UK: Belhaven Press.

Barnett, T., J. Tumashabe, G. Bantebya, R. Ssebuliba, J. Ngasongwa, D. Kapunga, M. Ndelike, M. Drinkwater, G. Nitti, and M. Haslwinimer. 1995. Field Report: The Social Impact of HIV/AIDS on Farming Systems and Livelihoods in Rural Africa: Some Experiences and Lessons from Uganda, Tanzania, and Zambia. *Journal of International Development* 7: 163-176.

Barnett, T., and A. Whiteside. 2002. *AIDS in the Twenty-First Century: Disease and Globalization.* Basingstoke, UK: Palgrave Macmillan.

Beegle, K. 2005. Labor Effects of Adult Mortality in Tanzanian Households. *Economic Development and Cultural Change 53(3): 655-684.*

Booysen, F. le R. 2003. HIV/AIDS and Poverty: Evidence from the Free State Province. *South African Journal of Economic and Management Sciences, N.S. 6.2: 419-38.*

Bryceson, D., F. Deborah, and J. Fonseca. 2005. Risking Death for Survival: Household and Village Responses to the Threat of Hunger and HIV/AIDS in Rural Malawi . Paper presented at the International Conference on HIV/AIDS, Food and Nutrition Security, April 14-16, South Africa. Available at: http://www.ifpri.org/events/conferences/2005/durban/papers/brycesonWP.pdf

Central Statistical Office, Ministry of Health, Macro International. 2003. Zambia Demographic Health Survey (ZDHS), 2001/2002, Lusaka, Zambia.

Chapoto, A. 2006. The Impact of AIDS-related Prime-age Mortality on Rural Farm Households: Panel Survey Evidence from Zambia. Ph.D. dissertation, Michigan State University.

Chapoto, A., and T. Jayne. Forthcoming. Security of Widow's Access to Land in the Era of HIV/AIDS: Panel Survey Evidence from Zambia. Lusaka, Zambia: Food Security Research Project.

de Waal, A. 2003. How Will HIV/AIDS Transform African Governance? *African Affairs 102:* 1-23.

Donovan, C., L. Bailey, E. Mpisi, and M. Weber. 2003. *Prime-Age Adult Morbidity and Mortality in Rural Rwanda: Effects on Household Income, Agricultural Production and Food Security Strategies*. Research report. Kigali: Food Security Research Project, Ministry of Agriculture, Livestock, and Forestry.

Drimie, S. 2002. *HIV/AIDS and Land: Case Studies from Kenya, Lesotho, and South Africa*. Report for Southern Africa Regional Office of the Food and Agricultural Organization (FAO), Human Sciences Research Council, Pretoria, South Africa.

Drinkwater, M. 1993. *The Effects of HIV/AIDS on Agricultural Production Systems in Zambia. An Analysis and Field Reports of Case Studies Out in Mpongwe, Ndola Rural District and Teta, Serenje District*. Rome. FAO.

FAO. 2003. *HIV/AIDS and Agriculture: Impacts and Responses*. *Case Studies from Namibia, Uganda and Zambia*. Rome: FAO. Downloadable at: http://www.fao.or/sd/2003/PE12013fien.htm

FAO. 2004. *HIV/AIDS, Gender Inequality and Rural Livelihoods. The Impact of HIV/AIDS on Rural Livelihoods in Northern Province, Zambia*. Rome: FAO.

Fitzgerald, J., P. Gottschalk, and R. Moffitt. 1998. An Analysis of Sample Attrition in Panel Data. The Michigan Panel Study on Income Dynamics. *Journal of Human Resources* 33: 251-299.

Goldberger, A. 1972. *Selection Bias in Evaluating Treatment Effects: Some Formal Illustrations*. Madison, Wisconsin: University of Wisconsin Press.

Gregson, S., H. Waddell, and S. Chandiwana. 2001. School Education and HIV Control in Sub-Saharan Africa: From Discord to Harmony? *Journal of International Development* 13: 467-85.

Heckman, J. 1976. The Common Structure of Statistical Models of Truncation, Sample Selection, and Limited Dependent Variables, and a Simple Estimator for Such Models. *Annals of Economic and Social Measurement* 5: 475-492.

Hosegood, V., N. McGrath, K. Herbst, and I. Timaeus. 2004. The Impact of Adult Mortality on Household Dissolution and Migration in Rural South Africa. *AIDS* 18: 1-6.

Jayne, T.S., M. Villarreal, P. Pingali, and G. Hemrich. 2005. HIV/AIDS and the Agricultural Sector: Implications for Policy in Eastern and Southern Africa. *Electronic Journal of Agricultural Development Economics* 2.1.

Kitange H.M., H. Machibya, and J. Black. 1996. Outlook for Survivors in sub-Saharan Africa: Adult Mortality in Tanzania. *British Medicine Journal,* PubMed Abstract 312: 216-220.

Kwaramba, P. 1997. *The Socio-Economic Impact of HIV/AIDS on Communal Agricultural Systems in Zimbabwe.* Working Paper 19. Harare: ZFU, Friedrich Ebert Stifting Economic Advisory Project.

Lundberg, M., M. Over, and P. Mujinja. 2000. Sources of Financial Assistance for Households Suffering an Adult Death in Kagera, Tanzania. *South African Journal of Economics* 68:5:947-984. World Bank Policy Research Working Paper No. 2508.

Mather, D., C. Donovan, T.S. Jayne, M. Weber, E. Mazhangara, L. Bailey, K. Yoo, T. Yamano, and E. Mghenyi. 2004. *A Cross-Country Analysis of Household Responses to Adult Mortality in Rural Sub Saharan Africa: Implications for HIV/AIDS Mitigation and Rural Development Policies.* MSU International Development Working Paper No. 82. East Lansing: Michigan State University.

Megill, D.J. 2004. *Recommendations on Sample Design for Post Harvest Surveys in Zambia Based on the 2000 Census.* Working Paper No. 10. Lusaka, Zambia: Food Security Research Project.

Rosenbaum, P., and D.B. Rubin. 1983. The Central Role of the Propensity Score in Observational Studies for Causal Effects. *Biometrika* 70: 41-55.

SAFAIDS. 1998. *Socio-Economic Impact of Adult Mortality and Morbidity on Households in Kafue District, Zambia.* Harare, Zimbabwe.

Stokes, C.S. 2003. *Measuring Impacts of HIV/AIDS on Rural Livelihoods and Food Security*. Rome: Sustainable Development Department (SD), FAO.

Strauss, J., P.J. Gertler, O. Rahman, and K. Fox. 1993. Gender and Life-Cycle Differentials in the Patterns and Determinants of Adult Health. *The Journal of Human Resources* 28.4: 791-837.

Thiam, Macoumba, R. Perry, and V. Piché. 2003. *Migration and HIV in Northern Senegal. Population Reference Bureau*. Downloadable at: http://www.prb.org/Template.cfm?Section=PRB&template=/ContentManagement/ContentDisplay.cfm&ContentID=9699

Tibaijuka, A.K. 1997. AIDS and Economic Welfare in Peasant Agriculture, Case Studies from Kagabiro Village, Kagera Region, Tanzania. *World Development* 25.6: 963-975.

Topouzis, D. 2000. *Measuring the Impacts of HIV/AIDS on the Agricultural Sector in Africa.* Geneva: UNAIDS Best Practice Collection.

UNAIDS. 1999. *A Review of Household and Community Responses to the HIV/AIDS Epidemic in the Rural Areas of Sub-Saharan Africa.* Geneva: UNAIDS.

Wooldridge, J.M. 2002. *Econometric Analysis of Cross Section and Panel Data*. Boston: MIT Press.

World Bank. 1999. *Confronting AIDS: Public Priorities in a Global Epidemic*. Revised edition. New York: Oxford University Press.

World Heath Organization. 2004. *Fact Sheet 1 HIV/AIDS: the Infection*. Retrieved April 28. http://library.unesco-iicba.org/English/HIV_AIDS/cdrom%20materials/WHO/WHOhtml%201.htm

Yamano, T., and T.S. Jayne. 2004. Measuring the Impacts of Working-Age Adult Mortality on Small-Scale Farm Households in Kenya. *World Development* 32.1: 91-119.

Yamano, T., and T.S. Jayne. 2005. Working Age Adult Mortality and Primary School Attendance in Rural Kenya. *Economic Development and Cultural Change* 53.3: 619-653.