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

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Impact of HIV/AIDS-Related Deaths on Rural Farm Households' Welfare in Zambia: Implications for Poverty Reduction Strategies

Abstract

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. This paper uses nationally representative longitudinal survey data on 5,420 rural farm households in Zambia, to measure the impacts of prime-age (PA) adult mortality on crop production and cropping patterns, household size, livestock and non-farm income, taking into account the probable endogeneity of prime-age mortality. The paper extends the 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.

Using prior death and age group-specific drought shocks as instruments for prime-age death between 2001 and 2004, the Hausman-Wu chi square test for endogeneity shows that indeed death variables are endogenous for pooled ordinary least squares (OLS) models. Differencing the time-invariant unobserved household characteristics largely addressed the endogeneity problem. Based on these difference models, we report the impact of premature prime-age mortality on rural households. The main findings include: *first*, irrespective of gender and/or position in the household of the deceased person, household size declines by a factor less than one member suggesting that afflicted households are partially successful in replenishing their family size. *Second*, 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. *Third*, the effects of PA death on farm production are sensitive to the gender and position in the household of the deceased. For example, death of a PA male resulted in an 11% decline in total land cultivated whilst death of a PA female resulted in a 3% decline of cultivated land and the death of male heads/spouses resulted in a 20% reduction in land cultivated. *Fourth*, in contrast to the general 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, our findings indicate no clear pattern of shifts to labor-saving crops. The death of non-spouse females in the household is actually associated with a 5% decline in area under roots and tubers. *Fifth*, poorer households experience a 13% decline in gross value of output when the male household head dies while non-poor households are able to maintain or even increase their gross value of crop production since they are more able to attract men and boys when a core males dies. *Seventh*, the value of cattle assets appear to suffer greatly from the death of a PA male head of household whilst the impacts on the other PA death are negative but not statistically significant. Last but not least, there is strong evidence to suggest that afflicted households liquidate small animals to mitigate the impact of PA death.

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, the results show that 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 in 2000. Overall, these findings suggest that poorer households headed by HIV/AIDS widows are in especially precarious positions.

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1.0 INTRODUCTION

At this point in time, little is known about whether adult mortality due to AIDS causes different or more severe shocks to household welfare than mortality of adult members due to other causes. Most micro-level HIV/AIDS impact studies in the literature hypothesize about the impacts of the epidemic but rarely quantify them.[2] 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. The behavioral responses factored into macroeconomic-level models of the impacts of HIV/AIDS on economic growth are largely assumed rather than derived from micro-level empirical findings. Not surprisingly, their predicted effects on economic growth and development differ substantially. For example, Cuddington (1993) estimates that an HIV prevalence of 10 percent implies a reduction in economic growth of less than 1 percent. By contrast, Sachs et al. (2001) calculate that the 2.2 million AIDS-related deaths in 1999 reduced Africa's gross domestic product growth rate by 35 percent. The wide variation in these predictions is exacerbated by the paucity of quantitative micro-level information on how households respond to HIV/AIDS.

Using comprehensive rural farm household longitudinal data from Zambia, we measure 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, we control for initial poverty status, landholding size, effective dependency ratio, and the gender and position of the deceased person. Moreover, we take into account the possibility that prime-age adult death in the household is endogenous 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. Using prior death and age group-specific drought shocks as instruments for prime-age death, the Hausman-Wu chi square test for endogeneity shows that indeed death variables are endogenous for pooled OLS models and not endogenous when we difference out the time-invariant unobserved household characteristics. Given this finding, the paper report results from differenced models. 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.

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[2] For example see Haslwimmer, 1994; FA0, 2003; UNAIDS, 1999; Barnett et al., 1995; Du Guerny, J. 1999; Drinkwater, 1993; Mutangadura, 1999; Topouzis, 2000; Stokes, 2003; SAFAIDS, 1998; Kwaramba, 1997; Pitayanon, et al., 1997; Tibaijuka, 1998; Rugalema, 1998.

The remainder of the paper is organized as follows: Section 2 briefly reviews the literature on HIV/AIDS' impacts on rural household behavior and welfare in sub-Saharan Africa, and highlights key methodological issues involved in analyzing these issues. Section 3 describes the data and methods used in this paper. Results, presented in Section 4, are divided into three subsections: impact on household size and composition; impact on land use and crop production; and impact on values of livestock and non-farm income. Conclusions and implications for agricultural policy are discussed in Section 5.

2. REVIEW OF EMPIRICAL STUDIES

This section reviews some of the household-level studies measuring the impact of premature prime-age mortality in rural farm households in sub-Saharan Africa. We begin by looking at some of the data and methodological challenges to be overcome in empirical measurement of impacts of AIDS. We then review the available literature on the effects of mortality and morbidity on household composition, crop production, livestock and off-farm income in developing countries.

2.1 Empirical limitations of prior studies

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, there are only a few longitudinal studies to examine the effects of disease-related mortality on afflicted households. 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 do not allow us to measure effects of mortality on outcomes since there is no information prior to the death event; such studies only allow us to compare *ex post* outcomes of afflicted versus non-afflicted households, although this reveals nothing about impacts of mortality. 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[3].

[3] 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

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 without testing for endogeneity (e.g. Ainsworth and Dayton, 2000; Beegle, 2003; 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, the number of possible differences among households is infinite, hence it is not possible to control for all differences; thus, there is the need to test for endogeneity and, if present, explore other methods that may control for endogeneity of prime-age of mortality due to illness. These three major limitations of existing studies should be kept in mind in the following review of empirical findings on the impact of premature HIV/AIDS-related death on farm households.

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.

2.2 Effects on household composition and labor availability

The most immediate impact of HIV/AIDS-related illness and death is on the human capital base, principally in terms of the availability and allocation of labor (Rugalema, 1999; Topouzis and du Guerny 1999). At the household level, labor input diminishes as a prime-age adult succumbs to protracted illness and the labor of other households and extended family members is diverted to care. The death of any productive member of the household constitutes a permanent loss of labor for agricultural and off-farm employment and other social and home care activities (although assets will no longer be diverted to caring for the patient) (White and Robinson, 2000). This labor shock can also cause shocks to the household's capital resources as income streams are lost, and as medical and funeral expenses rise. The death, if a male head, can also be accompanied by loss of land for the remaining household members.

Some studies have shown that some households experiencing premature prime-age mortality due to HIV/AIDS-related causes have adopted a mixture of coping strategies including: an increased in- and out-migration of household members, an increased rate of fostering, and higher rates of remarriage for surviving spouses (Ntozi, 1997; Urassa et al, 2001). However, the way in which

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"affected." Households not directly suffering a death may be non-afflicted, but it is doubtful that there are any non-afflicted households in hard-hit communities of Eastern and Southern Africa.

households adjust to internal labor supply shocks varies according to the resources of the households. For example, better-off households may be able to hire workers or attract additional members to at least partially offset the loss of another (see Yamano and Jayne 2004, Beegle, 2003, Ainsworth, Ghosh, and Semali, 1995). Yamano and Jayne (2004) show that households suffering the death of the head-of-household or spouse were largely unable to replace the labor lost through the death, whereas households suffering the death of another adult were able to attract new household members. Without such adaptation, either through altered structures or roles, and/or through external assistance, families and households may become non-functioning social and productive units and ultimately dissolve (Hosegood et al., 2004). However, in most studies the vast majority of households (with 2 or more members) suffering the death of an adult remain intact and do not dissolve (Mather et al., 2005).

2.3 Effects on agricultural production and cropping patterns

Existing research has presented mixed evidence on the impacts of mortality on agricultural households and consequently there is no clear consensus on appropriate programmatic responses, especially considering the opportunity cost of scarce resources. Some studies provide evidence of reduction in area cultivated, shifts to less labor-intensive crops, and reduced weeding (Barnett et al, 1995; Topouzis and du Guerny, 1999; Topouzis, 2000; Harvey, 2004). The view that emerges here is that mitigation policy should prioritize labor-saving technology. However, other research in Uganda finds no significant change in agricultural production induced by labor shortages (Barnett and Blaike, 1992). Also, Barnett et al. (1995) conclude from case study research in Uganda, Tanzania, and Zambia, that the effects of adult mortality on rural livelihoods may vary considerably within and across countries given numerous factors such as the rate of HIV prevalence, population densities, the nature of the cropping system, and the size of the local labor market.

Beegle (2003), using panel data from Kagera, Tanzania, finds that although cash cropping is temporarily scaled back following a male death and wage income falls, afflicted households do not shift towards subsistence crops. Putting these findings in context, Beegle (2003) also notes that the areas of highest AIDS-related mortality in Tanzania (such as Kagera) are in the Lake Victoria basin, an area with high population density and, thus, a large labor supply and relatively high labor/land ratios. However, her study lacks measures of aggregate output and cannot draw conclusions on changes in total crop production or the composition of crop production. Also, the study evaluated short-term effects during the early years of the epidemic (1991-1993) and the extent to which these findings hold over the longer run is uncertain.

A study in Kenya by Yamano and Jayne (2004) found that rural households suffering a prime-age death between 1997 and 2000 generally experienced a decline in agricultural output relative to non-afflicted households, but the magnitude and statistical significance of this finding was a function of the gender, age, and position in the household of the deceased person as well as the household's initial level of wealth prior to incurring the shock. They found no evidence for significant losses in cultivated land and net crop output among households in the top half of the wealth distribution. These results suggest that the effects of mortality are highly context-specific and should not be over-generalized. Once again, however, the three-year time frame over which effects were measured raises questions about the potential longer-term impacts.

Barnett et al. (1995) find little evidence of impact of HIV/AIDS in Tanzania but in Uganda they find some discernible evidence where poor households shift to subsistence crops over the period 1989-1993. More recent work by Dorward (2003) using a non-linear programming model and a household typology in Malawi to predict input and output responses to various shocks, such as price, drought, and adult illness, shows that responses to adult illness such as reduced area cultivated and outcomes such as lower yields vary considerably by characteristics of the household, such as percentage loss in household labor, income and asset levels.

Other studies have noted that the recent shift in area cultivated from maize to root tubers in much of southern Africa may be reflecting labor shortages and small farmers' attempts to shift to less labor intensive crops (Barnett, 1994; FAO, 1993; FAO, 1995; FAO, 2004; FASAZ, 2003; Shah, 2002). It is possible that the AIDS epidemic has contributed to these shifts, but one has to acknowledge that such shifts may also be due to major changes in agricultural policy, such as market reform programs that eliminated pan-territorial price supports for maize and also reduced fertilizer subsidies (used primarily on maize) in much of eastern and southern Africa, resulting in a shift of household incentives from growing maize to tubers. The failure to take account of such policy changes may result in mis-attributing the shifts in cropping patterns to AIDS-related causes.

2.4 Effects on assets and non-farm income

Farm households are known to rely on remittance and non-farm income as a primary means to afford assets such as oxen, scotch carts, ploughs, and fertilizer, which are used to capitalize farm production (Reardon et al., 1995). Unfortunately, such sources of income are often at risk among AIDS-afflicted households, particularly those that were already asset poor and vulnerable (Donovan et al., 2003; Mushati et al., 2003). Morbidity and death of a household member tighten cash constraints on agricultural production as medical and funeral expenses rise and care giving by other members further reduces household income-earning potential. Topouzis and du Guerny (1999) note that households respond initially by disposal of assets that are reversible, including liquidating savings, seeking remittances from the extended family and borrowing from informal or formal sources of credit. If necessary, the sale or disposal of productive assets typically follows use of these sources of support but may jeopardize a household's future livelihood (Stokes, 2003). This is supported by evidence from Kenya which shows that households first attempt to dispose of small animals and other assets with the least impact on long-term production potential. Cattle and productive farm equipment are sold in response to severe cash requirements after incurring a death in the family (Yamano and Jayne, 2004). Such *ex post* coping strategies are costly in the short term and may cause households not to recover from impacts of death even in the long-term.

From this review it can be hypothesized that the effects of HIV/AIDS-related deaths are heterogeneous, that the magnitude and significance of the effects will be largely conditioned by the gender and household position of the deceased individual, and that effects may depend on household-specific characteristics, such as initial vulnerability and poverty prior to the onset of illness and a household's ability to attract new members. If this hypothesis receives more empirical support from ongoing studies, then it will be necessary to move away from generalized conclusions about the main factors constraining afflicted households' ability to recover and begin formulating appropriate policy and programmatic responses based on the specific characteristics of the region, the regional economy, the localized farming system, the profitability and riskiness of alternative crops, and available resources.

3.0 DATA AND METHODS

3.1 Data

The study uses nationally representative longitudinal data on 5,420 households in 394 standard enumeration areas (SEAs)[4] 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 reinterviwed. 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.

3.1.1 Sampling procedure

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.[5]

[4] "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.
[5] 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).

Zambia is divided into nine provinces, which are further divided into 70 districts (see map of Zambia in appendix 1). For the Census enumeration, a cartographic operation was conducted to define census supervisory areas (CSAs), which were further divided into standard enumeration areas (SEAs).[6] 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 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).

3.1.2 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 a 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.[7]

[6] 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.

[7] 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 et al., 1996).

Longitudinal data often provide an understanding of the dynamic behavior of individual households not possible with cross-sectional data. However, one major detracting feature of panel data surveys is that they are almost always affected by some level of attrition over time. Attrition is a result of a number of factors such as changes in population (e.g. dissolutions due to

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	Descriptive results in 5342 valid reinterviwed households							
			Household with at least one prime-age deaths due to illness				Cause of death		Predicted AIDS-related deaths[e]	
			Male		Female		Disease	Other[d]	by WHO classification[f]	One major sign and at lease one minor sign
	(a)	(b)	(d)		(e)		(f)	(g)	(h)	(i)
	Number	Number(%)	Number	AMR[c]	number	AMR	number		number (%)	number (%)
Central	714	573 (80.3)	34	14.4	34	16.1	68	4	13 (19.1)	16 (23.5)
Copperbelt	393	312 (79.4)	12	14.8	16	14.6	28	3	9 (32.1)	12 42.9)
Eastern	1331	1126 (84.6)	68	14.6	71	18.5	139	7	33 (23.7)	55 (39.6)
Luapula	777	619 (79.7)	24	12.1	29	15.1	53	4	15 (28.3)	26 (49.1)
Lusaka	214	161 (75.2)	8	19.2	19	16.6	27	1	7 (25.9)	14 (51.9)
Northern	1363	1027 (75.3)	42	10.3	46	13.1	88	4	31 (35.2)	37 (42.0)
Northwestern	472	324 (68.6)	15	9.3	7	10.0	22	-	3 (13.6)	6 (27.3)
Southern	872	690 (79.1)	33	15.1	51	17.3	84	6	28 (33.3)	43 (51.2)
Western	786	588 (74.8)	18	16.4	44	17.7	62	1	23 (37.1)	31 (50.0)
Total	6922	5420 (78.3)	254	14.0	317	15.4	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% were recorded as dissolved, and 5.2% were categorized as “non-contact” (not home but still resident). [c]AMR (adult mortality rate)=Prime-age deaths/1000 prime-age person years. [d]Other deaths were caused by unexpected causes such as accidents, murder and snake bite, and were excluded from the analysis in Section 4. [e]Cause of death is defined as HIV/AIDS using lay diagnosis data of the deceased (see section 2). [f]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).

death or relocation), non-contact (qualified respondents away from home), non-response and refusals. Non-random sample attrition may create selection biases.

As expected, our sample was not immune to attrition and of the 6,922 households interviewed in 2001, 5,420 (78.3%) were re-interviewed in May 2004. If we exclude attrition caused by enumerators not re-visiting several SEAs in 2004 that were included in the 2001 survey, the re-interview rate rises to 88.7%. And if we exclude attrition caused by adult household members being away from home during the enumeration period and those refusing to be interviewed, the re-interview rate rises to 94.5%. Other than those who refused to participate in the second survey, we will not know whether death could have unraveled, dissolved or dispersed the other households, or whether other reasons (observable and non-observable) may have led to non-contact (Alderman et al., 2003). Therefore, our data only measure the effects of mortality and illness on households that remained intact over the 3-year survey interval.

Table 2 presents the relationship between household attrition, dissolution, and household size in 2001. The findings show that the percentage of households "attriting" is inversely related to household size (column C). 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. In contrast, 65.5% of the sample contained households with 5 or more members and among these households only 47% of attrition due to dissolution was observed (columns D and E). In addition, column F shows that dissolution was a more important cause of household attrition among smaller households than among larger households. By contrast, larger households were more likely to incur a prime-age adult death (columns G and H). This is because the probability that a household will incur a prime-age adult death is positively correlated with the number of adult members initially in the household.

To test for possible bias in results due to household attrition, we compare the mean levels of control variables measured in May 2001 for households that were re-interviewed versus those that attrited. The means of many variables differ statistically between re-interviewed and attrited households (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 data presented in Table 2 showing that attriting households were smaller to start with in 2001. Systematic differences between attritors and non-attritors, coupled with a high attrition rate, may cause concern about inference with this data. Also, if the attrited households suffered a higher incidence of PA mortality between 2001 and 2004, we would have attrition bias when estimating the *ex ante* socioeconomic characteristics of individuals who died of AIDS-related causes.[8] So we should be worried about the possibility of systematic attrition leading to selection bias. In order to deal with potential attrition bias, we adopt the inverse probability weighting method as discussed in detail in section 3.2.3.

[8] Available evidence on attrition rates in longitudinal surveys in developing countries range from 5 to 30 percent for 2 rounds (see Alderman, et al, 2001; Yamano and Jayne, 2004). For a discussion of IPW see Wooldridge, 2002.

Table 2: Relationship between household size, attrition, dissolution, and prime-age mortality

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 reinterviwed 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]Colum F=Column D/Column C,
[c]only includes households in which a prime-age individual in the initial 2001 survey died; does not include households which added members after 2001 who subsequently died. 36 households incurred more than one prime-age death
[d]Column H=ColumnG/(Columns B-C)

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
	(A)	(B)	(C)	(D)	(E)	(F)
Age of household head (years)	44.71	15.04	42.50	15.04	2.21**	5.72
Mean education of head and spouse	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
HH with chronically ill adult (%)	1.27	0.46	1.31	0.50	-0.04	-0.58
Prime-age death between 1996-2000	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 ZMK)	1843.1	3961.8	1819.2	3570.8	23.91	1.10
Value of assets ('000 ZMK)	901.09	2793.2	549.7	1751.0	351.26**	5.76
Productive assets ('000 ZMK)[b]	107.80	399.49	52.77	238.21	55.02**	6.23
Distance to nearest tarred/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 1999/2000 and Supplemental Survey, 2001 and 2004
Notes:
** indicates 1 percent; *indicates 5 percent and + indicates 10 percent 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.

3.1.3 Relationship between Adult mortality and HIV/AIDS

While not all disease-related mortality can be attributed to AIDS in any given country or region, recent epidemiological studies demonstrate that in Eastern and Southern Africa, HIV has become the leading cause of disease-related death among adults between 15 and 59 years of age (Ainsworth and Semali, 1998; UNAIDS/WHO, 1998; Ngom and Clark, 2003; World Bank, 1999). Given the difficulty and cost of obtaining reliable estimates of AIDS-related mortality, some studies have used a combination of serological surveys to track the HIV status of sampled adults over time (Urassa et al., 2001) and/or "verbal autopsies" in which medical fieldworkers interview caregivers of the deceased to record information regarding signs and symptoms of the terminal illness, all of which help to reduce the probability of incorrect diagnosis (Garenne et al., 2000; Urassa et al., 2001).

In the survey, an effort was made to collect information about symptoms leading to death of the deceased in an effort to try to explore the potential differences between defining the death as adult mortality due to illness in general and defining it as prime-age mortality when the cause is predicted as AIDS-related. If the reason for cause of death was given as 'disease,' follow up questions on the symptoms leading to death (lay diagnosis) were asked for each adult who died between 2001 and 2003. The lay diagnosis (LD) questions were included to aid in developing an algorithm for prime-age mortality where the cause is predicted as AIDS-related.[9] The major clinical symptoms for which data were collected are chronic diarrhea, prolonged fever (intermittent and constant), and weight loss of more than 10% of body weight. The minor signs were prolonged cough, prolonged difficulty in breathing, prolonged pneumonia, thrush in the mouth and 'rash', which is considered to be an indicator of generalized *pruritic dermatitis* if it occurred in combination with two major signs.[10]

A review of literature on verbal autopsies and lay diagnoses shows that there is no generally accepted ideal method of estimating AIDS-specific mortality in a Zambian population-based sample. Therefore we could not get a "gold standard" diagnosis on a true population basis, since the validation of verbal autopsy studies in the literature is flawed (the validation samples come from clinical samples and therefore are not likely to be representative of the population) (Gretchen Birbeck, personal communication).[11] Using the World Health Organization (WHO) standard algorithm for diagnosis of HIV infection in the absence of blood tests, we find that 28.4% of the disease-related deaths in our sample are estimated to be AIDS-related (columns h and i , Table 3). However, because we did not collect information on all of the WHO minor symptoms, it is likely that our classification of AIDS and non-AIDS deaths' underestimates the percentage of deaths related to AIDS. For this reason we made a decision to confine our analysis

[9] Lay diagnosis is a method used to collect information on cause-specific mortality from bereaved relatives where the medical certification is not available (see Araya et. al., 2004). The use of modified verbal autopsy along with these more standard proxies will improve our ability to attribute observed impacts and responses to AIDS (Donovan et al. 2003, Mather et al. 2004).

[10] According to Doctor and Weinreb, 2003, such an identification of 'AIDS' deaths' may lack sensitivity to the extent that certain illnesses will be missed. Also it lacks specificity to the extent that any non-HIV tuberculosis or cancer will also fit the criteria.

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to the impacts of prime-age mortality due to disease in general. Hereafter, to save words, we refer to disease-related prime-age (15-59 years) mortality as “PA mortality”.

Table 4 summarizes the number of afflicted and non afflicted households. Among the afflicted households, death is disaggregated by age, gender and position of the deceased in the household. The majority of the deaths due to illness (63.4 %) are as a result of mortality of other non core male and female household members.

Table 4: Characteristics of non-afflicted and afflicted[a] households

Category	Poor	Non Poor	Total
	(A)	(B)	(C)
	------------ numbers ------------		
Non Afflicted (no PA death or chronic illness)	2122	2085	4207
Household with chronically ill PA adults and no deaths’	300	280	580
Prime-age mortality (ages 15 to 59)			
Male heads	53	38	91
Female Heads or spouse	61	61	122
Other males	75	92	167
Other females	76	126	202
Elderly mortality (ages 60 and above)			
Elderly male	60	68	128
Elderly female	41	49	90
Number of households[a]	2,675	2,667	5,342

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

Notes: [a]Afflicted households are those in which a prime-age person died or has a chronically ill member between 2001-2004. The number of household is the sum of death by gender and position (excluding elderly deaths’), households with chronically ill PA members and no death and non-afflicted households less number of households incurring more than one death between 2001 and 2004. There are 27 households with more than one prime-age death of which 12 are in the poor category and 15 in the non-poor category.

3.2 Model and estimation strategies

3.2.1 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 prime-age death as an explanatory variable. The following base model is formulated:

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

where Y_{it} denotes changes in outcomes, such as household composition, area under cultivation, value of farm output, and non-farm income in household i at time t; $D_{it} = 1$ if a household experienced death between 2001 and 2004 and 0 otherwise; the parameter γ_t denotes a time-varying intercept[12]; 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 (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.

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 difference between the outcome measures for each observation, 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, we could use this simple difference-in-difference estimator to evaluate the impact of death.

However, rural households are heterogeneous in many variables that change and evolve differently for different households such as stock of education, income and assets levels). There is growing evidence that the effects of prime-age death differ between households depending on their initial conditions in terms of assets, income and stock of education (see Yamano and Jayne, 2004; Ainsworth and Dayton, 2000; Beegle, 2003; 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:

[12] Wooldridge, 2002 page 254.

$$Y_{it} = \gamma_t + D_{it}\delta + X_i^0 \bullet t\varphi + \alpha_i + \varepsilon_{it} \quad i = 1,\ldots, N \quad t = 1,\ldots, T \qquad [3]$$

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

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

However, in order to analyze the differential impacts of PA mortality we interacted these initial (pre-death) characteristics 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:

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

3.2.2 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. Therefore, this study adopts and extends the model and estimations methods of Yamano and Jayne (2004) who chose to use methods that did not put a lot of restrictions on the data. As an extension of their study, this paper estimates impacts of mortality on various household outcomes taking into account the 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 a dummy variable for chronic illness (H) in the household, provincial dummy variables (P), interaction terms of deaths between 2001 and 2004 and pre-death household characteristics (X^o*D) and deaths between 2001 and 2004 the following model is estimated:

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

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[13]; agricultural production and cropping patterns variables: changes in total land cultivated, land cultivated by crop category (cereals, roots and tubers crops, high value crops) and gross value of crop

[13] Due to data limitations we could not disaggregate children 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 attiring young boys and girls to replenish the pool of physical labor or sent away to live with relatives to ease the burden on food security.

production per hectare; and value of livestock assets and non-farm income variables included: 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 premature adult death may differ depending on the gender of the deceased member, D_i was stratified by gender of the deceased, households with the male prime-age adult death (D^M) and with the female prime age adult death (D^F), and further stratified by gender and position in household of deceased, households with male heads death (D^{MH}), with female heads/spouses death (D^{FH}), with other prime-age male death (D^{MO}), and with other PA females death (D^{FO}). The latter enabled us to test for the possible status-differentiated effects of adult death.

Chronic illness variable (H): The model specified in equation 4 is static considering only permanent adjustments to the shock imposed to the household by prime-age adult deaths, failing to capture any dynamics associated with an adult death and outcomes for the surviving household members. This is because household responses to a death may not be constrained to one-time adjustments. In the case of HIV/AIDS, the lag between infection and death may result in some *ex ante* adjustments by the household to cope with illness and ultimately death of any household member. For that reason, a dummy variable that controls for current prime-age chronic illness was included in equation 4.[14]

Household pre-death conditions (X_i^o) *:* X^o is a vector of initial household conditions. This vector is comprised of asset poverty status, land holding size, and households' effective dependency ratio in 2000.[15] 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 capture the extent to which non-poor households, households with large landholding size and/or households with initial low effective dependency ratios cope with the impact of PA adult deaths differently than poorer households, households with small landholding size and/or households with high dependency ratios, respectively. Ideally, these initial conditions should be measured prior to the onset of chronic illness, but due to data limitation we are unable to precisely determine the onset of illness.

Province x time dummies (A) *:* Although the difference-in-difference estimator presented in this paper controls for unobserved time-invariant household characteristics, there may be area-specific time-variant effects that might be corrected with both the prime-age death and the outcome. To control for such area-specific time-variant effects, Provincial x time interaction dummies were added to the estimation models.

It must also be noted that the control group may be tainted by the fact that in areas where the epidemic is more widespread, no household in the community may remain unaffected. The increasing deaths and illness due to HIV/AIDS may for example result in a breakdown of social

[14] See Beegle (2003) for a discussion of impact of death and illness on time allocation.
[15] See Rosenzweig (1998) for a discussion of supposition that households' composition responds to the economic environment facing households.

capital and local institutions that affect the whole community (afflicted and non-afflicted). With a tainted control group our results may be biased, so we included the lagged HIV/AIDS prevalence as a way to control for the extent of disease in an area and the probability of individuals contracting the disease.

3.2.3 Econometric issues

The model discussed above is faced with two econometric issues, namely the likely endogeneity of death variables and attrition bias. Ignoring these issues may result in inconsistent and biased results. Therefore, this paper attempted to address these issues simultaneously as discussed below.

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. Comparison of mean characteristics in 2001 (table 3) seem to suggest systematic differences between attritors and non-attritors. Coupled with high attrition rate, this may cause concern about inference with this data. Also, if the attrited households suffered a higher incidence of PA mortality between 2001 and 2004, we would have attrition bias when estimating the impact of premature adult HIV/AIDS-related mortality. So we should be worried about the possibility of systematic attrition leading to selection bias.

The literature addressing the correction of selection bias is extensive, and a complete review of this literature is beyond the scope of this paper.[16] In order to deal with potential attrition bias, we adopt the inverse probability weighting method (IPW), 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 method (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 used interview quality variables to predict the re-interview of a household; in particular we use 59 enumeration teams to predict re-interview. Each enumeration team was headed by a supervisor who was authorized to decide whether enumerators give up trying to contact designated households. The re-interview model is specified as follows

$$\text{Prob}(R_{it} = 1) = f(HIV_{t-j}, X_{i,2000}, E_{it}) \qquad (5)$$

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

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

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), ownership of various assets, and monogamous versus polygamous household, and E_{it} is a set of 59 enumeration teams. All of the variables in (5) are observable even for individuals in households that were not re-interviewed in 2004. Equation (5) is estimated with Probit for attrition between the 2001 and 2004 surveys, obtaining predicted probabilities (Pr_{2001}). Then, we compute the inverse probability ($1/Pr_{2001}$), which we applied to the models estimated in section 4.

Identification of impact of death

The DID fixed effects estimator of equation 4 is confounded by the possibility that prime-age death variables are endogenous, hence OLS results may be biased. There is growing evidence that households afflicted by prime-age mortality are not randomly distributed, for they tend to display certain features with respect to initial income, asset levels, education, etc. (see Ainsworth and Semali, 1998; Ainsworth and Dayton, 2000; Yamano and Jayne, 2004; Beegle, 2003). Unfortunately, these studies did not empirically test for the likely endogeneity of prime-age mortality.

Beegle (2003) 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 is an endogenous occurrence, resulting from distinct patterns of behavior, particularly with respect to sexual activity, and perhaps influenced by economic and social conditions. *Second,* individuals chose to live in households in response to illness or recent death. For example, seriously ill individuals may move into a household seeking terminal care and would like to die and be buried in their home area. Since these individuals 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 receiving household's or the returning individual's economic circumstances.

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).[17] Using the same data set as in this paper, Chapoto and Jayne's (2005) study on the characteristics of individuals who died of disease related deaths between 2001 and 2004 in Zambia exhibited the following characteristics: (1) 61% of the prime-age deaths observed in the nationally-representative rural sample were women; (2) 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; (3) females are more likely to die at an earlier age than their male counterparts; (4) relatively wealthy men (defined according to household assets

[17] 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.

and income) are 1.4 to 1.8 times more likely to die than relatively poor men; (5) relatively wealthy and poor women are equally likely to die of disease-related causes; (6) among relatively poor women, those having some form of formal or informal business income are 15% less likely to die of disease-related causes than those without any form of business income; (7) by contrast, among relatively non-poor women, those with business income were 7% more likely to die than those without business income; (8) irrespective of income status, prime-aged men and women experiencing a prior death in their household 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 8 years; and (9) men and women living two or more months away from home per year are 2 to 10 times more likely to die than men and women living at home throughout the year. These characteristics seem to buttress the argument against treating premature adult death in the household as a random event. If prime-age mortality remains correlated with individual and household characteristics such as social status, education, and wealth – which are also important determinants of incomes and other welfare indicators – failure to control for these characteristics may generate biased estimates of the impact of adult mortality on household welfare.

The DID fixed effects methods employed by Yamano and Jayne (2004) may result in biased estimates if the death variables remain endogenous even after controlling for time-invariant individual and household characteristics. 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 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 by gender position in the household at two levels. First, we pool the two years of data and test to see if mortality is endogenous.[18] Second, we test 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 differences will be sufficient.

The challenge was finding instruments with some explanatory power in distinguishing between afflicted and non-afflicted households, and not directly correlated with the welfare indicators of

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[18] *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, pages 621-625).

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 directly 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 we 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. To that effect we considered using 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.[19] Below is a discussion about the possible pathways in which these instruments are linked to prime-age death.

Lagged HIV/Prevalence: An investigation of the correlation between prime-age mortality rates from our household survey data and district HIV prevalence rates from antenatal clinics as reported in Zambia's Demographic Health Survey (CSO, MoH and Macro International, 2003) show a strong relationship between prime-age mortality and HIV prevalence rates making HIV prevalence a possible instrument (see Figure 2, in appendix).[20] The Pearson correlation coefficient of 0.84 suggested that provincial-level adult mortality rates observed in our survey data are closely associated with HIV-prevalence rates. 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. 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. For example, women's use of the clinics where HIV testing is performed may be correlated with income levels, thus high income people are more likely to use these facilities than poor people. Despite the high correlation between HIV prevalence and prime-age mortality, HIV prevalence failed to pass the overidentification test suggesting that the variable is also correlated with the outcome variables. Therefore, as suggested earlier we include HIV prevalence as a control in both the first and second stage models.

Prime-age deaths in 1996-2000: In the 2001 survey, respondents were asked about prior mortality of household members during the 1996-2000 period. As mentioned earlier, the Chapoto and Jayne (2005) study on the characteristics of individuals who died of disease related deaths between 2001 and 2004 found that individuals in households experiencing prior death

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[19] An instrumental variable must satisfy two requirements: it must be correlated with the included endogenous variable(s), and orthogonal to the error process.

[20] 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.

were more likely to die of disease-related causes in the 2001-2004 period. Thus, prior death in the household was used as an instrument, yet it is also possible that death in the 1996-2000 period may be related to the dependent variables in the 2001-2004 period.

Rainfall shocks : A long history of variation in rainfall may be correlated with earlier migration in and out of the community. For example, drought may induce people to leave the rural areas and their families to seek income in the cities and send food home. However, once away from the family some may rely on risky livelihood strategies that expose them to HIV infection and on their return 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.[21] 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 et al. (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.

Since we are dealing with deaths that occurred between 2001 and 2004, it is more likely that people dying of HIV/AIDS-related causes might have contracted the disease five to eight years ago. Therefore, our 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. We use this particular year 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 gender and age influences who migrates. To improve the predictive power of the instruments, we compute gender- and age-specific drought shock variables. In particular, we compute eight variables 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. Our results were not sensitive to which drought year we selected, 1991/92 or 1994/95. Due to high multicollinearity between the deviations in rainfall by year we only use deviations from one drought year to avoid spurious correlations.

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

4.0 EMPIRICAL RESULTS

We begin this section by discussing the results from the reinterview model, followed by a brief discussion of the results from the first stage regression models, where the suitability and strength of our instruments is tested. Next, we present 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. Having determined whether the prime-age death variables are still endogenous or not after purging the time-variant unobservable effects by taking differences, the remainder of the section presents the results from appropriate models measuring the impacts of PA death on rural household variables.

4.1 Reinterview model

Results in section 3.12, Table 3 indicated that attrited households differ from non-attrited households in terms of their 2000 values of observed variables suggesting that we should not ignore possible attrition bias. So we estimated a reinterview model in order to use the IPW method. The results from the re-interview model (Table 5) show that households headed by older adults were 0.4 percent more likely to be re-interviewed compared to households headed by younger adults. Households with more adult males, adult females, and children were more likely to be re-interviewed. Thus, larger households were less likely to have dissolved and also it was more likely for an enumerator to find a qualifying respondent in larger households during the second survey.

Households who experienced an adult death between 1996 and 2000 were less likely to be re-interviewed compared to households experiencing no death during the same period. Also, landholding size and production assets are positively associated with reinterview. The lagged HIV prevalence variable is negatively associated with re-interview and statistically significant at the 10 percent level of significance. This suggests 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.

Households located in a district that is on the line of rail were on average 5 percent less likely to be reinterviwed compared to those households not on the line of rail. 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 percent. This may be because enumerators were less likely to attempt to re-visit households in remote or relatively inaccessible locations. The enumeration team dummies are jointly significant, suggesting that differences in enumeration team effort could be a strong predictor of re-interview. Also, the 2000 households' characteristics are jointly significant as determinants of re-interview. In any case, the results in Table 5 suggest the importance of controlling for attrition, as is done in the remainder of the analysis.

Table 5: Household-level re-interview model (Probit[a])

Covariates	1=Households contained in 2001 and 2004 Surveys, 0=Households contained only in 2001		
	dy/dx	Z	p>z
Demographic characteristics in 2000			
Polygamous household (=1)	0.000	0.00	0.997
Female headed (=1)	-0.020	-1.44	0.151
Age of household head (years)	0.004	1.92	0.055
Age of household head squared (years)	-0.000	-1.39	0.165
Mean years of education of head and spouse	-0.002	-1.64	0.102
Number of male adults	0.016	2.71	0.007
Number of female adults	0.018	3.05	0.002
Number of children under age 6 years	0.016	2.64	0.008
Number of children age 6-11	0.007	2.03	0.042
Prime-age adult mortality and illness in 1996-2000			
Chronically ill adults in 2000(=1, 0 otherwise)	-0.062	-3.81	0.000
Death of head/spouse in 1996-2000 (=1, 0 otherwise)	-0.060	-1.75	0.079
Death of non head/spouse on 1996-2000 (=1, 0 otherwise)	-0.009	-0.48	0.634
Household assets in 2000			
ln (Value of assets (ZMK))	0.003	2.54	0.011
ln (Landholding size(Ha))	0.029	4.89	0.000
Community variables			
District HIV prevalence rate in 1999	-0.001	-1.67	0.096
Distance to the nearest tarmac (Km)	-0.000	-1.16	0.246
Distance to the nearest district town (Km)	-0.000	-0.26	0.792
On line of rail	-0.050	-2.30	0.021
Agro-ecological zones			
Zone 1-Least rainfall (=1)	-0.010	-0.17	0.087
Zone 3-higher rainfall (=1)	-0.069	-1.56	0.119
Zone 4-highest rainfall (=1)	-0.135	-2.47	0.014
Enumeration team dummies included[b]	Yes	Yes	Yes
Joint tests (X^2)			
Household characteristics	167.56 [p=0.000]		
Enumeration Team effects	204.25 [p=0.000]		
Community variables	15.61[p=0.029]		
Predicted probability of re-interview[c]	0.795		
Number of households	6922		

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

Notes: [a]Estimated coefficients are marginal changes in probability. Absolute z-scores, calculated using heteroskedasticity robust standard errors clustered for households. Enumeration teams are included but not reported in the table. [c]Predicted probability of re-interview is estimated at model mean values

4.2 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. We test the former condition by F-test of the joint significance of the instruments in the first-stage regression. The inverse of the F-statistic is proportional to the bias in the second stage (Duncan and Strauss, 1997). Table 6 reports the first-stage F-statistics for the significance of the identifying instruments. 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 for mortality of individuals who were heads or spouses in their household. Lagged HIV prevalence did not pass the overidentification test as an instrument and hence was not used as an instrument but as a regressor in both the first and second stage regression models. 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 one case, changes in area under high value crops, we reject the null hypothesis that our instruments are not correlated with the error term. So our test for endogeneity should be interpreted with these shortcomings in mind. Tables A6 and A7 in the appendix present the first- and second-stage regression results from which the results in Table 6 are derived.

Table 6. First-stage F-statistic for significance of identifying instruments, Pseudo R^2 and % correctly predicted

	F-test for instruments						% correctly predicted and (Pseudo R^2)	
	Prior Death		1994/95 Rainfall deviations by age group shocks		All Instruments			
	Pooled Sample	First differenced	Pooled Sample	First differenced	Pooled Sample	First differenced	Pooled Sample	First differenced
Prime-age mortality	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)
Male head death	0.26	0.03	143.52**	137.34**	143.99**	137.58**	98.3(0.11)	97.6(0.24)
Female heads/spouses death	1.50	1.66	230.88**	221.44	230.88**	221.47**	97.7(0.17)	97.7(0.34)
Other males death	45.98**	18.46**	278.29**	226.25**	321.65**	233.40**	96.9(0.16)	97.0(0.33)
Other females death	11.34**	2.86+	264.34**	252.5**	275.49**	254.61**	96.4(0.16)	96.5(0.35)

Source: 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. HIV prevalence rate and months away from home in 2000 for all adults failed to pass the overidentification test because they are correlated with the outcome variables in the second stage models.

4.3 Is prime-age death endogenous?

As discussed in section 3.2.3 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 7 columns A to D, summarizes the results from the Hausman-Wu test for endogeneity and Sargan N*R-squared test for overidentification of exclusion restrictions. A complete set of the first and second stage results are presented in tables A6 to A14 in the appendix. The results in Table 7, column A, show that prime-age death is endogenous when we compare OLS and IV results for the pooled sample. Thus, in all the cases except when measuring the impact of death on 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 1-5% level of significance. 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 we difference out the time-invariant unobserved household characteristics as shown in equation 4 and further test for endogeneity of prime-age death variables. Any evidence of endogeneity at this stage would indicate that even after differencing out 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 7, column B, indicate that differencing of the household time-invariant unobservable characteristics redressed the endogeneity problem, since we fail to reject the null hypothesis that all prime-age mortality variables are exogenous. These findings offer some support for the validity of earlier studies using fixed effects, RE or DID (but not explicitly testing for endogeneity). Since we do not know of any study that attempted to test for endogeneity of prime-age mortality when measuring household outcomes, there is need for further research in this area. Given these findings we feel comfortable to present the results from OLS models using differenced data.

Table 7: Summary table of Hausman Wu Chi-square test and Sargan N*R square test for overidentification for pooled and differenced samples.

Household outcomes	Hausman Wu Chi-square test[a]		Sargan N*R square test of overidentification[b]	
	Pooled Sample	First differenced	Pooled Sample	First differenced
	(A)	(B)	(C)	(D)
Land cultivated				
Total area cultivated	13.32**	3.44	3.82	6.27
Area under cereals	9.65*	3.21	4.87	7.46
Area under tubers	5.51	5.26	6.97	8.47
Area under high value crops	9.75*	6.06	8.62	9.74+
Household demographics				
Household size	12.44**	3.09	5.18	6.11
Males	20.24**	1.76	5.83	6.36
Females	9.66*	2.62	5.42	4.37
Boys	10.05**	7.52	6.64	4.80
Girls	16.80**	0.63	2.02	4.25
Crop production				
Gross value of output [Zkw]	16.46**	0.62	8.61	5.50
Gross value of output/ha [Zkw/ha]	2.17	5.03	3.00	3.62
Assets and off-farm income				
Farm equipment	16.78**	6.23	0.52	6.61
Values of cattle	22.41**	0.45	6.15	7.79
Values of small animals	14.37**	1.30	4.42	5.29
Off-farm income	134.62**	3.02	0.80	10.12

Source: 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%.

4.4 Impact of prime-age death on household composition

The results in table 8 (columns A and B) show that irrespective of gender and/or position in the household of the deceased person, household size declines by less than one person. For example, the death of any prime-age male reduces the size of the household by 0.87 members and death of a PA woman reduces the size of the household by 0.72 members. Compared to households without deaths, the death of male head of the household results in a reduction of household size by 0.63 and the death of females who were heads or spouses of their households reduces household size by 0.80. The death of another adult male reduces the household size by 0.98 persons whilst death of other females reduces the household size by 0.62.

Changes in household size, shown in column A and B, are the sum of changes in men, women, boys and girls in columns C to J. As mentioned earlier, due to data limitations we were unable to split boys and girls into two age groups, age 5 and under and age 6 to 11, so we only look at effects of death on boys and girls ages 11 and under. Looking across the row, it can be seen that the reduction of household size due to male heads/spouses death is mainly caused by a reduction of 0.68 in the number of adult males. The changes in number of females and boys are positive whilst that for girls is negative but these estimates are not statistically significantly different from zero. The drop in adult males is less than one, suggesting partial replacement of males. In contrast, the death of PA female heads or spouses and other females reduces the size of the household by 0.59 and 0.42 respectively and this reduction is due to the changes 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. We get slightly different results for other non-core males death. The reduction in household size due to other males death is a result of a decline in the number of males by 0.42 as well as a reduction in the number of girls by 0.32. 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 males 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 0.90 and 0.74 respectively. Thus, there is greater partial replacement of household members by males (though not statistically significant) in the event of female elderly death compared to elderly male death. Death of elderly males and females also results in a decline in number of girls. Although statistically significant at the 20% percent level, death of elderly males 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.

Interestingly, we find positive changes in household size though not statistically significant in households that have currently chronically ill adults. This increase in household size though not unity is mainly due to an increase in the number of females by 0.13. Also, we find that households with chronically ill adults have a reduction in number of boys by 0.06 and girls by 0.03 but the reductions are not statistically significant. This result seems to suggest that women

Table 8: The impact of PA mortality on household composition by gender and position of the deceased

Covariates	Δ Household size		Change in number of : Males		Females		Boys		Girls	
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)
Prime-age (PA) adult mortality										
Male	-0.87**		-0.53**		-0.00		-0.08		-0.25*	
	(4.01)		(6.09)		(0.05)		(0.87)		(2.41)	
Female	-0.72**		0.09		-0.48**		-0.16*		-0.16+	
	(3.50)		(1.16)		(6.02)		(2.02)		(1.72)	
Male head/spouse		-0.63*		-0.68**		0.03		0.06		-0.04
		(2.28)		(4.92)		(0.30)		(0.38)		(0.31)
Female head/spouse		-0.80*		0.06		-0.59**		-0.19		-0.09
		(2.28)		(0.55)		(4.56)		(1.38)		(0.56)
Male non-head/spouse		-0.98**		-0.42**		-0.03		-0.17		-0.36*
		(3.35)		(3.89)		(0.25)		(1.47)		(2.54)
Female non-head/spouse		-0.62*		0.11		-0.42**		-0.13		-0.18
		(2.48)		(1.19)		(4.33)		(1.31)		(1.58)
Elderly mortality										
Elderly males	-0.90**	-0.90**	-0.68**	-0.69**	-0.08	-0.08	0.13	0.14	-0.27*	-0.26*
	(2.74)	(2.73)	(5.03)	(5.09)	(0.60)	(0.63)	(1.05)	(1.07)	(2.16)	(2.09)
Elderly females	-0.75*	-0.74*	0.10	0.09	-0.44**	-0.44**	-0.11	-0.11	-0.30+	-0.29+
	(2.18)	(2.18)	(0.82)	(0.77)	(2.84)	(2.85)	(0.71)	(0.68)	(1.87)	(1.82)
Chronically ill PA adults (=1)	0.10	0.10	0.06	0.06	0.13**	0.13**	-0.06	-0.06	-0.03	-0.03
	(0.87)	(0.87)	(1.38)	(1.33)	(2.86)	(2.83)	(1.01)	(1.00)	(0.55)	(0.50)
Constant	-1.03	-1.03	0.14	0.14	0.01	0.01	-0.57	-0.56	-0.61	-0.61
	(1.14)	(1.14)	(0.65)	(0.63)	(0.04)	(0.04)	(1.45)	(1.44)	(1.10)	(1.10)
Province x time dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
F-test on Mortality	15.26**	7.85**	18.78**	10.06**	18.14**	10.40**	2.51+	1.50	4.71**	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	5305	5305	5305	5305	5305	5305	5305	5305	5305	5305

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.

are the main caregivers in the household and death of females may exert more negative impacts on care of the children and ill members.

Do these findings support the general assumption in most qualitative literature and popular discussion suggesting that, in general, households incurring prime-age death face severe agricultural labor constraints based on the notion that death of a prime-age adult reduces household's labor supply and increases its dependency ratio? Unfortunately, results in Table 8 alone cannot adequately provide definitive answers to this important question. *First,* there seem 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 larger household sizes compared to non-afflicted households (see table A2 in the appendix). In addition, we have to bear in mind that in general most agricultural households are likely to face labor shortages of some kind at particular times of the season. Based on these reasons we suggest caution before making any conclusions that assume that the loss of a PA adult will cause the household to face greater labor shortages than non-afflicted households. To seek more clarity on this issue, we look at the impact of death on household composition by considering the differential impacts due to the differences in initial pre-death wealth status, land holding size and effective dependency ratios.

Also, we test the sensitivity of our findings by stratifying the sample into two groups based on the initial pre-death value of household assets in the 2001 survey[22] and then estimate the models in Table 8 with gender and position mortality variables. We do this because the ability of a household to respond to any kind of death shock is subject to some of these factors and to ignore them in the discussion may lead us to make incorrect conclusions (Drimie, 2002; Yamano and Jayne, 2004).

Does the impact on household composition differ by initial household conditions?

First, we look at the results from models with interactions terms between death by gender and position and pre-death household poverty status, landholding size and effective dependency ratio to capture the likely differential impacts of the death shock. The hypothesis to be tested is that poverty exacerbates the impacts of death and that poor households are less able to cope with the shock.

Wealth status in 2000: The results of the interaction terms between death and wealth status as shown in table 9 are not statistically significant except for the male heads/spouses death and wealth status interaction which is statistically significant at the 10% level. The positive coefficient suggests that the reduction in household size is greater in poorer households compared to non-poor households. In this case it would seem that non-poor households are attracting boys and other males (statistically significant at 15%) to replace the labor lost among households incurring male head/spouse death. Notwithstanding the loss of knowledge about farm practices and income of the deceased, older boys and other males may be filling the labor void left by the deceased male head in non-poor households. Since all the other interaction

[22] Value of assets 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.

terms are statistically insignificant we only do some simulations to compare the impact on household size due to male head/spouse death between poor and non-poor households. In order to do this we evaluate the impact of male head of household death on household size, change in males and boys for two scenarios: (1) poor households (bottom 50% of value of assets distribution), mean land size (3.10 hectares) and mean effective dependency ratio (1.33); and, (2) non-poor households (upper 50% of value of assets distribution), mean land size and mean dependency ratio. (See table A3 in the appendix for descriptive statistics on initial (pre-death) household characteristics.) We find that household size goes down by -0.093 in non-poor households compared to -0.712 in poorer households. The implications of this finding are that poorer households have substantially greater difficulties in coping with the death of core male household members while non-poor households are likely to almost fully restore household size to former pre-death levels. These results seems to support earlier findings in Kenya that poor households experiencing a male head death are less able to cope with the shock due to limited household resources to support additional members.

Turning to the models stratified by poverty status, results in Table 10 show that among poor households, male head/spouse death causes an almost unity decline in household size whilst among non-poor households the impact is statistically insignificant. Therefore, the significant negative impact on household size in the full sample is to an extent influenced by what is going on in households that are in the bottom 50% of the assets distribution. Although, the impact on total household size as a result of female head/spouse or other females death is not statistically significant at the 10% level, the reduction in household size in both poor and non-poor households is mainly explained by the change in the number of females. Additional other male death among non-poor households results in a more than one person reduction in household size. Looking across the columns under non-poor we find that this decline is due to a reduction in males and young girls consistent with the finding in the full sample models in table 9 column I.

Effective dependency ratio (EDR) in 2000: Tables A1 and A2 in the appendix show that both *ex ante* and *ex post* EDR ratios of afflicted households are generally equal to those of non-afflicted households. Households incurring prime-age female death (heads/spouses and other females) between 2001 and 2004 had a decline in mean effective dependency ratio in 2001 of 0.16 and 0.35, respectively. Households incurring PA mortality of male heads/spouses and other males had a decline in EDR of 0.34 and 0.41. Non-afflicted households had a decline of mean EDR of 0.34. It is likely that most afflicted households are able to restore their dependency ratios, at least to some extent, by attracting new PA members or sending away children to other relatives, or that afflicted households are in general further along in the household lifecycle, such that some children are old enough to have switched from the numerator to the denominator of the dependency ratio, or have already left to start their own households. Given this background we note that the impact of PA mortality on household composition may depend on the initial household effective dependency ratio. To empirically test this apparent relationship we interacted death variables by pre-death EDR in 2000. The results in Table 9 show that not all interaction terms are statistically significant except for deaths of female members, heads/spouses and other females. Table 9, columns H and J show that there are differences in the change in number of

Table 9: The impact of PA mortality on household composition by initial household pre-death characteristics.

Covariates	Δ Household size		Change in number of:							
			Males		Females		Boys		Girls	
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)
Prime-age (PA) adult mortality										
Male head/spouse	-0.758**	-0.715*	-0.645**	-0.637**	0.056	0.071	-0.037	-0.017	-0.132	-0.132
	(2.76)	(2.34)	(4.76)	(3.95)	(0.50)	(0.65)	(0.26)	(0.11)	(0.98)	(0.90)
Female head/spouse	-0.912**	-1.035*	0.114	0.080	-0.565**	-0.485**	-0.292*	-0.385*	-0.169	-0.244
	(2.61)	(2.48)	(0.97)	(0.61)	(4.38)	(3.68)	(2.25)	(2.31)	(1.12)	(1.37)
Male non-head/spouse	-0.926**	-0.883**	-0.429**	-0.409**	-0.031	-0.017	-0.140	-0.134	-0.326*	-0.323*
	(3.24)	(3.16)	(3.96)	(3.81)	(0.28)	(0.15)	(1.27)	(1.24)	(2.40)	(2.44)
Female non-head/spouse	-0.514*	-0.503*	0.100	0.127	-0.424**	-0.412**	-0.074	-0.097	-0.116	-0.122
	(2.06)	(2.01)	(1.10)	(1.37)	(4.43)	(4.20)	(0.75)	(1.00)	(1.04)	(1.11)
Elderly mortality										
Elderly males	-0.808*	-0.828*	-0.724**	-0.731**	-0.103	-0.115	0.215+	0.212	-0.197	-0.193
	(2.49)	(2.56)	(5.19)	(5.27)	(0.79)	(0.89)	(1.67)	(1.65)	(1.62)	(1.60)
Elderly females	-0.555+	-0.577+	0.036	0.029	-0.472**	-0.477**	0.042	0.038	-0.161	-0.166
	(1.66)	(1.72)	(0.29)	(0.23)	(3.08)	(3.12)	(0.27)	(0.24)	(1.03)	(1.07)
Chronically ill PA adults (=1)	0.119	0.121	0.050	0.049	0.125**	0.127**	-0.040	-0.042	-0.016	-0.014
	(1.02)	(1.03)	(1.16)	(1.16)	(2.74)	(2.78)	(0.75)	(0.78)	(0.29)	(0.26)
1999 HIV Prevalence rate	0.059	0.058	0.002	0.002	0.011	0.011	0.030	0.029	0.016	0.017
	(0.66)	(0.64)	(0.08)	(0.06)	(0.43)	(0.43)	(0.75)	(0.71)	(0.42)	(0.43)
Pre-death HH Characteristics										
Poverty status (1=non poor)	-0.180*	-0.173+	0.010	0.036	0.027	0.024	-0.074+	-0.095*	-0.143**	-0.138**
	(2.05)	(1.92)	(0.28)	(1.02)	(0.81)	(0.70)	(1.80)	(2.23)	(3.39)	(3.15)
Landholding size (Ha)	-0.089**	-0.084**	-0.004	-0.003	-0.002	-0.000	-0.038**	-0.036**	-0.045**	-0.044**
	(4.92)	(4.57)	(0.61)	(0.45)	(0.30)	(0.03)	(4.41)	(4.05)	(5.49)	(5.26)
Dependency ratio(number)	-0.423**	-0.440**	0.166**	0.164**	0.096**	0.088**	-0.375**	-0.377**	-0.310**	-0.316**
	(10.57)	(10.74)	(7.87)	(7.37)	(6.69)	(6.02)	(15.73)	(15.03)	(15.28)	(15.06)
PA death by poverty status										
Male heads *poverty status		1.014+		0.063		-0.136		0.755*		0.331
		(1.78)		(0.21)		(0.61)		(2.49)		(1.25)
Female H/S * poverty status		-0.168		-0.304		-0.024		0.160		-0.001
		(0.25)		(1.29)		(0.09)		(0.65)		(0.00)
Other males*poverty status		-0.074		-0.207		0.330		0.161		-0.358
		(0.13)		(0.98)		(1.52)		(0.72)		(1.40)

Table 9 cont'd

Other females*poverty status		-0.551		-0.384*		-0.121		-0.015		-0.030
		(1.13)		(2.10)		(0.62)		(0.08)		(0.13)
PA death by 2000 land size										
Male heads/spouses*land size		-0.219+		-0.035		0.025		-0.116*		-0.094+
		(1.82)		(0.73)		(0.51)		(2.15)		(1.88)
Female heads/spouses*land size		0.038		-0.054		0.041		0.015		0.035
		(0.25)		(1.11)		(0.91)		(0.25)		(0.55)
Other adult males*land size		-0.106		-0.040		-0.069*		-0.022		0.026
		(1.07)		(1.40)		(2.04)		(0.60)		(0.64)
Other adult females*land size		0.027		0.042*		-0.011		0.014		-0.018
		(0.42)		(2.10)		(0.41)		(0.47)		(0.63)
PA mortality by dependency ratio										
Male heads*EDR[f]		0.216		0.051		0.074		-0.005		0.096
		(0.67)		(0.37)		(0.68)		(0.03)		(0.75)
Female heads/spouses* EDR		-0.481		-0.021		0.206		-0.350+		-0.316+
		(1.06)		(0.13)		(1.08)		(1.86)		(1.66)
Other adult males* EDR		0.058		0.044		0.005		0.010		-0.001
		(0.24)		(0.43)		(0.07)		(0.08)		(0.01)
Other adult females* EDR		0.561**		0.018		0.173*		0.153+		0.218+
		(2.85)		(0.22)		(2.20)		(1.81)		(1.82)
Province x time dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	-0.891	-0.827	-0.060	-0.053	-0.283	-0.254	-0.382	-0.340	-0.166	-0.180
	(0.43)	(0.40)	(0.10)	(0.09)	(0.46)	(0.41)	(0.41)	(0.37)	(0.15)	(0.16)
Joint tests										
Prime-age mortality	8.14**	7.16**	9.89**	7.61**	10.24**	8.22**	1.85	2.01+	2.53*	2.78*
Elderly mortality	4.71**	5.04**	13.49**	13.90**	5.12**	5.33**	1.48	1.42	1.85	1.88
Asset poverty status*PA mortality		1.65		1.55		0.69		2.11+		2.94*
Land size*prime-age mortality		5.81**		1.79		1.10		5.12**		7.20**
Dependency ratio*PA mortality		24.19**		13.10**		10.32**		50.90**		18.13**
R-squared	0.15	0.15	0.14	0.14	0.10	0.11	0.19	0.19	0.17	0.17
Number of observations	5304	5304	5304	5304	5304	5304	5304	5304	5304	5304

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.

Table 10: The impact of PA mortality on household composition by gender and position in household by poverty status

Covariates	Δ Household size		Change in number of: Males		Females		Boys		Girls	
	Poor	Non Poor	Poor	Non Poor	Poor	Non Poor	Poor	Non Poor	Poor	Non Poor
Prime-age (PA) adult mortality										
Male head/spouse	-0.995**	-0.221	-0.654**	-0.751*	0.040	-0.088	-0.231	0.558*	-0.150	0.061
	(3.27)	(0.42)	(4.84)	(2.52)	(0.24)	(0.51)	(1.27)	(2.12)	(0.80)	(0.26)
Female head/spouse	-0.706	-0.900	0.169	-0.172	-0.600**	-0.518**	-0.206	-0.115	-0.069	-0.095
	(1.58)	(1.55)	(0.92)	(0.96)	(3.13)	(2.61)	(1.15)	(0.51)	(0.34)	(0.39)
Male non-head/spouse	-0.710+	-1.111*	-0.204	-0.586**	-0.089	0.028	-0.271	-0.065	-0.146	-0.488*
	(1.94)	(2.29)	(1.39)	(3.43)	(0.59)	(0.16)	(1.59)	(0.37)	(0.80)	(2.23)
Female non-head/spouse	-0.319	-0.674+	0.314*	0.029	-0.388*	-0.435**	-0.157	-0.154	-0.088	-0.114
	(0.83)	(1.87)	(2.10)	(0.23)	(2.47)	(3.30)	(1.04)	(1.10)	(0.53)	(0.67)
Elderly mortality										
Elderly males	-1.250**	-0.515	-0.677**	-0.726**	-0.328*	0.099	0.011	0.307+	-0.256	-0.195
	(3.24)	(0.93)	(3.54)	(3.76)	(2.11)	(0.47)	(0.06)	(1.67)	(1.64)	(0.90)
Elderly females	-0.211	-1.100+	0.240	-0.055	-0.438*	-0.351	0.219	-0.368	-0.231	-0.327
	(0.52)	(1.86)	(1.49)	(0.29)	(2.02)	(1.52)	(1.15)	(1.42)	(1.01)	(1.22)
Chronically ill adults (=1)	0.286+	-0.145	0.052	0.062	0.233**	0.012	-0.002	-0.162+	0.003	-0.056
	(1.84)	(0.75)	(0.89)	(0.88)	(3.86)	(0.16)	(0.02)	(1.84)	(0.04)	(0.61)
Constant	1.000**	-1.162	-0.000	0.165	-0.000	-0.010	-1.000	-0.538	2.000**	-0.779
	(55.97)	(1.17)	(0.00)	(0.70)	(0.00)	(0.04)	(0.006)	(1.24)	(35.21)	(1.32)
Province x time dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Joint tests for										
Prime-age mortality	4.87**	3.32*	7.36**	4.77**	4.45**	4.56**	1.69	1.47	0.46	1.59
Elderly mortality	5.35**	2.36+	7.66**	7.23**	4.32*	1.24	0.66	2.18	1.83	1.23
R-squared	0.20	0.17	0.19	0.18	0.17	0.15	0.18	0.16	0.18	0.16
Number of observations	2651	2653	2651	2654	2651	2654	2651	2654	2651	2654

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 boys and girls by initial EDR in households experiencing female heads/spouses and other female death. Among households with higher effective dependency ratios in 2000, other female death results in a smaller reduction in numbers of boys and girls compared to households that had a lower EDR in 2000. This could be explained by the fact that households with a higher EDR in 2000 and experiencing non-core female deaths were able to partially replace the lost female by attracting other females in the household. In order to determine the magnitude of the differential impact of females' death on household size and composition due to initial dependency ratio we estimated the impact on eight different household "profiles" as shown in table 11.

Table 11: Simulations[a]: impact of core and non core female death on household composition.

Prime-age Death	Profile	Effective Dependency in 2000		Land size in 2000	Wealth status in 2000	Changes in number:				
		Lower quartile	Upper quartile			HH Size	Males	Females	Boys	Girls
Female heads or spouses	1	Mean		Mean	Mean	-1.64	-0.23	-0.10	-072	-0.56
	2	0.6		Mean	Non Poor	-1.37	-0.37	-0.26	-0.39	-0.33
	3	0.6		Mean	Poor	-1.21	-0.07	-0.23	-0.55	-0.33
	4		1.80	Mean	Non Poor	-1.95	-0.40	-0.01	-0.81	-0.71
	5		1.80	Mean	Poor	-1.78	-0.09	0.01	-0.97	-0.70
Other Females	6	Mean		Mean	Mean	0.05	0.06	-0.28	0.14	0.10
	7	0.6		Mean	Non Poor	-0.63	-0.14	-0.46	0.02	-0.08
	8	0.6		Mean	Poor	-0.08	0.24	-0.34	0.04	-0.05
	9		1.80	Mean	Non Poor	0.04	-0.12	-0.26	0.21	0.18
	10		1.80	Mean	Poor	0.59	0.26	-0.13	0.22	0.21

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

Notes: [a]Simulation outcomes are based on regression models in Table 10.

Table 11, profiles 2 to 5 show that among households experiencing a female head/spouse mortality, household size declines by more than one person whilst household size declines by less than one person for households suffering the death of another female (other than the head or spouse of the head). We concentrated on changes in number of boys and girls because the results in Table 9 show that initial effective dependency rates influence (at the 10% significance level) the impact of a adult woman's death on the number of boys and girls remaining in the household. Among both non-poor and poor households with initial high EDR in 2000 the decline in the number of boys and girls is higher than for households having low a EDR. For example, among poor households with a high initial EDR, the death of a female core members (head or spouse) results in a reduction of the number of boys and girls by 0.97 and 0.70 whilst similarly poor households having a relatively low EDR experience an estimated 0.55 decline in the number of boys, and a 0.33 increase in the number of girls. We observe a similar pattern of results for death of female heads/spouses among non-poor households. Turning to profiles 7 to 10, the results are mixed. For other females death in both poor and non-poor households with high EDR in 2000, the number of boys went up by about 0.20 suggesting that households suffering the death of non-head/spouse females are trying to cope with the shock by attracting boys into the household. Surprisingly, the number of girls went down by 0.08 and 0.05 among poor and non-poor households with lower EDR in 2000 while the number of girls went up by 0.18 and 0.21 among the same households but with high EDR in 2000. This finding suggests that girls are attracted into households with initial high EDR to assist in caring for other children, the elderly or the sick when a female adult dies.

Land holding size in 2000: The land/labor ratio[23] provides a rough measure of the household's potential supply of labor per hectare owned. *A priori* we expect that households with lower land/labor ratios in 2000 are less likely to need to attract new members if the household experiences a death, whilst we might expect to see households with high land/labor ratios attempting to attract new members in the event of a death. However, descriptive results in tables A1 and A2, do not show any significant differences in land/labor ratio between afflicted and non-afflicted household, either *ex ante* or *ex post*. Since changes in adult equivalency is endogenous we estimated models with interaction of PA mortality between 2001 and 2004 and initial land holding size in 2000 in order to determine the differential impact of death on household composition by initial land holding size. Despite the loss of wealth due to illness and prime-age death it is likely that non-poor households may be 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 Table 9, show that there is differential impact on household size among households experiencing male head death. Among poor households with small (25th percentile of landholding size, 1.06 hectares) and large land sizes (75th percentile in 2000, 4.0 hectares), and using the mean effective dependency ratio of 1.33, the death of a male head of household results in a decline in household size of 0.66 and 0.43 respectively. Among wealthier households, the results indicate that household size *rises* by 0.35 and 0.59 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.

4.5 Impact of PA death on farm and crop production

There are at least three pathways in which farm production can be affected by prime-age mortality. *First*, the reduction in household size may result in labor shortages, which force 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 and promotion of labor-saving crop technologies. Results from the impact of mortality on household composition in the preceding section show that there is partial replacement of members when a prime-age member dies but less so for relatively poor households experiencing the death of a household head or spouse. *Second*, the death of an adult may also entail a loss of agricultural husbandry, management, and marketing knowledge, requiring a change in crop mix. Even in households coping by attracting new members, the skills of the new member may not

[23] We use adult equivalents as a proxy of farm labor.

match the skills of the deceased, who we found to be primarily boys and girls. *Third*, crop mix 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). Therefore, the results presented in this section should be interpreted taking into account the dynamics of household composition from the preceding section.

The results in table 12 (column A) show that, in general, adult male mortality resulted in an 11% decline in total land cultivated; this effect is significant at the 10% significance level. Female death of any kind resulted in a 3% decline of cultivated land but the impact is not significant at the 10% level. Surprisingly, we find a 29% 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 to crop cultivation that the younger male heads (who tend to be the primary earners of off-farm income in sampled households).

By gender and position in the household (table 12, column B), we find that death of male heads/spouses results in the reduction of land cultivated by 20% (cereal area declines by 11%). The death of a female head or spouse results in a 9% reduction in cereal cultivation (significant at the 10% level). All the other mortality categories are negative but not statistically significant. This finding seems to follow from our earlier findings that households experiencing male heads/spouse death experience a higher decline in household size and without full replacement of household members, land cultivated is cut back to cope with the labor shortage.

In order to directly test the hypothesis that households experiencing deaths switch to less labor-intensive crops, we disaggregated changes of area cultivated into area under cereals, tubers and root crops, and high value crops (table 12, columns C to H). By gender, the 11% decline in land cultivated among households incurring a male death is due to the reduction in area under cereals and high value crops. The coefficient on changes in roots and tubers is positive but not statistically significant. In contrast, we observe a 4% decline in area under roots and tubers in households experiencing PA female mortality. When distinctions are made between gender and position of the deceased, we find that PA mortality of male and female heads/spouses and other males resulted in the decline of area under cereals of 11.0, 9.0 and 8.0 percent, respectively. 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 would have concluded that households incurring male deaths had a statistically significant decline in land cultivated but missed the fact that the death of older members has the most important impact on crop area cultivated. In contrast to the findings by Davison (1998) and Yamano and Jayne (2004), we do not find very large negative impact differences on cereal production between mortality of female and male heads/spouses of the household. These results seem to suggest that, in general, both male and female heads/spouses in rural Zambia are equally important to growing food crops (cereals). However, the results in table 12 column H show that among households experiencing male head/spouse death, area under high value crops declined by 3%, suggesting that, to some extent, the death of a male core member of the household adversely affects cash cropping. Interestingly, the death of other males results in an increase in area under roots and tubers by 3%,

Table 12: 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	-0.11+		-0.09**		0.01		-0.02+	
	(1.91)		(2.71)		(0.52)		(1.87)	
Female	-0.03		-0.04		-0.04+		-0.01	
	(0.65)		(1.36)		(1.91)		(1.04)	
Male head/spouse		-0.20*		-0.11*		-0.03		-0.03+
		(2.03)		(2.07)		(0.93)		(1.95)
Female head/spouse		-0.01		-0.09+		-0.01		-0.01
		(0.14)		(1.90)		(0.21)		(0.27)
Male non-head/spouse		-0.08		-0.08*		0.03		-0.02
		(1.09)		(2.11)		(1.21)		(1.04)
Female non-head/spouse		-0.04		-0.00		-0.05*		-0.01
		(0.61)		(0.04)		(2.07)		(0.90)
Elderly mortality								
Elderly males	-0.31**	-0.31**	-0.11**	-0.11**	-0.06+	-0.06+	-0.01	-0.01
	(3.65)	(3.67)	(2.86)	(2.94)	(1.87)	(1.86)	(0.48)	(0.49)
Elderly females	-0.04	-0.05	-0.02	-0.02	0.03	0.03	0.03	0.03
	(0.44)	(0.46)	(0.32)	(0.36)	(0.73)	(0.71)	(1.15)	(1.14)
Chronically ill PA adults (=1)	0.01	0.01	0.02	0.02	0.00	0.01	-0.01	-0.01
	(0.33)	(0.32)	(0.46)	(0.44)	(0.14)	(0.16)	(1.06)	(1.07)
Constant	0.13	0.13	-0.09	-0.09	-0.01	-0.01	0.27*	0.27*
	(0.63)	(0.63)	(0.67)	(0.67)	(0.34)	(0.36)	(2.24)	(2.24)
Province x time dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
F-test on Mortality	2.13	1.50	4.79**	3.15**	1.92	1.72	2.18	1.43
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.

although not statistically significant. But we do find a significant 5% decline in area under roots and tubers among households experiencing the death of other women. These findings do not seem to support 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, there might be differential impacts by pre-death household characteristics in 2000 survey. We analyze this in the next section. Surprisingly, we find no evidence that households with currently chronically ill adults cut back on their land under cultivation.

Does the impact on land cultivated and crop mix differ by initial household conditions?

Turning to results from models with interactions terms between mortality variables and pre-death household characteristics, we discuss the likely differential impacts of the death shock on land cultivated and crop mix by wealth status, effective dependency ratio and landholding size.

The interaction terms between death and wealth status are jointly statistically significant. However, there seem to be differential impacts by poverty status among households experiencing mortality of male heads/spouses and other males as shown by the statistically significant interactions in table 13. The negative interaction coefficients suggest that the reduction in land cultivated is greater in non-poor households compared to poor households. We evaluated the impact of mortality of male heads/spouses and other males on land cultivated under for two scenarios: (1) poor households (bottom 50% of value of assets distribution), mean land size (3.10 hectares) and mean effective dependency ratio (1.33); and (2) non-poor households (upper 50% of value of assets distribution), mean land size and mean dependency ratio. From these simulations, we find that land cultivated and area under cereals decline by 73% and 51% among non-poor households experiencing mortality of male core members of the household compared to 36% and 22% decline among households in the same situation but in the bottom 50% of the 2000 assets distribution. In contrast, the impacts are lower in both poor and non-poor households experiencing female heads/spouse death. For example, among poor households experiencing female head/spouse of household death, total land cultivated and area under cereals declined by 3.8% and 17%, respectively, compared to a decline in total land cultivated and area under cereals by 1.8% and 19% among households in the same circumstances but non-poor. We get a less severe but similar pattern of results to mortality of male head/spouse among households incurring mortality of other PA males. These results seem to suggest that other PA males are also key to crop production in rural Zambia and their death causes land cultivated and area under different crops to decline in both poor and non-poor households.

Turning to the models stratified by poverty status, results in table 14 seem to reinforce the above observations that land cultivated, area under cereals and area under roots and tubers significantly decline among non-poor households incurring deaths of core male members and male non core members. Similar to the findings by Yamano and Jayne (2004), we find that mortality of male head of the household in poor households is associated with reductions in area under high-value crops. However, we do not find any other statistically significant impact of mortality among households in the bottom 50% of the assets distribution except in the death of elderly males. As mentioned earlier we suspect that elderly males in poor households remain productive even beyond age 59. Although the impact on area under roots and tubers is not statistically

Table 13: The impact of PA mortality on cultivated land by gender, position and initial household pre-death characteristics

Covariates	Δ ln(Area cultivated)		Change in natural log of area under (ha):					
			Cereals[a]		Tubers and root crops[b]		high-value crops[c]	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Prime-age (PA) adult mortality								
Male head/spouse	-0.215*	-0.259**	-0.118*	-0.151**	-0.031	-0.025	-0.034+	-0.032+
	(2.24)	(2.70)	(2.26)	(2.84)	(1.09)	(0.87)	(1.91)	(1.68)
Female head/spouse	-0.002	-0.005	-0.081+	-0.096+	-0.006	-0.009	-0.006	-0.005
	(0.03)	(0.06)	(1.82)	(1.73)	(0.22)	(0.22)	(0.30)	(0.16)
Male non-head/spouse	-0.069	-0.068	-0.077+	-0.078*	0.031	0.035	-0.018	-0.016
	(0.95)	(0.93)	(1.95)	(2.01)	(1.26)	(1.43)	(1.03)	(0.99)
Female non-head/spouse	-0.010	0.011	0.016	0.021	-0.049+	-0.034	-0.015	-0.013
	(0.15)	(0.15)	(0.48)	(0.66)	(1.90)	(1.33)	(0.92)	(0.83)
Elderly mortality								
Elderly males	-0.314**	-0.315**	-0.113**	-0.114**	-0.061+	-0.062+	-0.009	-0.007
	(3.68)	(3.67)	(3.01)	(3.00)	(1.82)	(1.82)	(0.50)	(0.39)
Elderly females	-0.029	-0.033	-0.011	-0.012	0.033	0.030	0.025	0.026
	(0.29)	(0.34)	(0.20)	(0.21)	(0.83)	(0.77)	(1.13)	(1.16)
Chronically ill PA adults (=1)	0.010	0.013	-0.010	-0.009	0.003	0.003	-0.008	-0.009
	(0.29)	(0.36)	(0.57)	(0.52)	(0.24)	(0.26)	(1.07)	(1.12)
1999 HIV Prevalence rate	-0.070*	-0.070*	-0.029+	-0.029+	0.000	0.000	-0.018*	-0.018*
	(2.18)	(2.15)	(1.71)	(1.70)	(0.05)	(0.07)	(2.14)	(2.21)
Pre-death household characteristics in 2000								
Poverty status (1=non-poor, 0=poor)	-0.131**	-0.118**	-0.061**	-0.051**	-0.030**	-0.026*	0.013*	0.015*
	(4.64)	(3.98)	(4.20)	(3.39)	(2.94)	(2.41)	(2.45)	(2.55)
Landholding size (Ha)	-0.029**	-0.028**	-0.018**	-0.019**	-0.003	-0.002	-0.001	-0.001
	(5.81)	(5.45)	(6.20)	(5.98)	(1.43)	(1.01)	(0.53)	(0.37)
Effective dependency ratio(number)	0.003	0.002	0.004	0.005	-0.006	-0.005	-0.001	0.000
	(0.21)	(0.18)	(0.63)	(0.70)	(1.33)	(1.23)	(0.42)	(0.02)
PA death by 2000 poverty status								
Male heads/spouses*poverty status		-0.385*		-0.297**		0.029		-0.006
		(1.97)		(2.80)		(0.50)		(0.16)
Female heads/spouses*poverty status		-0.021		-0.021		-0.018		-0.001
		(1.13)		(0.25)		(0.30)		(0.02)
Other adult males*poverty status		-0.305*		-0.114		-0.035		-0.037
		(2.11)		(1.46)		(0.67)		(1.29)

Table 13 cont'd

Other adult females*poverty status		-0.010		-0.027		-0.105*		-0.008
		(0.60)		(0.43)		(2.03)		(0.25)
PA death by 2000 land holding size								
Male heads/spouses*land size		0.050+		-0.024		0.013		-0.003
		(1.67)		(1.55)		(1.43)		(0.61)
Female heads/spouses*land size		-0.026		-0.020		-0.001		-0.002
		(1.14)		(1.05)		(0.11)		(0.18)
Other adult males*land size		0.010		0.008		-0.003		-0.002
		(0.55)		(0.70)		(0.51)		(0.24)
Other adult females*land size		-0.009		0.003		-0.013+		-0.001
		(0.52)		(0.42)		(1.68)		(0.31)
PA death by 2000 dependency ratio								
Male heads/spouses*dependency ratio		-0.184		-0.106*		-0.014		0.019
		(1.46)		(2.12)		(0.45)		(1.09)
Female heads/spouses* dependency ratio		0.036		-0.009		-0.002		0.007
		(0.32)		(0.13)		(0.03)		(0.22)
Other adult males* dependency ratio		0.030		0.005		-0.025		-0.021+
		(0.40)		(0.13)		(1.52)		(1.82)
Other adult females* dependency ratio		0.012		-0.001		0.026		-0.014
		(0.23)		(0.03)		(1.38)		(1.25)
Province x time dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	1.562*	1.545*	0.542	0.531	0.034	0.027	0.551*	0.553*
	(2.43)	(2.39)	(1.43)	(1.41)	(0.38)	(0.29)	(2.15)	(2.20)
Joint tests								
Prime-age mortality	1.52	2.04+	3.09*	3.85**	1.68	1.17	1.39	1.11
Elderly mortality	6.87**	6.86**	4.59*	4.46*	1.90	1.86	0.78	0.77
Poverty status*prime-age mortality		6.50**		5.78**		2.74*		1.56
Land size*prime-age mortality		1.53		1.12		1.49		0.24
Effective dependency ratio*PA mortality		0.49		0.95		1.33		1.11
R-squared	0.21	0.21	0.22	0.22	0.26	0.26	0.18	0.18
Number of observations	5304							

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. [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 fruits.

Table 14: The impact of PA mortality on cultivated land by gender and position in household by poverty status

Covariates	Δ ln(Area cultivated)		Change in natural log of area under (ha): Cereals[a]		Tubers and root crops[b]		high-value crops[c]	
	Poor	Non Poor	Poor	Non Poor	Poor	Non Poor	Poor	Non Poor
Prime-age (PA) adult mortality								
Male head/spouse	-0.060	-0.328*	-0.010	-0.248**	-0.044	0.008	-0.031**	-0.058
	(0.48)	(2.13)	(0.16)	(2.62)	(1.01)	(0.22)	(2.66)	(1.33)
Female head/spouse	-0.112	0.122	-0.054	-0.071	-0.017	-0.017	0.001	-0.009
	(0.96)	(1.06)	(1.16)	(0.85)	(0.41)	(0.37)	(0.10)	(0.19)
Male non-head/spouse	0.047	-0.205*	-0.051	-0.124*	0.057	-0.000	0.010	-0.034
	(0.38)	(2.16)	(0.84)	(2.10)	(1.36)	(0.01)	(0.67)	(1.08)
Female non-head/spouse	0.113	-0.046	0.044	-0.007	0.034	-0.086*	0.014	-0.025
	(0.97)	(0.59)	(0.99)	(0.14)	(0.78)	(2.53)	(0.81)	(0.90)
Elderly mortality								
Elderly males	-0.601**	-0.110	-0.206**	-0.069	-0.145**	0.002	0.001	-0.015
	(4.33)	(0.91)	(3.50)	(1.15)	(2.80)	(0.05)	(0.05)	(0.45)
Elderly females	-0.218	0.038	-0.061	0.003	-0.008	0.052	-0.013	0.056
	(1.37)	(0.27)	(0.84)	(0.03)	(0.13)	(1.07)	(1.33)	(1.25)
Chronically ill adults (=1, 0 otherwise)	0.079	-0.061	0.022	-0.030	0.009	-0.006	0.004	-0.019
	(1.44)	(1.26)	(0.95)	(0.99)	(0.42)	(0.36)	(0.67)	(1.34)
Constant	1.054**	0.045	-0.390	-0.075	0.000	-0.022	1.131**	0.210+
	(6.04)	(0.22)	(0.34)	(0.50)	(0.65)	(0.53)	(8.81)	(1.82)
Province x time dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Joint tests for								
Prime-age mortality	0.54	2.77*	0.73	3.06	0.90	1.67	2.24+	1.02
Elderly mortality	10.50**	0.43	6.55**	0.66	3.94*	0.59	0.89	0.87
R-squared	0.26	0.26	0.26	0.26	0.30	0.33	0.39	0.20
Number of observations	2651	2654	2651	2654	2651	2654	2651	2654

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.

significant, death of other males and females seems to induce a shift from cereals to roots and tubers

The interaction terms between PA mortality variables and EDR as well as mortality and landholding size in 2000 are not jointly significant, suggesting that there are no differential impacts of PA death by initial dependency ratio or land holding size. In all cases only the coefficient on male head/spouse death is statistically significant on changes of area under cereals and total land cultivated, respectively. The interaction term between male heads/spouses death and EDR in 2000 is negative implying that among households with higher EDR in 2000, male head of household death results in a larger decline in area under cereals compared to similar households that had lower EDR in 2000. In contrast, the interaction term on landholding size in 2000 and male head/spouse death is positive implying that among households with larger landholding sizes, male head of household death results in slightly less decline in land cultivated compared to households in similar situations but having smaller landholding sizes in 2000. For example, among households with landholdings in the 75th percentile and incurring mortality of male head/spouse, total land size declined by 50% compared to 64% among similar households but with land sizes in the 25th percentile. This result is surprising, because *a priori* we would expect the reverse to happen. This would mean that remaining household members are switching to other non-farm activities because of the departure of the core person responsible for the farm enterprise. We empirically check this fact later in the paper when we look at impact of mortality on off-farm income.

Crop production

Ex ante afflicted households had higher gross value of output and gross value of crop output per hectare for the crop season 1999/2000 compared to non-afflicted households. Generally, households incurring prime-age death between 2001 and 2004 experienced a decline in gross value of crop production and gross value of crop output per hectare (table A1 in the appendix).[24] Due to large standard errors, the difference-in-difference descriptive statistics were not statistically significant even at the 10% level. Unlike in the Kenyan study where gross value of crop output was observed to go down significantly due to a switch to high value crops, our findings show a slight decrease.

Table 15 presents the regression results from models measuring impact of PA death on 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.

We get similar results from models measuring the impact of PA mortality on gross output per hectare except for the statistically insignificant but positive impact among households experiencing male head of household death. Although insignificant, this result is surprising because there is no evidence to suggest that these households shifted to high value crops and, in

[24] There values are calculated by summing up the product of gross quantity harvested and mean prices between 1999/2000 and 2003/2004 seasons after first reflating the prices in 2000/01 to 2003/2004 prices.

Table 15: The impact of PA mortality on gross value of output and gross output per hectare by gender and position in household

Covariates	Δ ln(Gross value of output)				Δ ln(Gross value of output/ha)			
	-----------Full sample----------		Poor	Non poor	--------Full sample------		Poor	Non poor
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)
Prime-age (PA) adult mortality								
Male	-0.106				-0.007			
	(1.52)				(0.12)			
Female	-0.070				-0.027			
	(1.07)				(0.44)			
Male head/spouse		-0.119	-0.175	-0.042		0.085	-0.118	0.292*
		(1.03)	(1.07)	(0.23)		(0.84)	(0.76)	(2.16)
Female head/spouse		-0.038	0.034	-0.047		-0.016	0.168	-0.165
		(0.41)	(0.24)	(0.36)		(0.17)	(1.22)	(1.23)
Male non-head/spouse		-0.113	0.032	-0.267*		-0.061	-0.089	-0.060
		(1.32)	(0.24)	(2.21)		(0.77)	(0.66)	(0.57)
Female non-head/spouse		-0.079	-0.042	-0.057		-0.030	-0.116	-0.012
		(0.94)	(0.26)	(0.55)		(0.40)	(0.78)	(0.14)
Elderly mortality								
Elderly males	-0.090	-0.090	-0.241	0.017	0.200*	0.203*	0.311*	0.123
	(0.89)	(0.88)	(1.45)	(0.12)	(2.38)	(2.42)	(2.20)	(0.98)
Elderly females	-0.042	-0.041	-0.031	-0.086	-0.025	-0.022	0.112	-0.129
	(0.40)	(0.39)	(0.17)	(0.68)	(0.26)	(0.22)	(0.69)	(0.99)
Chronically ill PA adults (=1)	-0.057	-0.057	-0.086	-0.038	-0.073+	-0.072+	-0.170**	0.018
	(1.44)	(1.43)	(1.32)	(0.70)	(1.86)	(1.83)	(2.67)	(0.34)
Constant	0.261	0.261	0.351	0.252	0.140	0.142	-0.703**	0.207
	(1.26)	(1.26)	(1.62)	(1.10)	(0.54)	(0.55)	(1.03)	(0.74)
Province x time dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
F-test on prime-age mortality	2.30+	1.30	0.37	1.59	0.16	0.50	0,77	1.45
R-squared	0.15	0.15	0.22	0.23	0.21	0.21	0.27	0.27
Number of observations	5305	5305	2651	2654	5305	5305	2651	2654

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.

fact, land cultivated declined by a larger percentage among households incurring male head of household death.

Does the impact on crop production differ by initial household conditions?

We test for potential differential impacts by initial household conditions by estimating models with interactions of PA mortality with household wealth status, land holding size and effective dependency ratios in 2000. Table 16 column B shows that PA mortality impact on gross value of output does not differ by initial poverty status. In contrast, the impact of male head of household death on gross value of output per hectare seems to be influenced by initial poverty status (column D). The statistically significant positive interaction term on male head death and poverty status implies that among wealthier households, gross value of crop production increases more than in assets-poor households experiencing the same shock. For example, evaluating the impact of male head death on gross value of output per hectare at mean land size, mean effective dependency ratio, we find that output per hectare went up by 42% in wealthier households experiencing male head death compared to a 13% 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, earlier we found that wealthier households incurring male head of household death attract boys and other males suggesting labor lost from male head of household is taken up by boys and/or other males. It is beyond the scope of this paper to analyze agricultural intensification that may occur due to PA mortality. We find similar results when the sample is stratified into two groups by value of assets in 2000. Table 16 column D shows a statistically significant positive (29%) impact on gross value of crop production per hectare among households with male head of household death. Death of other males results in a reduction of gross value of output per hectare of 26% (column D). This decline could be explained in two ways. *First*, it could be because of labor shortage due to the death of other male PA adults. Earlier, in section 4.4, we found that mortality of other males resulted in a reduction in the number of young girls who might have provided extra farm labor. *Second*, other male members may possess extra knowledge and farming skills that are lost when they die. The rest of the impacts of mortality by gender and position of the deceased on gross value of output and gross value of output per hectare are not statistically significant.

Turning to the likely impact of PA mortality by initial land holding size, results in table 16 show some statistically significant differential impacts on gross value of output due to male head death and on gross value of crop output per head due to either male and female head or spouse death. The negative coefficient on the interaction of male head death and land holding size implies that among households with larger landholdings and death of male head, gross value of output decreases more compared to similar households but with small initial land holdings. Evaluated at mean effective dependency ratio and mean wealth status, we find that gross value of output decreased by 41.4 % among households with land holding sizes in the 75th percentile and having a male head of household death compared to 20.2% in similar households but having land holding sizes in the 25th percentile.

Table 16: The impact of PA mortality on crop output and output per hectare, by gender and position in household

Covariates	Change in natural log of:			
	Gross value of output		Gross value of output/ha)	
	(A)	(B)	(C)	(D)
Prime-age (PA) adult mortality				
Male head/spouse	-0.092	-0.131	0.171	0.184+
	(0.75)	(1.23)	(1.58)	(1.86)
Female head/spouse	-0.002	0.069	0.004	0.087
	(0.02)	(0.69)	(0.04)	(0.87)
Male non-head/spouse	-0.115	-0.101	-0.061	-0.060
	(1.38)	(1.18)	(0.79)	(0.74)
Female non-head/spouse	-0.045	-0.029	-0.011	-0.018
	(0.53)	(0.32)	(0.15)	(0.22)
Elderly mortality				
Elderly males	-0.092	-0.085	0.202*	0.207*
	(0.91)	(0.84)	(2.40)	(2.46)
Elderly females	-0.024	-0.026	-0.021	-0.018
	(0.23)	(0.25)	(0.21)	(0.18)
Chronically ill PA adults (=1)	-0.058	-0.055	-0.072+	-0.072+
	(1.45)	(1.37)	(1.84)	(1.82)
1999 HIV Prevalence rate	-0.098**	-0.097**	-0.045+	-0.045+
	(3.51)	(3.53)	(1.80)	(1.78)
Pre-death household characteristics in 2000				
Poverty status (1=non-poor, 0=poor)	-0.103**	-0.095**	0.025	0.019
	(3.11)	(2.77)	(0.80)	(0.57)
Landholding size (Ha)	-0.036**	-0.035**	-0.009	-0.008
	(6.47)	(6.00)	(1.61)	(1.39)
Effective dependency ratio(number)	0.004	0.002	0.002	0.002
	(0.26)	(0.17)	(0.13)	(0.14)
PA death by 2000 poverty status				
Male heads/spouses*poverty status		0.159		0.557**
		(0.69)		(3.18)
Female heads/spouses*poverty status		-0.153		-0.337+
		(0.84)		(1.80)
Other adult males*poverty status		-0.269		0.109
		(1.54)		(0.66)

Table 16 cont'd

Other adult females*poverty status		-0.033		0.014
		(0.18)		(0.09)
PA death by 2000 land holding size				
Male heads/spouses*land size		-0.072*		-0.133**
		(2.42)		(5.20)
Female heads/spouses*land size		0.029		0.051*
		(1.18)		(2.02)
Other adult males*land size		0.005		0.000
		(0.26)		(0.02)
Other adult females*land size		-0.009		-0.002
		(0.50)		(0.09)
PA death by 2000 dependency ratio				
Male heads/spouses*dependency ratio		-0.056		0.074
		(0.41)		(0.65)
Female heads/spouses* dependency ratio		0.178		0.142
		(1.28)		(1.01)
Other adult males* dependency ratio		-0.045		-0.065
		(0.65)		(0.95)
Other adult females* dependency ratio		0.060		0.030
		(0.75)		(0.41)
Province x time dummies	Yes	Yes	Yes	Yes
Constant	2.164**	2.148**	0.911	0.902
	(3.72)	(3.71)	(1.45)	(1.43)
Joint tests				
Prime-age mortality	0.72	0.93	0.77	1.16
Elderly mortality	0.38	0.36	3.11**	3.23**
Poverty status*prime-age mortality		2.86**		2.11*
Land size*prime-age mortality		6.47**		3.72**
Effective dependency ratio*PA mortality		0.59		0.64
R-squared	0.16	0.17	0.21	0.21
Number of observations	5305	5305	5305	5305

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

We obtain somewhat different results on the impact of gross value per hectare. For example, at mean effective dependency ratio and mean wealth status, we find that gross value of output per hectare increased by 2.9% among households with land holding sizes in the 75th percentile and having a male head of household death compared to 41.9% in similar households but having land holding sizes in the 25th percentile.

In the event of female head/spouse death, table 16 column D also shows the impact on gross value of output per hectare is opposite that of male head death. The significant positive coefficient on female head/spouse death and land holding size implies that among households with larger land holdings and death of female head/spouse of the household, the impact on gross value of output per hectare is larger compared to similar households but with small initial land holdings. Evaluated at mean effective dependency ratio and mean wealth status, we find that gross value of output per hectare increased by 31% among households with land holding sizes in the 75th percentile and having a female head/spouse of household death compared to an increase of 16% in similar households but having landholding sizes in the 25th percentile.

The is no evidence for any differential impact of PA death on either gross value of output or gross value of output per hectare by initial (pre-death) effective dependency ratio since all interactions between mortality variables and EDR are statistically insignificant. Also, we fail to reject the null hypothesis that the joint effect of the interaction terms is not statistically different from zero.

4.6 Impact of PA mortality value of livestock and off-farm income

4.6.1 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 can increase households' vulnerability to income shocks, and may decrease household use of cash inputs and animal traction in crop cultivation, which will tend to result in lower productivity and overall crop production (Mather et al., 2004). Due to data limitations, we could not obtain a comparable measure of value of assets between the two surveys, so our focus is limited to value of livestock. In addition we analyze the impact of mortality on non-farm (off-farm) income.

The results in table 17, columns A and B, show that there is a negative impact of PA mortality on value of cattle but the impact by both gender and position in the household of the deceased are not statistically significant except among households experiencing death of a male head of household. Among households experiencing a male head death, values of cattle declined by about 30% 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 does not seem to strongly apply among households incurring male head of household death.

Table 17. The impact of PA mortality on assets and off-farm income by gender and position in household

Covariates	Change in natural log of:					
	Values of cattle		Values of small animals[a]		Off-farm income[b]	
	(A)	(B)	(C)	(D)	(E)	(F)
Prime-age (PA) adult mortality						
Male	-0.300+		-0.298+		-0.017	
	(1.78)		(1.67)		(0.09)	
Female	-0.211		-0.375*		-0.079	
	(1.27)		(2.44)		(0.45)	
Male head/spouse		-0.344+		-0.622*		0.073
		(1.71)		(2.28)		(0.24)
Female head/spouse		-0.080		-0.342+		-0.185
		(0.34)		(1.61)		(0.74)
Male non-head/spouse		-0.250		-0.055		-0.123
		(1.14)		(0.24)		(0.50)
Female non-head/spouse		-0.236		-0.390*		0.047
		(1.06)		(2.16)		(0.20)
Elderly mortality						
Elderly males	-0.225	-0.223	-0.312	-0.323	0.405	0.401
	(0.76)	(0.76)	(1.31)	(1.35)	(1.57)	(1.55)
Elderly females	-0.080	-0.080	-0.008	-0.020	-0.012	-0.010
	(0.26)	(0.26)	(0.03)	(0.08)	(0.04)	(0.03)
Chronically ill PA adults (=1)	-0.059	-0.059	-0.086	-0.090	-0.032	-0.033
	(0.53)	(0.53)	(0.88)	(0.92)	(0.29)	(0.29)
Constant	-1.968	-1.970	0.551*	0.542*	-0.560	-0.555
	(1.61)	(1.61)	(2.01)	(1.99)	(0.77)	(0.77)
Province x time dummies	Yes	Yes	Yes	Yes	Yes	Yes
F-test on mortality	2.55+	1.26	4.53*	2.90*	0.11	0.22
R-squared	0.13	0.13	0.18	0.18	0.35	0.35
Number of observations	5309 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]Small animals include goats, sheep, pigs, chicken, ducks and rabbits. [b]Off-farm income include salary and wage income, informal and formal business income.

Table 17, columns C and D, show the impact of PA mortality on values of small animals. We do find significant impacts of PA mortality on values of small animals among households experiencing both male and female deaths, 29.8% and 37.5%, 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 62% decline, followed by other females' death with a 39% decline, and 34% reduction in values of small animals among households with female head/spouse death. The result on female head or spouse death of a 34% decline in value of small animals is only significant at the 10% level. Generally, these results seem to suggest that afflicted households cope with mortality of males and/or females by selling off small animals.

Does the impact on values of livestock differ by initial household conditions?

Results in table 18, column B, show no evidence of differential impacts of mortality on values of cattle by initial pre-death household characteristics. In contrast, there seem to be differential impacts on values of small animals among households experiencing a male head of household death. Table 18, column D, shows a negative interaction between wealth status and male head death, implying a greater decline in values of small animals among wealthier households experiencing male head death compared to poor households experiencing a similar shock. For example, evaluating the impact on values of small animals at mean land size, mean effective dependency ratio, we find that value of small animals reduced by 72.4% in wealthier households experiencing male head death compared to a 47% decline in assets-poor households.

Off-farm income

Previous studies have suggested that off-farm income sources are at risk among households experiencing PA mortality[25], particularly among those that are asset poor and vulnerable to begin with. In this section we test the hypothesis that a reduction in PA adults due to prime-age mortality results in a reduction of off-farm income. Unfortunately, the results in table 17, columns D and E, show mixed results that are not statistically significant for all cases of mortality by gender and position in the household of the deceased.

Turning to differential impacts by initial household characteristics, table 18, column E, shows that there seem to be differential impacts by initial effective dependency ratio and by landholding size in households experiencing female head or spouse death. The statistically significant negative interaction between pre-death EDR in 2000 and female head/spouse death implies that there is a greater decline in off-farm income among households with higher EDR in 2000 and experienced female head or spouse death compared to households experiencing a similar shock but having lower EDR in 2000. Evaluated at mean land holding size and mean wealth status, we find that off-farm income decreased by 9.71% among households with EDR in the 75th percentile and having a female male head or spouse of household death compared to an increase of 9.37% in similar households but having EDR in the 25th percentile.

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

Table 18: The impact of PA mortality on assets and off-farm income by initial household pre-death characteristics

Covariates	Change in natural log of:					
	Values of cattle		Values of small animals[a]		Off-farm income[b]	
	(A)	(B)	(C)	(D)	(E)	(F)
Prime-age (PA) adult mortality						
Male head/spouse	-0.409+	-0.340+	-0.725**	-0.770**	0.044	0.033
	(1.69)	(1.70)	(2.81)	(2.84)	(0.14)	(0.10)
Female head/spouse	-0.043	0.031	-0.302+	-0.171	-0.160	-0.473+
	(0.18)	(0.12)	(1.82)	(1.65)	(0.63)	(1.70)
Male non-head/spouse	-0.258	-0.263	-0.068	-0.051	-0.111	-0.125
	(1.17)	(1.19)	(0.32)	(0.23)	(0.45)	(0.52)
Female non-head/spouse	-0.202	-0.185	-0.331+	-0.307	0.093	0.108
	(0.92)	(0.88)	(1.91)	(1.63)	(0.40)	(0.47)
Elderly mortality						
Elderly males	-0.212	-0.220	-0.298	-0.288	0.394	0.373
	(0.73)	(0.75)	(1.27)	(1.22)	(1.53)	(1.45)
Elderly females	-0.060	-0.067	0.024	0.028	0.002	-0.017
	(0.20)	(0.22)	(0.09)	(0.11)	(0.01)	(0.06)
Chronically ill PA adults (=1)	-0.064	-0.062	-0.093	-0.089	-0.034	-0.028
	(0.58)	(0.56)	(0.97)	(0.93)	(0.30)	(0.25)
1999 HIV Prevalence rate	0.046	0.048	-0.082	-0.082	-0.356**	-0.354**
	(0.46)	(0.49)	(1.25)	(1.25)	(3.96)	(3.95)
Pre-death household characteristics in 2000						
Poverty status (1=non-poor, 0=poor)	-0.859**	-0.849**	-0.230**	-0.186**	-0.298**	-0.287**
	(9.42)	(8.82)	(15.54)	(14.42)	(3.21)	(2.96)
Landholding size (Ha)	0.043**	0.041*	0.052**	0.052**	-0.036*	-0.042*
	(2.74)	(2.48)	(4.47)	(4.17)	(2.08)	(2.36)
Effective dependency ratio(number)	0.031	0.021	0.003	0.002	0.040	0.041
	(0.80)	(0.53)	(0.09)	(0.06)	(1.11)	(1.10)
PA death by 2000 poverty status						
Male heads/spouses*poverty status		0.148		-0.254+		0.580
		(0.28)		(1.65)		(0.90)
Female heads/spouses*poverty status		0.213		-0.643		0.148
		(0.45)		(1.26)		(0.29)
Other adult males*poverty status		-0.297		-0.489		-0.172
		(0.63)		(1.07)		(0.36)

Table 18 cont'd

Other adult females*poverty status		-0.245		-0.024		-0.434
		(0.58)		(0.06)		(0.94)
PA death by 2000 land holding size						
Male heads/spouses*land size		0.051		0.098		0.023
		(0.62)		(1.26)		(0.21)
Female heads/spouses*land size		-0.104		0.011		0.191*
		(1.23)		(0.15)		(2.03)
Other adult males*land size		0.020		-0.004		0.062
		(0.40)		(0.09)		(0.71)
Other adult females*land size		0.038		-0.013		0.012
		(0.69)		(0.27)		(0.19)
PA death by 2000 dependency ratio						
Male heads/spouses*dependency ratio		0.095		-0.001		-0.277
		(0.39)		(0.00)		(0.82)
Female heads/spouses* dependency ratio		0.365		0.432		-0.159**
		(1.10)		(1.10)		(2.91)
Other adult males* dependency ratio		0.136		-0.102		0.251
		(0.76)		(0.46)		(1.63)
Other adult females* dependency ratio		0.063		-0.034		0.075
		(0.30)		(0.18)		(0.34)
Province x time dummies	Yes	Yes	Yes	Yes	Yes	Yes
Constant	-2.192	-2.225	2.751*	2.719*	5.758**	5.736**
	(0.80)	(0.81)	(2.19)	(2.17)	(2.90)	(2.89)
Joint tests						
Prime-age mortality	1.42	0.97	3.28*	2.86*	1.55	1.18
Elderly mortality	0.26	0.29	0.71	0.65	0.19	0.84
Poverty status*prime-age mortality		10.26**		28.24**		1.05
Land size*prime-age mortality		1.67+		3.70**		1.71
Effective dependency ratio*PA mortality		0.93		0.30		1.47
R-squared	0.14	0.14	0.22	0.22	0.35	0.35
Number of observations						

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]Small animals include goats, sheep, pigs, chicken, ducks and rabbits. [b]Off-farm income include salary and wage income, informal and formal business income.

Table 19: The impact of PA mortality on assets and off-farm income by gender and position in household by poverty status

Covariates	Change in natural log of:					
	Values of cattle		Values of small animals[a]		Off-farm income[b]	
	Poor	Non Poor	Poor	Non Poor	Poor	Non Poor
Prime-age (PA) adult mortality	(A)	(B)	(C)	(D)	(E)	(F)
Male head/spouse	-0.296	-0.666	-0.352	-0.120**	-0.181	0.802
	(1.26)	(1.18)	(1.02)	(2.60)	(0.52)	(1.37)
Female head/spouse	0.010	0.145	0.229	-0.503	-0.258	-0.183
	(0.04)	(0.34)	(0.59)	(1.43)	(0.67)	(0.48)
Male non-head/spouse	-0.136	-0.394	0.155	-0.163	-0.167	-0.210
	(0.56)	(1.02)	(0.47)	(0.56)	(0.51)	(0.54)
Female non-head/spouse	-0.328	-0.376	-0.028	-0.246	0.442	0.041
	(1.31)	(1.15)	(0.08)	(1.23)	(1.28)	(0.13)
Elderly mortality						
Elderly males	0.046	-0.621	-0.479	-0.338	0.290	0.589
	(0.16)	(1.20)	(1.15)	(1.09)	(0.83)	(1.48)
Elderly females	0.181	-0.439	-0.049	0.098	0.509	-0.089
	(0.50)	(0.92)	(0.12)	(0.33)	(1.42)	(0.18)
Chronically ill adults (=1, 0 otherwise)	0.005	-0.270	-0.018	-0.168	0.177	-0.156
	(0.04)	(1.34)	(0.12)	(1.25)	(1.12)	(0.91)
Constant	0.000	-2.006	-2.708**	0.760**	0.000	-0.595
	(0.00)	(1.50)	(8.44)	(4.13)	(0.02)	(0.75)
Province x time dummies	Yes	Yes	Yes	Yes	Yes	Yes
Joint tests for						
Prime-age mortality	1.00	1.16	1.99+	2.65*	0.91	0.63
Elderly mortality	0.14	1.25	0.40	0.62	0.62	1.10
R-squared	0.30	0.20	0.28	0.24	0.45	0.35
Number of observations	2651	2654	2651	2654	2651	2654

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]Small animals include goats, sheep, pigs, chicken, ducks and rabbits. [b]Off-farm income include salary and wage income, informal and formal business income.

In contrast, the interaction between interaction between landholding size in 2000 and female head/spouse death is statistically significant and positive implying that there is a smaller decline in off-farm income among households who had bigger landholding in 2000 and experienced female head or spouse death compared to households experiencing a similar shock but having smaller landholdings in 2000. Evaluated at mean EDR and mean wealth status, we find that off-farm income increased by 15.35% among households with landholdings in the 75th percentile and having a female male head or spouse of household death compared to a decrease in off-farm income of 40.8% in similar households but having landholdings in the 25th percentile. This result suggests that the deceased female head was central in sourcing income off the farm among households with limited land resources. However, their death result in a significant decline in off-farm income

5.0 CONCLUSIONS AND POLICY IMPLICATIONS

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 measure 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 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, we controlled for initial poverty status, landholding size, effective dependency ratio, and the gender and position of the deceased person. Moreover, we take into account the possibility that prime-age adult death in the household is endogenous.

The study highlights 10 main findings. *First*, 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 and not endogenous after differencing out the time-invariant unobserved household characteristics. These findings offer some support for the estimates of earlier studies using fixed effects, random effects or difference-in-difference (but which didn't explicitly test for endogeneity). Since there are very few, if any, other studies examining the endogeneity of prime-age mortality when measuring household outcomes, there is need for further research to test whether controlling for time-invariant unobservables through differencing the household panel data adequately accounts for the likely endogeneity of household mortality.

Second, based on the difference models, the study reports the impact of premature prime-age mortality on rural households' welfare. We find that, 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 most adults are considered to make important contributions to their families, both materially, in their roles as nurturers and teachers, and in less tangible ways, it is likely that the most severe economic effects would 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 than often suggested in the conceptual literature on this topic.

Third, irrespective of gender and/or position in the household of the deceased person, household size declines by less than one member. This indicates that households are to some extent successful in replenishing their household sizes after the death of a household member, though the net impact on labor productivity is most likely negative. However, households' initial poverty levels affect the relationship between a prime-age death and changes in household composition. For example, among households experiencing a male head death, we find that household size changes by -0.093 in non-poor households compared to -0.712 in poorer households. Poorer households have substantially greater difficulties in coping with the death of core male household members while non-poor households 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 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, especially in 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.

Fourth, both prior to households' experiencing adult mortality and after, the effective dependency ratios of afflicted households are roughly equal to those of non-afflicted households. Actually, households incurring prime-age female death (heads/spouses and other females) between 2001 and 2004 experienced a *decline* in mean effective dependency ratio in 2001 of 0.16 and 0.35, respectively, suggesting that households are partially able to adjust dependency ratios, by attracting older girls into the household with initial high EDR to assist in caring for other children, the elderly or the sick when other females die. Despite the fact that women in households experiencing death may well face increased demands on their time for domestic tasks and crop production, our results indicate that the relative burden of dependents in relation to healthy adults is not much different for non-afflicted and afflicted households.

Fifth, the effects of PA mortality on farm production were also sensitive to the gender and position in the household of the deceased. For example, death of a PA male resulted in an 11% decline in total land cultivated whilst death of a PA female resulted in a 3% decline of cultivated land. The death of male heads/spouses resulted in a 20% reduction in land cultivated. All the other mortality categories are negative but not statistically significant. This finding appears to be consistent with the findings above 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. We also find that land cultivated and area under cereals decline more in relatively non-poor households than poor households after the death of a male household head. These results seem to suggest that despite the fact that the death of productive members may result into a reduction in the total cultivated land, the position and gender of the deceased member matters.

Sixth, 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 switch to these less labor-intensive crops than non-afflicted households. While many have identified HIV/AIDS as the cause of recent shifts in area cultivated from maize to less labor-intensive root and tuber cultivation in Zambia as well as other parts of southern Africa, it is important to acknowledge that 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. The potential for such national and/or regional cropping trends exemplifies the importance of investigating cropping patterns of afflicted households in comparison with the non-afflicted population. 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). 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%. 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, who would benefit from these technologies, who has effective access to new technologies, and which technologies promote efficiency of allocation of public resources across sectors.

Seventh, 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 poor households experiencing the death of a male household head. Gross value of output actually increased by 42% in wealthier households experiencing male head/spouse death (admittedly a finding that is hard to explain) whilst among poorer households gross value of crop production declined by 13%. There is evidence to suggest that wealthier households incurring male head-of-household death attract boys and other males to join the household. Also, since there was a net decline in land cultivation among both poor and non-poor households due to male head death, these results seem to suggest greater agricultural intensification in wealthier households experiencing male head death. 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.

Eighth, our results indicate that initial landholding size greatly influences the change in the value of crop output due to male head death (and on gross value of crop output per head due to either male and female head or spouse death). Evaluated at mean effective dependency ratio and mean wealth status, we find that gross value of output decreased by 41.4 % among households with land holding sizes in the 75^{th} percentile and having a male head of household death compared to 20.2% in similar households but having land holding sizes in the 25^{th} percentile.

Nineth, 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 to mitigate the impact of PA death. The sale or liquidation of livestock as a means of coping with illness and death of prime-age adults is costly in the short-term and may also compromise the household's future livelihood (Stokes, 2003). Another possible explanation why the results show a significant decline in cattle assets among households experiencing male head-of-household mortality is that property of the deceased man (including cattle) is often redistributed to surviving relatives. Cattle assets are not only a stock of wealth but are also an input into agricultural production (through draft power for land preparation) which in some cases raises the average product of other inputs such as fertilizer (Xu et al., 2005). Therefore, in order to support the food security and farm productivity of households afflicted by male head mortality, 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 cultural changes that empower widows who need not be pushed into poverty further by assets redistribution after their husband's death. Also, programs such as the 'Heifer project' may need to be targeted to poor households and especially households with male head of household death.

Tenth, 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 those with lower initial dependency ratio.

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, the results show that 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 in 2000. Overall, these findings suggest that poorer households headed by HIV/AIDS widows are in especially precarious positions.

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 full long-run effects of prime-age adult death. This would entail tracking affected households over a long time frame.

Also, the situation in which a relatively small percentage of households incur 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. This study and most prior household-level panel studies, using difference-in-difference, household fixed-effects, or random-effects models, have measured the effects of mortality *in afflicted households* on differenced household-level outcomes, typically over a 2–5 year time frame, compared to differenced outcomes on non-afflicted households. Yet 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. In communities hard-hit by HIV/AIDS, households not directly incurring a death may nevertheless be affected by taking in orphans, losing access to resources owned by kin-related “afflicted” households, intra-household resource transfers to afflicted households, and broader effects of high mortality rates on communities’ economic and social structures. Future studies may need measure the effects of mortality on rural welfare other than at the household level.

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APPENDICES

Appendix 1:

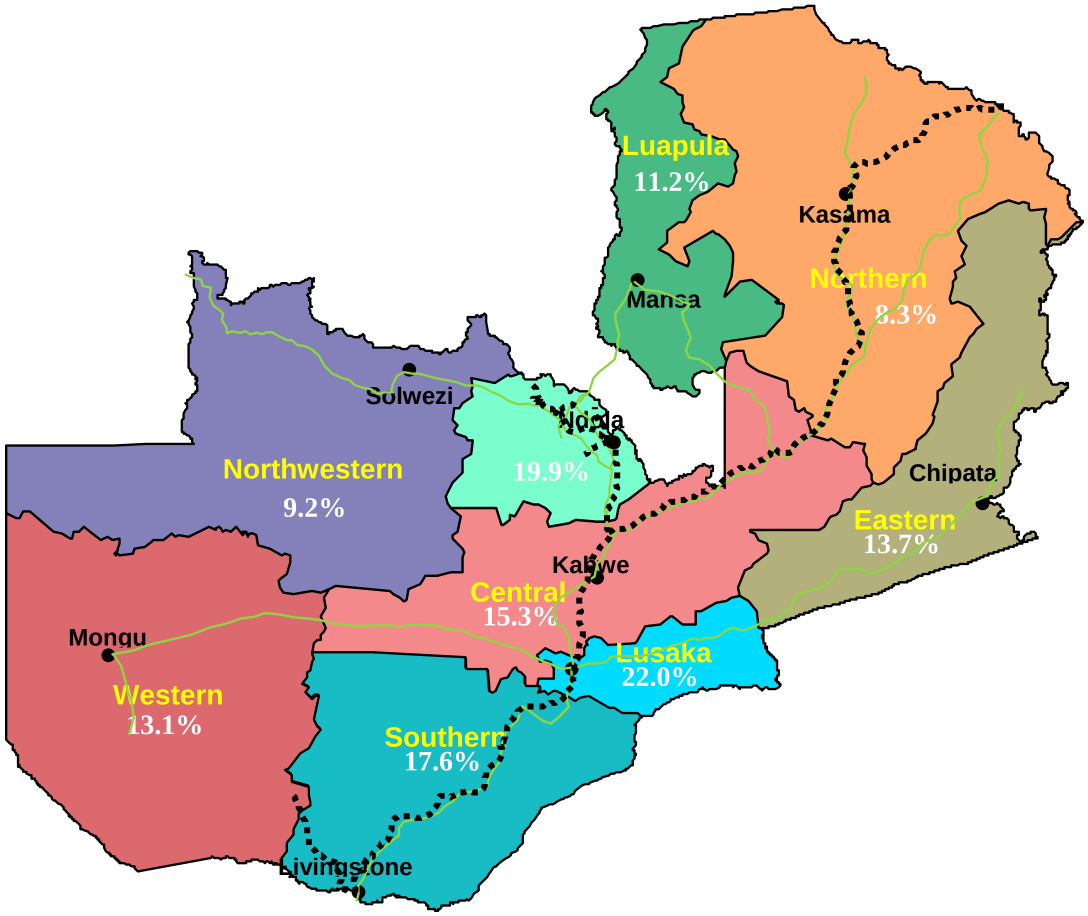

Figure 1. Zambia's HIV Prevalence Rates, by Province, 2001-2002.

Source: Zambia Demographic and Health Survey, 2001-02. Preliminary Report, Washington: Measure\ DHS+ ORC Macro, 2001-02 referenced in "Prosperity, Hope and Better Health for Zambians" USAID, 2004.

Appendix 2:

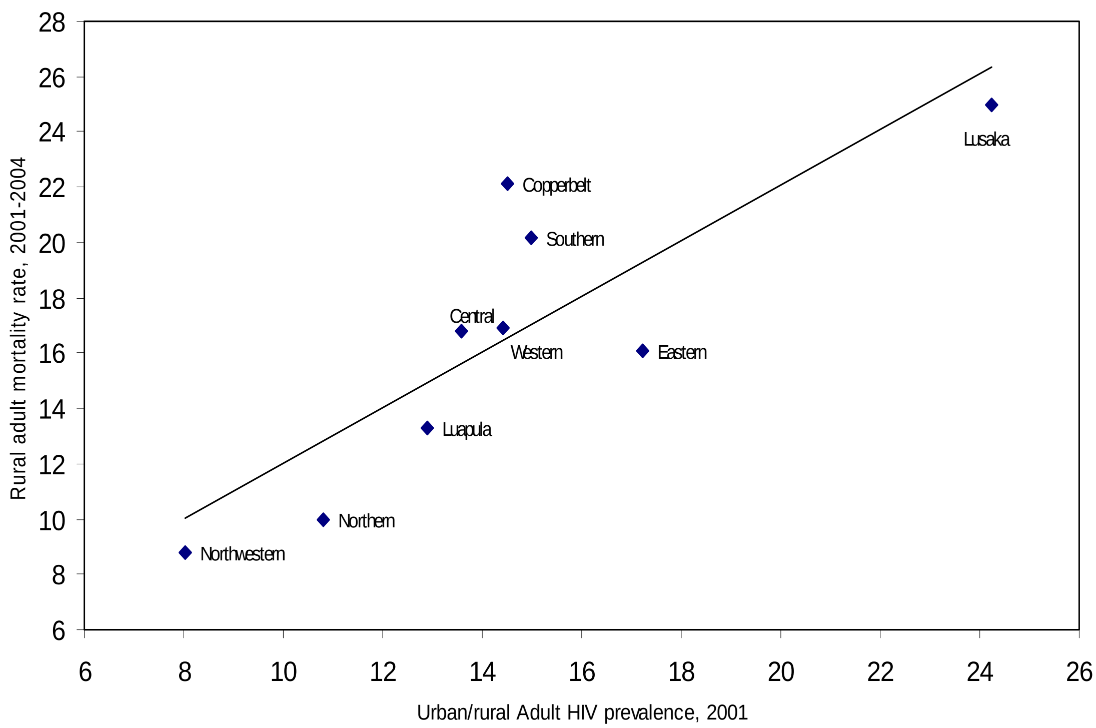

Figure2. Correlation between Provincial adult mortality rates from CSO 2001 and 2004 household survey data and 2001 HIV + Prevalence Rates, Zambia.

Notes: Pearson correlation coefficient is 0.84.

Sources: Adult mortality rates derived from the 2001 and 2004 household surveys. HIV+ prevalence rates are from 2001 Sentinel Surveillance Site information published by CSO, MoH and Macro International, 2003 .

Table A1: Mean values by year and whether household is afflicted or non-afflicted

	Non Afflicted HH		HH with PA death		HH with male death		HH with female death	
	99/00	0304	99/00	0304	99/00	0304	99/00	0304
	----------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 A2: Mean values by year and whether household is afflicted or non-afflicted

	2001	2004	2001	2004	2001	2004	2001	2004	2001	2004
	Non Afflicted HH		HH with male head death		HH with female head or spouse death		HH with other male death		HH with other female death	
	----------------------------------Mean value -------------------------------------									
Household composition										
Effective dependency ratio	1.33	0.99	1.19	0.98	1.00	0.84	1.38	0.97	1.37	1.04
Household size	5.97	5.88	6.07	5.19	6.64	5.69	7.82	6.67	7.72	6.95
Male	1.57	1.83	1.69	1.27	1.82	2.09	2.42	2.25	2.02	2.33
Female	1.62	1.86	1.71	2.04	2.06	1.68	2.21	2.39	2.52	2.36
Boys	1.34	1.08	1.23	0.93	1.36	0.91	1.50	1.08	1.54	1.13
Girls	1.43	1.10	1.44	0.96	1.40	1.02	1.69	0.95	1.64	1.12
Farm production										
Land cultivated	1.91	1.75	1.95	1.28	2.14	1.82	2.37	2.00	2.35	1.98
Cereals	1.38	1.23	1.44	0.93	1.61	1.30	1.89	1.46	1.72	1.51
Tubers	0.46	0.39	0.44	0.28	0.38	0.32	0.35	0.36	0.51	0.28
High value crops	0.07	0.13	0.07	0.06	0.15	0.20	0.12	0.18	0.12	0.20
Gross value of output ('000 Zkw)	1383.4	1445.2	1246.5	994.1	1387.1	1207.8	1666.5	1493.2	1577.5	1503.8
Gross value of output per ha ('000 Zkw)	927.6	850.9	826.2	836.0	818.9	719.7	777.7	725.3	771.4	739.0
Land cultivated/adult equivalents ratio	0.65	0.64	0.60	0.68	0.67	0.75	0.59	0.63	0.68	0.63
Assets and off-farm income										
Values of cattle ('000 Zkw)	766.5	1379.2	555.2	332.2	549.5	1014.9	2085.1	2028.5	2191.5	2479.4
Values of small animals ('000 Zkw)	127.3	178.5	107.8	89.1	142.8	152.3	153.0	188.7	167.3	204.9
Off farm income ('000 Zkw)	991.0	1040.3	1123.2	1590.1	2167.0	1432.1	1140.0	747.1	1034.5	1334.5
Percent with off farm income	62.8	51.1	67.0	59.3	73.0	63.9	59.3	47.9	61.9	48.5
Wealth status in 2000 (% non poor)	50.3		58.2		49.2		44.9		37.6	

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

Table A3: Descriptive statistics: right hand variables of impact models

Variables	Full sample				Poor				Non poor			
		Percentile				Percentile				Percentile		
	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
Current chronically ill adults (=1)	0.126	-	-	-	0.128	-	-	-	0.124	-	-	-
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

Table A4: Correlation matrix: First stage regressions variables

	pdeath	a2s94	a3s94	a4s94	a5s94	a6s94	a7s94	a8s94	a9s94	eldmdth	eldfdth	cill	away	hiv	astpov	lhold	depr
pdeath	1.00																
a2s94	0.02	1.00															
a3s94	0.04	0.03	1.00														
a4s94	0.01	0.06	0.03	1.00													
a5s94	0.00	0.05	0.05	0.02	1.00												
a6s94	0.02	0.00	0.03	0.02	0.06	1.00											
a7s94	0.01	0.01	0.03	0.00	0.00	0.01	1.00										
a8s94	0.00	0.01	0.05	0.00	0.00	0.00	0.00	1.00									
a9s94	0.01	0.05	0.01	0.00	0.00	0.00	0.00	0.00	1.00								
eldmdth	0.03	0.01	0.01	0.02	0.01	-0.01	-0.01	-0.01	-0.01	1.00							
eldfdth	0.02	0.00	-0.01	-0.01	0.00	-0.01	-0.01	-0.01	0.00	0.02	1.00						
cill	0.04	0.02	0.02	0.02	0.00	0.02	0.01	0.00	0.00	0.03	0.03	1.00					
away	0.06	0.02	0.05	0.01	0.01	0.05	-0.01	0.02	0.02	0.00	0.00	0.02	1.00				
hiv	0.07	0.01	0.03	0.02	0.01	0.01	0.02	0.02	0.01	0.02	-0.01	-0.04	0.02				
astpov	0.02	0.01	0.01	0.02	0.02	0.03	0.00	0.01	0.00	0.01	0.01	0.01	0.06	-0.01	1.00		
lhold	0.04	0.01	0.01	0.00	-0.01	0.00	-0.01	0.00	0.00	0.01	0.02	0.06	0.06	-0.14	0.21	1.00	
depr	0.02	-0.01	0.00	0.01	0.01	-0.02	-0.02	0.00	0.01	0.03	0.04	0.07	0.03	-0.05	0.04	0.05	1.00

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

Key:

Label	Description		Label	Description
a2s94	1994/95 rainfall shock by age group 20-24		eldmdth	Elderly males death (ages 60 and above) (=1)
a3s94	1994/95 rainfall shock by age group 25-29		eldfdth	Elderly males death (ages 60 and above) (=1)
a4s94	1994/95 rainfall shock by age group 30-34		cill	Chronically ill adults (=1)
a5s94	1994/95 rainfall shock by age group 35-39		away	Months away from home of all adults in 2000 (number)
a6s94	1994/95 rainfall shock by age group 40-44		hiv	1995 HIV/AIDS prevalence rates (%)
a794	1994/95 rainfall shock by age group 45-49		astpov	Household assets poverty status in 2000 (1=non poor, 0=poor)
a8s94	1994/95 rainfall shock by age group 50-54		lhold	Household landholding size in 2000 (ha)
a9s94	1994/95 rainfall shock by age group 55-59		depr	Effective dependency ratio (number)

Table A5: Correlation matrix: Impacts models

	malhdth	Femhdth	modthd	fodthd	eldmdthd	eldfdthd	cill	hiv	lhold	depr	astpov
malhdth	1.00										
femhdth	0.00	1.00									
modthd	0.01	-0.01	1.00								
fodthd	0.03	0.02	0.08	1.00							
eldmdthd	-0.02	-0.02	0.03	0.04	1.00						
eldfdthd	-0.02	-0.02	0.02	0.00	0.02	1.00					
cill	0.00	-0.02	0.04	0.03	0.02	0.02	1.00				
hiv	-0.01	0.06	0.02	0.01	0.02	-0.01	-0.04	1.00			
lhold	-0.01	-0.01	0.03	0.03	0.01	0.02	0.06	-0.14	1.00		
depr	-0.02	-0.05	0.01	0.01	0.03	0.04	0.02	-0.05	0.05	1.00	
astpov	-0.02	0.00	0.02	0.05	0.01	0.01	0.01	-0.01	0.21	0.04	1.00

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

Key:

Label	Description
malhdth	Male heads prime-age death
femhdth	Female heads/spouses prime-age death
modthd	Other females prime-age death
fodthd	Other females prime-age death
eldmdthd	Elderly males death (ages 60 and above)
eldfdthd	Elderly females death (ages 60 and above)
cill	Chronically ill adults
hiv	1995 HIV/AIDS prevalence rates
lhold	Household landholding size in 2000 (ha)
depr	Effective dependency ration (number)
astpov	Household assets povety status in 2000 (1=non poor, 0=poor)

Table A6 : First stage regression results: Pooled probit[a].

Covariates	Dependent Variables: Death of prime-age adults			
	Heads/Spouses		Other males	Other females
	Male	Female		
	(A)	(B)	(C)	(D)
Excluded variables				
1994/95 rainfall shock by age group 20-24	0.003	0.033	0.272**	0.437**
	(0.07)	(0.76)	(7.44)	(7.95)
1994/95 rainfall shock by age group 25-29	0.046+	0.115**	0.226**	0.368**
	(1.68)	(4.84)	(7.01)	(9.28)
1994/95 rainfall shock by age group 30-34	0.066*	0.168**	0.277**	0.310**
	(2.06)	(6.62)	(8.45)	(6.76)
1994/95 rainfall shock by age group 35-39	0.102**	0.185**	0.207**	0.231**
	(3.70)	(7.22)	(5.34)	(4.89)
1994/95 rainfall shock by age group 40-44	0.154**	0.161**	0.178**	0.262**
	(5.41)	(5.25)	(3.45)	(4.58)
1994/95 rainfall shock by age group 45-49	0.175**	0.243**	0.127*	0.145*
	(5.74)	(7.35)	(1.99)	(2.16)
1994/95 rainfall shock by age group 50-54	0.240**	0.246**	0.256**	0.137*
	(6.10)	(5.16)	(4.80)	(2.01)
1994/95 rainfall shock by age group 55-59	0.254**	0.239**	0.157	0.191+
	(5.22)	(4.06)	(1.63)	(1.71)
Prior prime-age death between 1996-2000(=1)	0.002	-0.004	0.033**	0.018**
	(0.48)	(1.22)	(6.59)	(3.24)
Included variables				
1999 HIV/AIDS prevalence rates	-0.002**	0.001**	0.001*	-0.000
	(3.32)	(2.82)	(2.13)	(0.22)
Asset poverty status (1=non poor, 0=poor)	-0.007**	0.000	-0.000	0.011**
	(3.06)	(0.00)	(0.10)	(3.30)
Effective dependency ratio(number)	-0.001	-0.006**	0.001	0.000
	(1.42)	(5.84)	(0.47)	(0.34)
Current chronically ill adults (=1)	0.003	0.001	0.017**	0.017**
	(0.86)	(0.23)	(4.09)	(3.67)
Elderly males death (=1)	a	a	0.017+	0.032**
			(1.87)	(2.87)
Elderly females death (=1)	a	a	0.013	0.005
			(1.38)	(0.43)
Provincial dummies included	Yes	Yes	Yes	Yes
R-squared	0.113	0.155	0.161	0.164
Predicted p at $\bar{x}$	0.012	0.015	0.022	0.028
F-test for instruments				
Prior prime-age death	0.27	1.51	46.38**	10.60**
Age specific drought shocks	146.71**	237.11**	282.31**	263.33**
All excluded variables	147.38**	237.11**	325.19**	273.53**
Observations			10682	

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

Notes: [a]Estimated coefficients are marginal changes in probability. Absolute z-scores, calculated using heteroskedasticity robust standard errors clustered for households in parentheses. + significant at 10%; * significant at 5%; ** significant at 1% [b]Excluded since there was no variation in the dependent variable.

Table A7: First stage probit[a] regression results: for use in the 2nd stage differenced models.

Covariates	Dependent Variables: Death of prime-age adults			
	Heads/Spouses		Other males	Other females
	Male	Female		
	(A)	(B)	(C)	(D)
Excluded variables				
1994/95 rainfall shock by age group 20-24	0.012	0.044+	0.214**	0.330**
	(0.40)	(1.64)	(8.82)	(9.19)
1994/95 rainfall shock by age group 25-29	0.048*	0.088**	0.182**	0.282**
	(2.44)	(6.29)	(8.44)	(10.80)
1994/95 rainfall shock by age group 30-34	0.062**	0.117**	0.213**	0.247**
	(2.77)	(7.76)	(9.58)	(8.11)
1994/95 rainfall shock by age group 35-39	0.081**	0.124**	0.159**	0.186**
	(4.30)	(8.14)	(5.88)	(5.85)
1994/95 rainfall shock by age group 40-44	0.122**	0.117**	0.155**	0.229**
	(6.13)	(6.31)	(4.69)	(6.57)
1994/95 rainfall shock by age group 45-49	0.135**	0.163**	0.126**	0.152**
	(6.24)	(8.78)	(2.74)	(3.14)
1994/95 rainfall shock by age group 50-54	0.173**	0.157**	0.193**	0.134**
	(6.46)	(5.78)	(6.13)	(3.20)
1994/95 rainfall shock by age group 55-59	0.183**	0.152**	0.118+	0.157+
	(5.68)	(4.81)	(1.80)	(1.91)
Prior prime-age death between 1996-2000(=1)	0.001	-0.003	0.020**	0.009+
	(0.21)	(1.26)	(4.21)	(1.66)
Included variables				
1999 HIV/AIDS prevalence rates	-0.002**	0.001*	0.001	-0.001
	(2.63)	(2.05)	(1.23)	(0.89)
Asset poverty status (1=non poor, 0=poor)	-0.006*	-0.001	-0.001	0.006*
	(2.37)	(0.62)	(0.22)	(2.00)
Effective dependency ratio(number)	-0.000	-0.004**	0.001	0.000
	(0.54)	(3.93)	(0.63)	(0.46)
Current chronically ill adults (=1)	-0.001	-0.005*	0.005	0.003
	(0.37)	(2.14)	(1.54)	(0.80)
Elderly males death (=1)	b	b	0.007	0.017
			(0.89)	(1.40)
Elderly females death (=1)	b	b	0.010	0.009
			(1.27)	(0.72)
Provincial dummies included	Yes	Yes	Yes	Yes
R-squared	0.241	0.347	0.334	0.355
Predicted p at $\bar{x}$	0.007	0.007	0.012	0.015
F-test for instruments				
Prior prime-age death	0.04	1.58	17.69**	2.75+
Age specific drought shocks	138.53**	227.70**	224.25**	252.71**
All excluded variables	138.74**	227.70**	231.14**	254.81**
Observations			5341	

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

Notes: [a]Estimated coefficients are marginal changes in probability. Absolute z-scores, calculated using heteroskedasticity robust standard errors clustered for households in parentheses. + significant at 10%; * significant at 5%; ** significant at 1% [b]Excluded since there was no variation in the dependent variable.

Table A8 : Tests of endogeneity and overidentifying restrictions of PA mortality on land cultivated : Pooled Sample

	In(Land cultivated)		In(Area under cereals)		ln(Area under tubers)		ln(High value crops)	
	OLS	IV	OLS	IV	OLS	IV	OLS	IV
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)
PA male heads/spouse death (=1)	-0.092	-0.265	-0.051	-0.179	-0.136+	0.635	-0.336*	-0.654
	(1.55)	(0.63)	(0.76)	(0.51)	(1.86)	(1.17)	(2.49)	(0.41)
PA female heads/spouses death (=1)	0.035	-0.404	0.014	-0.419	0.014	-0.836+	0.245	-0.297
	(0.64)	(1.30)	(0.24)	(1.34)	(0.18)	(1.90)	(1.58)	(0.31)
PA other males death (=1)	0.116*	0.762*	0.154**	0.868*	-0.005	0.320	0.181	1.433
	(2.49)	(2.17)	(3.06)	(2.42)	(0.06)	(0.55)	(1.43)	(1.56)
PA other females death (=1)	0.054	-0.050	0.031	-0.182	0.029	-0.031	0.151	0.113
	(1.28)	(0.17)	(0.70)	(0.58)	(0.48)	(0.06)	(1.26)	(0.18)
Elderly males death (ages 60 and above) (=1)	-0.033	-0.059	-0.039	-0.064	-0.011	-0.015	-0.094	-0.054
	(0.62)	(1.09)	(0.69)	(1.10)	(0.15)	(0.19)	(0.68)	(0.33)
Elderly females death (ages 60 and above) (=1)	0.080	0.055	0.119+	0.093	-0.086	-0.099	0.177	0.093
	(1.30)	(0.87)	(1.65)	(1.27)	(1.09)	(1.20)	(1.46)	(0.70)
Current chronically ill adults (=1)	-0.013	-0.026	-0.000	-0.012	-0.016	-0.024	-0.082	-0.118+
	(0.56)	(1.06)	(0.01)	(0.46)	(0.52)	(0.73)	(1.32)	(1.77)
Lagged HIV/AIDS prevalence rates	-0.015**	-0.015**	-0.015**	-0.015**	-0.004	-0.003	0.052*	0.060*
	(4.01)	(3.91)	(3.82)	(3.80)	(0.61)	(0.48)	(2.43)	(2.14)
Asset poverty (1=non poor, 0=poor)	0.564**	0.564**	0.536**	0.538**	0.244**	0.253**	0.358**	0.382**
	(33.65)	(32.40)	(29.26)	(28.14)	(10.43)	(10.02)	(6.87)	(6.01)
Effective dependency ratio(number)	-0.002	-0.006	-0.002	-0.005	0.005	0.004	-0.054*	-0.050+
	(0.30)	(0.71)	(0.20)	(0.56)	(0.48)	(0.39)	(2.17)	(1.70)
Provincial dummies included	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	-0.025	-0.005	-1.186**	-1.168**	-0.389**	-0.400**	-2.944**	-3.061**
	(0.38)	(0.07)	(16.73)	(15.80)	(3.97)	(3.87)	(9.56)	(7.95)
F-test on prime-age mortality	2.71*	3.72*	2.70*	3.41**	0.94	1.06	3.15*	2.45*
Durbin-Wu-Hausman chi-sq test	13.32**		9.65*		5.51		9.75*	
Sargan N*R-sq test for overidentification	3.82		4.87		6.97		8.62	
R-squared	0.16	0.14	0.27	0.25	0.39	0.38	0.14	0.12
Observations	10682							

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. Endogenous variables: Death of prime-age males head death, females head/spouse, other males and other females. Instrumented by: Prior prime-age death, and 1994/195 rainfall by age drought shocks.

Table A9 : Tests of endogeneity and overidentifying restrictions of PA mortality on land cultivated : Differenced Data

	In(Land cultivated)		In(Area under cereals)		ln(Area under tubers)		ln(High value crops)	
	OLS	IV	OLS	IV	OLS	IV	OLS	IV
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)
PA male heads/spouse death (=1)	-0.323**	-0.941*	-0.318**	-0.892*	-0.221	-1.890	-0.078	0.365
	(3.48)	(2.35)	(2.79)	(2.28)	(1.45)	(1.33)	(0.33)	(0.10)
PA female heads/spouses death (=1)	-0.016	0.120	0.032	0.121	0.181	0.438	-0.162	-3.623
	(0.22)	(0.42)	(0.37)	(0.41)	(1.45)	(0.53)	(0.63)	(0.40)
PA other males death (=1)	-0.062	0.196	-0.116	0.124	0.124	3.082	-0.048	8.974
	(0.88)	(0.59)	(1.41)	(0.35)	(0.87)	(1.26)	(0.15)	(0.37)
PA other females death (=1)	-0.046	-0.098	-0.016	-0.159	-0.102	-1.899	0.566*	-4.149
	(0.72)	(0.34)	(0.24)	(0.53)	(0.74)	(0.77)	(2.46)	(0.27)
Elderly males death (ages 60 and above) (=1)	-0.306**	-0.318**	-0.200*	-0.210*	-0.473**	-0.440+	-0.746*	0.500
	(3.59)	(3.72)	(2.32)	(2.45)	(3.23)	(1.83)	(2.15)	(0.13)
Elderly females death (ages 60 and above) (=1)	-0.037	-0.050	-0.116	-0.129	-0.064	-0.187	0.312	0.003
	(0.37)	(0.50)	(0.93)	(1.03)	(0.37)	(0.97)	(1.13)	(0.00)
Chronically ill adults (=1)	-0.003	-0.005	-0.012	-0.014	0.043	0.025	-0.343*	-0.924
	(0.10)	(0.15)	(0.32)	(0.35)	(0.77)	(0.37)	(2.54)	(0.67)
Lagged HIV/AIDS prevalence rates	-0.009	-0.010+	-0.011+	-0.013+	-0.007	-0.012	-0.130**	0.028
	(1.53)	(1.74)	(1.78)	(1.96)	(0.50)	(0.76)	(2.61)	(0.06)
Asset poverty (1=non poor, 0=poor)	-0.217**	-0.222**	-0.210**	-0.212**	-0.124**	-0.124*	-0.161	0.025
	(8.14)	(8.17)	(7.01)	(6.95)	(2.88)	(2.33)	(1.20)	(0.04)
Effective dependency ratio(number)	0.002	0.001	0.005	0.005	-0.001	0.008	-0.091	-0.002
	(0.16)	(0.12)	(0.42)	(0.38)	(0.04)	(0.37)	(1.65)	(0.01)
Provincial dummies included	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	0.228*	0.261*	0.149	0.174	0.108	0.196	2.351**	7.204
	(2.22)	(2.46)	(1.22)	(1.41)	(0.49)	(0.76)	(2.82)	(0.51)
F-test on prime-age mortality	3.53**	2.10+	2.64*	2.05+	1.43	0.72	1.63	0.12
Durbin-Wu-Hausman chi-sq test	3.44		3.21		5.26		6.06	
Sargan N*R-sq test for overidentification	6.27		7.46		8.47		9.74+	
R-squared	0.04	0.03	0.05	0.04	0.04	0.02	0.03	0.00
Observations	5341							

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. Endogenous variables: Death of prime-age males head death, females head/spouse, other males and other females. Instrumented by: Prior prime-age death, and 1994/195 rainfall by age drought shocks.

Table A10 : Tests of endogeneity and overidentifying restrictions of PA mortality on household composition: Pooled Sample

	Household Size		Males		Females		Boys		Girls	
	OLS	IV	OLS	IV	OLS	IV	OLS	IV	OLS	IV
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)
Prime-age mortality										
Male heads	-0.414*	-1.927	-0.261**	-1.084	0.068	0.901	-0.139	-0.594	-0.082	-1.151+
	(2.01)	(0.92)	(3.02)	(1.22)	(0.90)	(1.17)	(1.47)	(0.91)	(0.98)	(1.80)
Female heads/spouse	0.032	-1.599	0.167+	0.248	0.043	-0.815	-0.097	-0.631	-0.080	-0.401
	(0.12)	(0.96)	(1.80)	(0.36)	(0.44)	(1.37)	(1.10)	(1.31)	(0.91)	(0.88)
Other males	0.995**	2.983+	0.500**	2.001**	0.411**	1.034+	0.056	-0.319	0.028	0.268
	(4.48)	(1.78)	(5.79)	(2.59)	(5.18)	(1.69)	(0.78)	(0.61)	(0.33)	(0.49)
Other females	0.970**	0.502	0.270**	-0.282	0.545**	0.465	0.078	0.458	0.076	-0.139
	(4.68)	(0.37)	(3.41)	(0.50)	(7.19)	(0.92)	(1.12)	(0.95)	(1.10)	(0.29)
Elderly mortality-ages ≥60										
Elderly males	-0.407+	-0.508*	0.034	0.004	0.139	0.119	-0.242**	-0.269**	-0.339**	-0.362**
	(1.82)	(2.21)	(0.42)	(0.05)	(1.63)	(1.34)	(3.18)	(3.48)	(4.19)	(4.44)
Elderly females	0.578*	0.475+	0.195*	0.152	0.341**	0.323**	0.067	0.055	-0.026	-0.055
	(2.21)	(1.75)	(2.20)	(1.55)	(3.30)	(3.04)	(0.66)	(0.53)	(0.26)	(0.54)
Chronically ill adults (=1)	0.471**	0.439**	0.226**	0.203**	0.274**	0.257**	-0.020	-0.017	-0.009	-0.004
	(5.08)	(4.57)	(6.06)	(5.14)	(7.69)	(6.97)	(0.56)	(0.46)	(0.23)	(0.09)
HIV/AIDS prevalence rates	-0.021	-0.022	0.006	0.002	-0.006	-0.005	-0.013*	-0.012*	-0.008	-0.008
	(1.57)	(1.51)	(1.18)	(0.38)	(1.32)	(0.89)	(2.47)	(2.02)	(1.50)	(1.55)
Poverty status (1=non poor)	1.446**	1.440**	0.587**	0.586**	0.315**	0.322**	0.268**	0.260**	0.277**	0.272**
	(24.15)	(22.75)	(24.11)	(22.41)	(13.95)	(13.39)	(10.70)	(10.06)	(11.03)	(10.39)
Provincial dummies included	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	5.355**	5.438**	1.196**	1.264**	1.611**	1.581**	1.278**	1.278**	1.270**	1.316**
	(23.77)	(21.48)	(13.08)	(12.01)	(20.10)	(17.64)	(14.02)	(12.78)	(14.36)	(13.83)
F-test on PA mortality	11.61**	3.81**	13.19**	3.64**	20.58**	7.04**	1.38	2.26+	0.79	3.74**
Durbin-Wu-Hausman test	12.44*		20.24**		9.66*		10.05*		16.80**	
Sargan N*R-sq test	5.18		5.83		5.42		6.64		2.02	
R-squared	0.10	0.08	0.09	0.04	0.07	0.04	0.02	0.01	0.03	0.01
Observations	10682									

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. Endogenous variables: Death of prime-age males head death, females head/spouse, other males and other females. Instrumented by: Prior prime-age death, and 1994/195 rainfall by age drought shocks.

Table A11 : Tests of endogeneity and overidentifying restrictions of PA mortality on household composition: Differenced Data

Prime-age mortality (=1)	Household Size		Males		Females		Boys		Girls	
	OLS	IV	OLS	IV	OLS	IV	OLS	IV	OLS	IV
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)
Male heads	-0.721**	-1.104	-0.687**	-0.967	0.113	0.127	-0.015	0.334	-0.133	-0.599
	(2.58)	(0.69)	(4.61)	(1.51)	(1.06)	(0.21)	(0.09)	(0.44)	(0.98)	(0.70)
Female heads/spouse	-0.798*	-1.294	0.006	0.375	-0.607**	-0.960*	-0.168	-0.836	-0.030	0.127
	(2.17)	(1.09)	(0.05)	(0.89)	(4.60)	(2.10)	(1.22)	(1.62)	(0.19)	(0.24)
Other males	-0.861**	-2.331	-0.420**	-0.494	-0.003	-0.238	-0.111	-1.207+	-0.327*	-0.391
	(2.88)	(1.45)	(3.75)	(0.87)	(0.02)	(0.46)	(0.97)	(1.72)	(2.33)	(0.56)
Other females	-0.435+	0.471	0.137	-0.062	-0.393**	-0.072	-0.090	0.765	-0.089	-0.160
	(1.79)	(0.36)	(1.47)	(0.14)	(4.19)	(0.18)	(0.90)	(1.25)	(0.82)	(0.29)
Elderly mortality-ages ≥60 (=1)										
Elderly males	-0.816*	-0.836*	-0.715**	-0.700**	-0.041	-0.057	0.150	0.131	-0.210	-0.209
	(2.45)	(2.46)	(5.57)	(5.36)	(0.31)	(0.43)	(1.23)	(1.02)	(1.57)	(1.55)
Elderly females	-0.579	-0.568	0.131	0.136	-0.459**	-0.462**	-0.084	-0.073	-0.166	-0.169
	(1.64)	(1.59)	(1.08)	(1.11)	(3.07)	(3.07)	(0.53)	(0.46)	(1.05)	(1.06)
Chronically ill adults (=1)	0.114	0.121	0.033	0.041	0.141**	0.138**	-0.059	-0.060	-0.001	0.002
	(0.96)	(1.00)	(0.79)	(0.96)	(3.16)	(3.05)	(1.06)	(1.05)	(0.02)	(0.04)
HIV/AIDS prevalence rates	-0.014	-0.011	-0.004	-0.005	-0.015*	-0.014*	0.008	0.012	-0.003	-0.003
	(0.77)	(0.56)	(0.51)	(0.63)	(2.43)	(2.14)	(0.93)	(1.34)	(0.35)	(0.42)
Poverty status (1=non poor)	-0.381**	-0.394**	-0.013	-0.013	0.013	0.009	-0.178**	-0.185**	-0.203**	-0.205**
	(4.57)	(4.61)	(0.41)	(0.40)	(0.41)	(0.28)	(4.47)	(4.49)	(4.96)	(4.96)
Provincial dummies included	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	0.429	0.400	0.253*	0.269*	0.476**	0.463**	-0.245+	-0.297*	-0.055	-0.036
	(1.39)	(1.24)	(2.13)	(2.17)	(4.38)	(4.07)	(1.71)	(1.99)	(0.41)	(0.25)
F-test on PA mortality	8.83**	5.30**	13.19**	3.64**	20.58**	7.04**	1.38	2.26+	0.79	3.74**
Durbin-Wu-Hausman test	3.09		1.76		2.62		7.52		0.63	
Sargan N*R-sq test	6.11		6.36		4.37		4.80		4.25	
R-squared	0.03	0.02	0.03	0.02	0.02	0.02	0.01		0.02	0.02
Observations	5341									

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. Endogenous variables: Death of prime-age males head death, females head/spouse, other males and other females. Instrumented by: Prior prime-age death, and 1994/195 rainfall by age drought shocks.

Table A12 : Tests of endogeneity and overidentifying restrictions of PA mortality on assets and off-farm income: Pooled sample

	In(Values of cattle)		ln(values of small animals)		ln(Off-farm income)	
	OLS	IV	OLS	IV	OLS	IV
	(A)	(B)	(C)	(D)	(E)	(F)
Male heads prime-age death (=1)	-0.551**	-1.507	-0.150	0.495	0.296	0.410
	(3.12)	(0.91)	(1.02)	(1.20)	(1.29)	(0.36)
Female heads/spouses prime-age death (=1)	-0.284	-0.500	-0.203	-0.243*	0.255	-0.167**
	(1.58)	(0.43)	(1.47)	(2.31)	(1.24)	(4.49)
Other male adults prime-age death (=1)	0.176	2.733*	-0.045	-0.093	-0.058	-0.260
	(1.03)	(2.07)	(0.39)	(1.25)	(0.35)	(1.20)
Other female adults prime-age death (=1)	0.324*	0.098	0.065	-0.191	-0.086	-0.091**
	(1.96)	(0.09)	(0.67)	(0.26)	(0.58)	(3.90)
Elderly males death (ages 60 and above) (=1)	0.353+	0.269	-0.222+	-0.262*	-0.340+	-0.331+
	(1.80)	(1.32)	(1.76)	(2.01)	(1.96)	(1.77)
Elderly females death (ages 60 and above) (=1)	0.219	0.145	0.284+	0.245+	-0.144	-0.245
	(0.95)	(0.62)	(1.95)	(1.65)	(0.71)	(1.17)
Current chronically ill adults (=1)	-0.084	-0.143+	0.059	0.032	-0.409**	-0.349**
	(1.01)	(1.65)	(1.04)	(0.55)	(5.17)	(4.02)
Lagged HIV/AIDS prevalence rates	-0.074**	-0.079**	-0.032**	-0.028**	0.060**	0.067**
	(6.98)	(6.84)	(3.82)	(3.02)	(4.35)	(4.52)
Asset poverty (1=non poor, 0=poor)	0.187**	0.230**	0.821**	0.839**	0.059	0.109+
	(38.73)	(36.62)	(44.53)	(41.84)	(0.97)	(1.67)
Effective dependency ratio(number)	0.021	0.016	0.037*	0.026	0.016	-0.009
	(0.80)	(0.60)	(2.18)	(1.49)	(0.65)	(0.35)
Provincial dummies included	Yes	Yes	Yes	Yes	Yes	Yes
Constant	0.647**	0.738**	2.879**	2.822**	1.250**	1.294**
	(3.65)	(3.72)	(19.28)	(17.23)	(5.22)	(5.00)
F-test on prime-age mortality	4.26**	3.73**	0.92	1.99+	0.92	31.54*
Durbin-Wu-Hausman chi-sq test	22.41**		14.37**		134.62**	
Sargan N*R-sq test for overidentification	6.15		4.42		0.80	
R-squared	0.24	0.22	0.23	0.19	0.05	0.04
Observations	10682					

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. Endogenous variables: Death of prime-age males head death, females head/spouse, other males and other females. Instrumented by: Prior prime-age death, and 1994/195 rainfall by age drought shocks.

Table A13: Tests of endogeneity and overidentifying restrictions of PA mortality on assets and off-farm income: Differenced

	In(Values of cattle)		ln(values of small animals)		ln(Off-farm income)	
	OLS	IV	OLS	IV	OLS	IV
	(A)	(B)	(C)	(D)	(E)	(F)
Male heads prime-age death (=1)	-0.394+	-0.974	-0.857**	0.688	-0.134	-0.837
	(1.72)	(0.76)	(3.42)	(0.49)	(0.40)	(0.47)
Female heads/spouses prime-age death (=1)	-0.023	0.125	-0.352	-1.535	-0.460+	-0.202
	(0.10)	(0.14)	(1.39)	(1.53)	(1.69)	(0.17)
Other male adults prime-age death (=1)	-0.249	-0.266	0.024	1.142	-0.133	-0.858
	(1.14)	(0.25)	(0.12)	(1.21)	(0.50)	(0.62)
Other female adults prime-age death (=1)	-0.152	-0.175	-0.284	-0.814	0.057	0.206
	(0.73)	(0.22)	(1.64)	(1.03)	(0.24)	(0.18)
Elderly males death (ages 60 and above) (=1)	-0.334	-0.338	-0.335	-0.342	0.460+	0.468+
	(1.11)	(1.12)	(1.38)	(1.40)	(1.72)	(1.72)
Elderly females death (ages 60 and above) (=1)	-0.129	-0.124	0.115	0.094	0.243	0.252
	(0.40)	(0.39)	(0.46)	(0.37)	(0.75)	(0.78)
Current chronically ill adults (=1)	-0.092	-0.091	-0.111	-0.136	0.020	0.034
	(0.83)	(0.81)	(1.18)	(1.40)	(0.18)	(0.29)
Lagged HIV/AIDS prevalence rates	-0.042**	-0.045**	-0.026+	-0.024	-0.109**	-0.109**
	(3.08)	(3.32)	(1.76)	(1.56)	(5.47)	(5.34)
Asset poverty (1=non poor, 0=poor)	-0.811**	-0.757**	-1.186**	-1.168**	-0.148	-0.155+
	(9.39)	(9.00)	(16.39)	(15.78)	(1.61)	(1.65)
Effective dependency ratio(number)	0.047	0.053	0.007	0.002	0.002	0.003
	(1.20)	(1.34)	(0.23)	(0.07)	(0.04)	(0.07)
Provincial dummies included	Yes	Yes	Yes	Yes	Yes	Yes
Constant	0.770**	0.904**	0.979**	0.940**	-0.625**	-0.611**
	(3.25)	(3.89)	(3.69)	(3.41)	(7.57)	(7.34)
F-test on prime-age mortality	1.36	0.91	4.19**	1.30	0.82	0.80
Durbin-Wu-Hausman chi-sq test	0.45		4.78		3.02	
Sargan N*R-sq test for overidentification	7.79		5.29		10.12	
R-squared	0.03	0.03	0.07	0.05	0.15	0.15
Observations	5341					

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. Endogenous variables: Death of prime-age males head death, females head/spouse, other males and other females. Instrumented by: Prior prime-age death, and 1994/195 rainfall by age drought shocks.

Table A14: Tests of endogeneity and overidentifying restrictions of PA mortality on gross value of output and gross output/ha

	ln(Gross value of output)				ln(Gross value of output/ha)			
	OLS	IV	OLS	IV	OLS	IV	OLS	IV
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)
	Pooled		First differenced		Pooled		First differenced	
Male heads prime-age death (=1)	-0.089	0.436	-0.174	-0.228	-0.206	0.113+	0.085	0.165
	(1.30)	(0.80)	(1.62)	(0.47)	(1.05)	(1.74)	(0.25)	(1.60)
Female heads/spouses prime-age death (=1)	-0.020	-0.973*	-0.051	0.148	-0.464*	-0.571*	-0.716*	-0.279
	(0.29)	(2.34)	(0.51)	(0.39)	(2.30)	(2.04)	(2.14)	(1.28)
Other male adults prime-age death (=1)	0.034	0.611	-0.080	-0.001	-0.156	-0.600	0.062	-0.252
	(0.57)	(1.32)	(0.95)	(0.00)	(1.30)	(1.21)	(0.27)	(0.97)
Other female adults prime-age death (=1)	0.026	0.164	-0.050	-0.213	-0.153	0.767	-0.254	0.190
	(0.49)	(0.39)	(0.59)	(0.54)	(1.30)	(0.70)	(1.09)	(0.17)
Elderly males death (ages 60 and above) (=1)	-0.061	-0.096	-0.147	-0.138	-0.031	-0.035	-0.112	-0.071
	(0.97)	(1.46)	(1.44)	(1.33)	(0.25)	(0.26)	(0.45)	(0.28)
Elderly females death (ages 60 and above) (=1)	0.037	0.014	-0.027	-0.025	0.132	0.163	-0.049	0.003
	(0.43)	(0.16)	(0.26)	(0.24)	(1.38)	(1.47)	(0.30)	(0.02)
Current chronically ill adults (=1)	-0.028	-0.049	-0.060	-0.056	-0.144*	-0.141+	-0.155	-0.156
	(0.96)	(1.61)	(1.50)	(1.40)	(2.16)	(1.94)	(1.40)	(1.36)
Lagged HIV/AIDS prevalence rates	-0.008+	-0.007	-0.016*	-0.017*	-0.019	-0.004	-0.038+	-0.029
	(1.80)	(1.45)	(2.46)	(2.51)	(1.64)	(0.33)	(1.71)	(1.28)
Asset poverty (1=non poor, 0=poor)	0.706**	0.709**	-0.195**	-0.194**	0.407**	0.432**	0.139+	0.161*
	(34.25)	(32.50)	(6.13)	(6.00)	(9.93)	(9.10)	(1.79)	(2.00)
Effective dependency ratio(number)	-0.004	-0.009	0.004	0.005	0.016	0.004	0.058+	0.056
	(0.45)	(0.92)	(0.31)	(0.38)	(0.88)	(0.20)	(1.67)	(1.57)
Provincial dummies included	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	13.107**	13.093**	0.852**	0.857**	6.199**	6.185**	12.989**	12.751**
	(159.95)	(148.79)	(7.15)	(7.09)	(75.65)	(70.29)	(63.53)	(57.20)
F-test on prime-age mortality	0.57	3.12*	1.07	0.42	3.47**	0.50	0.69	1.62
Durbin-Wu-Hausman chi-sq test	16.46**		0.62		2.17		5.03	
Sargan N*R-sq test for overidentification	8.61		5.50		3.00		3.62	
R-squared	0.17	0.14	0.03	0.03	0.05	0.03	0.04	0.03
Observations	10682		5341		10682		5341	

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. Endogenous variables: Death of prime-age males head death, females head/spouse, other males and other females. Instrumented by: Prior prime-age death, and 1994/195 rainfall by age drought shocks.