MEASURING THE IMPACTS OF WORKING-AGE ADULT MORTALITY ON SMALL-SCALE FARM HOUSEHOLDS IN KENYA

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ABSTRACT

Using a two-year panel of 1,422 Kenyan households surveyed in 1997 and 2000, we measure how working-age adult mortality affects rural households= size and composition, crop production, asset levels, and off-farm income. First, the paper uses adult mortality rates from available data on an HIV-negative sample to predict the proportion of deaths observed between 1997 and 2000 due to AIDS. Next, using a difference-in-differences estimation, we measure changes in outcomes between households afflicted by adult mortality vs. those not afflicted over the three-year survey period. The effects of adult mortality are highly sensitive to the gender and position of the deceased family member in the household. Households suffering the death of the head-of-household or spouse incurred a greater-than-one person loss in household size. The death of a male head-of-household between 16 and 59 years is associated with a 68% reduction in the net value of the household=s crop production. Female head-of-household or spouse mortality causes a greater decline in cereal area cultivated, while cash crops such as coffee, tea, and sugar are most adversely affected in households incurring the death of a male head-of-household. Off-farm income is also significantly affected by the death of the male head-of-household, but not in the case of other adult members. The death of other working-age family members is partially offset by an inflow of other individuals into the family and has less dramatic effects on the households= agricultural production, assets, and off-farm income. The effects of adult mortality are also sensitive to the household=s initial asset levels. Lastly, there is little indication that households are able to recover quickly from the effects of working-age head-of-household adult mortality; the effects on crop and non-farm incomes do not decay at least over the three-year survey interval.

INTRODUCTION

Development planners require solid information on how the death of adults in their prime productive years is affecting household behavior and welfare. In parts of Africa, mortality rates in the 15-59 age cohort have risen dramatically since the onset of HIV/AIDS. The estimated life expectancy in Sub-Saharan Africa is now 47 years, down by five since 1993, and an estimated 15 years shorter than it would have been in the absence of AIDS (UNAIDS/WHO, 2001). While there is general agreement that this unprecedented humanitarian disaster will have serious effects on development in Africa, the magnitude of these effects remain controversial and speculative, which may have contributed to the hesitant response of international donors and lenders even 20 years after the onset of the disease (de Waal 2003).

A number of studies have modeled the impact of HIV/AIDS on economic growth (e.g., Cuddington, 1993; Cuddington and Hancock, 1995; Bloom and Mahal, 1997). These studies typically involve computable general equilibrium or neoclassical growth models in which most of the behavioral consequences are assumed rather than derived from micro-level empirical findings. Other studies have attempted to measure the economic costs of HIV/AIDS through lost workdays valued at average wage levels (e.g., Leighton, 1996). Both approaches suffer from the paucity of quantitative micro-level information on how premature adult mortality affects household behavior and indicators of welfare such as farm production, income, and asset levels.

It is perhaps not surprising that there remains limited survey information on the effects of HIV/AIDS because of the difficulty and cost of obtaining reliable assessments of AIDS-related mortality. Studies assessing cause of death in survey data typically involve a combination of prior serological surveys in which HIV blood tests are required of adults who are subsequently tracked over time (Urassa et al., 2001), verbal autopsies@ in which medical fieldworkers interview a close caregiver of deceased individuals within sampled households to elicit signs and symptoms of the terminal illnesses and then make a diagnosis (Kahn et al., 1999; Quigley et al., 2000; Garenne et al., 2000; Urassa et al., 2001), and/or algorithm-based computer-generated diagnoses based also on caregiver survey information (Urassa et al., 2001). The use of multiple sources of information in surveys to determine cause of death is important to reduce the probability of incorrect diagnoses.

Because of the difficulties and costs of these approaches, 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. We are aware of no nation-wide studies that have quantitatively estimated the effects of the disease on farm production and off-farm income. The absence 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.

An alternative and complementary approach is to focus on understanding the effects of working-age adult mortality more generally, given the substantial AIDS-related increase over the last two decades in the proportion of African households suffering the death of adults in their prime earning years. While only a certain proportion of deaths can be attributed to AIDS, a review of recent epidemiological studies in Eastern and Southern Africa indicates that HIV is the leading cause of disease-related death among adults between 15-49 in all cases (e.g., Ainsworth and Semali, 1998; UNAIDS/WHO, 1998; Kahn et al., 1999). Moreover, the burgeoning literature devoted to understanding the dynamics of poverty requires a better grasp of the effects of premature adult mortality, regardless of cause, on household behavior and welfare. The effects of adult mortality can be more readily assessed through standard nationally-representative socio-demographic and economic household surveys.

This paper estimates the impact of adult mortality between the ages of 15 and 59 on household composition, crop production, asset holdings, and non-farm income using nationwide household survey data in rural Kenya. Kenya is one of the most heavily HIV-infected countries in the world: 13.9 percent of adults age between 15 and 49 are estimated to be living with HIV (UNAIDS/WHO, 2000). We use a two-year panel of 1,422 households in 22 districts surveyed in 1997 and 2000 to estimate difference-in-differences@ models of outcomes at the household level.

The findings of this study highlight the importance of dis-aggregating the effects of adult death by gender and status (i.e., the role and position of the individual) within the household. We find important gender and status differences in how adult mortality affects households= size and composition, crop cultivation patterns, agricultural output, and off-farm income. In some cases, these findings are consistent with household coping behaviors described by qualitative studies in the literature.

The next section describes the panel data used in this paper. Section 3 describes the characteristics of adults who passed away between the 1997 and 2000 surveys, and uses available epidemiological data to make ecologic inferences about the proportion of adult deaths observed in the sample due to AIDS. Section 4 presents the estimation procedure and variables used to estimate the effects of adult mortality. Results, presented in Section 5, are divided into three sub-sections: effects on household composition, farm production, and assets and off-farm income. Conclusions are discussed in Section 6.

DATA AND CONCEPTUAL ISSUES

Characteristics of the Sample

This paper uses a two-year panel of rural household surveys in 1997 and 2000.[1] In April 1997, a total of 1,578 households were randomly selected from 24 districts within the eight agriculturally-oriented provinces of the country. The sampling frame for the surveys was derived with assistance from the Central Bureau of Statistics. We excluded two pastoral districts (40 households) that differed substantially from other zones and had high rates of attrition. Thirty-eight households having farm sizes greater than 20 acres were also excluded to maintain the study=s focus on small-scale households.[2] Of the 1,500 remaining households that we attempted to revisit in the 2000 survey, 1,422 households in six provinces were located and re-interviewed (Table 1).[3] The attrition rate is 5.2 percent. The reasons for attrition are: the household moved away (19 cases), dissolved (nine cases), were not home or unable to be interviewed (45 cases), and refused to participate in the survey (five cases). Among these 78 households that could not be re-interviewed, we obviously lack data on adult mortality. It is possible that the incidence of working-age mortality is higher among these households than in the panel sample. A study from Kisesa, Tanzania, for instance, found that after the death of a male household head, 42.5 percent of households had dissolved (remaining members dispersed, or in the case of one-person households, the household no longer existed) within one year after the death (Urassa et al., 2001). If these 78 households experienced higher mortality rates than the average, the incidence of adult mortality in this paper would be underestimated. Therefore, the results in this paper should be treated as the measured impact of adult mortality among households remaining intact after experiencing a death in the household.

Table 1. Adult Mortality [a] by Province in Kenya.

Province District	Households interviewed in 1997&2000 (A)	Households interviewed only in 1997 (B)	Households with at least one working-age adult death in 1997-2000 [b] (C)	Number of deceased adults Working-age (D)	Elderly (E)	Average age of all deceased adults (F)
	- Number -	- Number -	- Number(%) -	- Number -		- Age -
Costal	88	3	5 (6 %)	6	9	61
Eastern	233	9	9 (4 %)	9	9	61
Nyanza	262	18	34 (13 %)	36	9	45
Kisumu/Siaya	177	11	32 (18 %)	34	7	43
Kisii district	85	7	2 (2 %)	2	2	60
Western	290	13	14 (5 %)	14	16	57
Central	174	7	5 (3 %)	6	5	55
Rift Valley	375	28	16 (4 %)	16	12	58
Total	1,422	78	83 (6 %)	87	60	54

Source: Tegemeo Institute (Nairobi)/Michigan State University Agricultural Monitoring and Policy Analysis Household Surveys in 1997 and 2000.
Note: (*a*) Deaths caused by accidents (13 cases) are not included. (*b*) Working-age is defined as 15-59 years of age.

[1] These surveys were designed and implemented under the TegemeoKenya Agricultural Marketing and Policy Analysis Project (TKAMPAP) Project, a joint collaboration between Egerton University/Tegemeo Institute, Michigan State University, and the Kenya Agricultural Research Institute, with financial supports from the U.S. Agency for International Development (USAID) Mission to Kenya. The survey instruments can be viewed at http://www.aec.msu.edu/agecon/fs2/kenya/index.htm

[2] In Kenya, smallholders are conventionally defined as household owning less than 20 acres.

[3] Those who were not re-interviewed had a higher value of animals in 1997 than those who were re-interviewed. We suspect that some of those who were not re-interviewed were pastoral households.

In 2000, when enumerators revisited the 1997 sampled households, they asked for the whereabouts of each individual in the demographic roster of the 1997 survey. Out of 9,177 household members in the 1997 survey, 8,624 members were identified again in the 2000 survey. The remaining 553 individuals who were not identified in the 2000 survey represents an attrition rate of 6.0 percent. Out of the 8,624 members enumerated in both 1997 and 2000, 6,856 members remained as household members, while the other 1,768 people were non-resident members in 2000.[4] Among those 6,856 resident individuals, 145 passed away before the 2000 survey.

The 2000 survey encountered 2,357 new household members not listed in the 1997 survey. There are several plausible explanations for this large number of new members.@ First, the new members may have married one of the household members and joined the sampled households. Second, they may have moved away from the household prior to the 1997 survey and moved back for some reason. Third, they may have been temporarily adopted by the sampled households, as people experiencing financial or health problems often send their children to relatives in rural areas when times are hard. Fourth, they may have been simply missed or mis-coded in the 1997 survey. Of the 2,357 new members listed in the 2000 survey, 55 of them passed away between the 1997 and 2000 surveys. Although our surveys did not ascertain the reasons for individuals= joining the household, Ainsworth and Semali (1995) found that a high proportion of HIV-positive individuals returned to their rural homes to receive terminal care after becoming ill. Using annual census data in two districts of Tanzania, Kitange et al. (1996) found that the homecoming sick constituted 11 and 19 percent of all deaths.

Of the 200 individuals in the 1,422 sampled households who passed away between 1997 and 2000, 160 were aged 15 years and over. Thirteen persons died because of accidents or violence, and are excluded from the analysis. Of the remaining 147 cases attributed by respondents to disease, 87 individuals were in the conventional working age range of 15 to 59 years. The other 60 cases of mortality involved individuals older than these age ranges. Adult mortality information for this panel sample is summarized in Table 1.

Defining households and members

While the effects of mortality are likely to vary depending on the role and position of the deceased person in the household, many of the variables necessary to empirically analyze these hypotheses are difficult concepts to define. For example, the notion of household membership has no universally applicable definition. Household headship also is a multifaceted and vague concept. While a greater empirical understanding of the effects of adult mortality on household outcomes requires some pragmatic subjectivity in variable construction, there is a need to critically appraise the definitions and limitations of data that are used (Guyer and Peters, 1987; Barnett and Whiteside 1999).

Apart from the tractability in survey design of determining the individuals in the sample based on their relationship to a household head@, there are several different *analytical* uses of the concept of household headship commonly found in literature (see Guyer and Peters 1987 for a review). Based on discussions in the field and with local researchers in Kenya, we find a general consensus that respondents= notion of headship@ is linked to who has the custody rights over the homestead=s land, although it may also be associated with other attributes not perfectly correlated with land rights. Acknowledging the subjectivity involved in the notion of headship, we partition the individuals who passed away between the 1997 and 2000 surveys into the following six groups to test for potential differences in effects of mortality on household-level outcomes:

- male adults 15-60 years old who are married and who are reported by the respondent to be head-of-household. We hereafter refer to this group as male heads@;
- female adults 15-60 years old who are married to the respondent-reported household heads or who are the respondent-reported household heads. This group is hereafter referred to as female heads/spouses@;

[4] Household members were defined as persons who were residing at the household compound for more than six of the past 12 months.

- other adult males 15-60 years old who are not in category 1 but do reside at the household (hereafter other adult males@);
- other adult females 15-60 years old who are not in category 2 but do reside at the household (hereafter other adult females@);
- males over 60 years old and residing at the household (hereafter, elderly males@); and
- females over 60 years old and residing at the household (hereafter, elderly females@).

RELATIONSHIP BETWEEN ADULT MORTALITY AND HIV/AIDS

Attributes of deceased individuals in the sample

In the period between the two surveys in 1997 and 2000, six percent of sampled households had at least one working-age adult death (Table 1). Households in the Kisumu and Siaya districts of Nyanza Province suffered the most working-age adult deaths. Of the 177 sampled households in Kisumu and Siaya districts, 18 percent of them incurred at least one working-age adult death between the 1997 and 2000 surveys. Nyanza Province has the highest rates of HIV prevalence in the country (NASCOP, 2001).

Table 1 also shows the numbers of deaths among individuals over 59 years. We do not find an unusually high number of deaths among this group in Kisumu and Siaya, but there is an inordinately high percentage of deaths in the standard working-age ranges. The average age of all adult deaths in Kisumu and Siaya districts is 43 years old, which is far lower than all the other districts, where the mean age at death for all adults was 58 years. High mortality rates in the 15-59 year age range combine with low mean age at death observed in Kisumu and Siaya provide an initial indication that AIDS is prevalent in these areas.

In Sub-Saharan Africa, especially early in the epidemic, men and women with higher education and income were more likely than others to contract HIV (World Bank, 1999). Ainsworth and Semali (1998) surveyed 11 studies on the relationship between HIV infection and socioeconomic status in Sub-Saharan Africa (Malawi, Rwanda, Tanzania, Uganda, and Zaire) in the late 1980s and early 1990s. They found a positive correlation between HIV infection and indicators of socioeconomic status, such as schooling, income, and occupation. They argue that men with higher education and income find it easier to attract casual sexual partners,[5] and that men (and women) with higher education and income are likely to travel more.[6] Ainsworth and Semali (1998) show that the probability of dying of AIDS in Kagera, Tanzania increases with education until the seventh years of schooling, while the probability of dying of other causes declines after 3 years of schooling.

According to a recent survey in Kisumu town, the capital of Nyanza Province and the third largest city in Kenya, the HIV prevalence rate was much higher among women, 31 percent, than men, 19.8 percent, in the 15 to 49 year age group (Buve et al., 2001). The gender difference was the largest in the youngest age group (15 to 19). The HIV prevalence rate was 23.0 percent among women and only 3.5 percent among men in this age group. In the second youngest age group (20 to 24), the HIV prevalence rate reached its peak for women at 38.3 percent, while it reached its peak, 34.8 percent, for men in the second oldest age group (30 to 39).

The results from our surveys are consistent with these findings to some extent. Table 2 presents basic characteristics of the working-age men and women who passed away since the 1997 survey. The age at death is much younger for women (35.2 years) than for men (41.7 years). A high percentage (50.0 percent) of deceased working-age men were found in the highest per-capita income quartile in 1997, while only 34.1 percent of other working-age men who were still alive at the second survey were found in the same quartile. More than half of the deceased working-age men (58.7 percent) were household heads.

[5] In Kenya, Deheneffe, Carael, and Noumbissi (1998) found a positive relationship between education and the probability of having at least one non-regular sexual partnership (any sexual relationship of less than one year) in the last 12 months among 1,083 men and 1,482 women age 15 to 49 in 1990.

[6] As information on HIV/AIDS spreads, both men and women with higher education and income may start protecting themselves better than men and women with lower education and income. A recent study from four African cities found a positive correlation between education and condom use (Lagarde et al., 2001).

Among deceased men, the average years of schooling was 7.0, which is about one year less than the average years of other working-age men.[7] More than half of deceased working-age women (53.7 percent) were daughters of their household heads. They had 5.8 years of schooling and did not coalesce within any particular income group.

Table 2. Characteristics of Deceased Working-age Adults [a]

	Deceased Working-age Adults		Other Working-age Adults	
	Male (A)	Female (B)	Male (C)	Female (D)
Number of working-age adults	46	41	3,772	3,779
Individual Characteristics				
Age (at death)	41.7	35.2	28.5	28.6
Schooling (years)	7.0	5.8	8.2	7.4
Relationship to the household head (%)				
Head/Spouse	58.7	26.8	23.7	33.5
Son/Daughter	30.4	53.7	56.8	49.6
Others	10.9	19.5	19.5	16.9
	100	100	100	100
1997 Household Income Quartile (%)				
Highest	50.0	34.1	15.8	18.1
Mid-high	19.6	14.6	26.5	27.9
Mid-low	15.2	34.1	26.8	26.9
Lowest	15.2	17.2	30.9	27.1
	100	100	100	100
Year of death (number)				
1997	8	2		
1998	13	17		
1999	13	15		
2000	12	7		

Source: Tegemeo Institute (Nairobi)/Michigan State University Agricultural Monitoring and Policy Analysis Household Surveys in 1997 and 2000. (*a*) Working-age is defined as 15-59 years of age.

Estimating the portion of deaths over the survey interval due to AIDS

Given the current urgency of understanding the effects of AIDS, one may ask to what extent are the deaths observed in this data due to AIDS. To address this question, we follow an ecologic approach commonly used in the epidemiology literature (e.g., Boerma et al., 2002) to obtain a rough estimate of the percentage of working-age deaths in our sample due to AIDS. This involves using adult mortality rates for various age and sex categories from a comparable HIV-negative sample to estimate the number of deaths expected to occur over the survey interval in the absence of HIV/AIDS. Morgenstern (1995) provides a review of ecologic studies and their limitations. In our case, the validity of the approach rests on the comparability of baseline adult mortality rates for HIV-negative individuals in the Kenyan sample with those drawn from our data source. We draw upon Urassa et al.=s (2001) study in Kisesa ward, Tanzania, which uses blood tests over a four year period, 1994-1998, to derive adult mortality rates for individuals known to be HIV-negative. We then compare these age- and sex-differentiated mortality rates with those obtained in the Kenyan sample from 1997-2000.

Kisesa ward is located less than 200 miles from Nyanza Province in Kenya where by far the highest proportion of working-age adult mortality from our survey was observed. As with the sampled districts in

[7] However, a direct comparison of the education levels of deceased men versus men still alive is not warranted because of the educational differences between younger and older age cohorts. Mean years of education in Kenya has increased over time. Because the deceased men were on average 12 years older than other men in the sample, it would be necessary to control for age differences in the comparison of education levels of deceased and other men.

Nyanza Province, Kisesa is located near the shores of Lake Victoria and the two areas share similar agro-ecological and disease profiles and have similar overall adult mortality rates (Boerma et al., 1997; GOK, 1997).[8] Both areas are close in proximity to the second largest cities in their respective countries, Kisumu town and Mwanza, Tanzania. Both areas are well connected by major truck highways to other regions of the country and to each other. While we feel these are reasonable *a priori* grounds for expecting adult mortality rates for HIV-negative individuals to be similar in the two areas, there is no way to determine the extent to which this is the case given the lack of data, and thus we proceed with the caveat that the validity of our estimates are contingent on this assumption.

The HIV-negative mortality rates used from the Tanzanian sample are likely to overestimate both areas= mortality rates in the absence of AIDS because the disease has pervasive community-level effects that indirectly raise adult mortality rates even among HIV-negative individuals (Barnett and Whiteside, 1999).[9] Therefore, this procedure is likely to provide a conservative estimate of the number of working-age deaths attributed to AIDS in the Kenyan panel sample.

Table 3 (columns A, B, and C) show the measured adult mortality rates for the Tanzanian sample, the full Kenyan sample, and for Kisumu and Siaya Districts. Consistent with secondary data on HIV prevalence by district, we find that adult mortality rates in Kisumu and Siaya are substantially higher than in the overall Kenya sample and the Tanzanian HIV-negative sample. Mortality rates for the Kisumu and Siaya samples were 4.9, 31.9, and 46.9 deaths per 1000 person years in the 15-24, 25-34, and 35-44 year age category, respectively. If we apply the adult mortality rates in the Tanzanian HIV-negative sample to the number of person years in the Kenyan sample from September 1997 to June 2000 (2.75 years), we can estimate the number of deaths that might have been expected in the absence of HIV, again subject to the caveats mentioned earlier. These estimated number of deaths are compared to the deaths actually recorded in our samples, in Columns D, E, F, and G in Table 3.

According to this procedure, the following picture emerges: First, the number of deaths predicted in the nationwide sample when applying the Tanzanian HIV-negative death rates are close to, or actually exceed the number of deaths recorded among Kenyan men in the 15-34 age categories and women aged 15-24 and 35-44 (columns D and E). This is consistent with our earlier caveat that the Tanzanian mortality rates are likely to overestimate mortality rates in Kenya in the absence of AIDS. However, even with these biases, there remain substantial discrepancies between predicted and actual deaths among men aged 35-44 and women aged 25-34. The number of deaths actually recorded for men 35-44 is almost double that of the rates predicted using the HIV-negative Tanzanian sample. Among women in the 25-34 age group, actual deaths were four times higher than predicted. Unsurprisingly, these findings are consistent with NASCOP (2001), which reports that men in their 30s and women in their 20s have the highest number of HIV prevalence and reported AIDS cases.

The situation in Kisumu and Siaya is more stark. Here we find that the estimated number of deaths using the HIV-negative Tanzanian group accounts for only one of the five deaths observed for men in the 25-34 age group, and only one of the 10 deaths for men in the 35-44 age group. The discrepancies are also very large for women in the 15-24 and 25-34 age groups. While sample sizes are small, it appears that the number of deaths in Kisumu and Siaya districts are six to ten times higher in the 35-44 and 25-34 age groups than what would have occurred between the 3-year survey period based on mortality rates from the HIV-negative sample from Tanzania. From this, it seems reasonable to conclude that, while epidemiological information on cause of death among individuals in our sample is unavailable, AIDS accounts for a large proportion of the recorded deaths for particular age/sex categories, particularly in the Nyanza area. While this study is not an HIV/AIDS study *per se,* the findings are intended to contribute to our knowledge of the effects of premature adult death on rural households, in light of the growing importance of prime age adult mortality associated with the HIV/AIDS epidemic.

[8] For example, the GOK (1997) reports that the leading causes of recorded death in Kisumu and Siaya (other than AIDS, which was not recorded) are malaria, respiratory and cardiovascular illnesses, and diarrhoea, as was found for the area of Kisesa studied by Boerma et al (1997).

[9] For example, AIDS is co-factored with other communicable diseases such as tuberculosis appear to raise the risks of contraction even by HIV-negative people (de Cock et al., 1992).

METHOD FOR ESTIMATING THE EFFECTS OF WORKING-AGE ADULT DEATH

One approach to modeling the micro-level effects of adult death on household behavior would be to construct a theoretical model based on behavioral assumptions about household responses to working-age mortality. However, very little is known about the dynamics of household behavioral response to adult death in Africa. Moreover, the limited descriptive information on household behavioral responses to AIDS shows great heterogeneity (Rugalema et al., 1999; Matangadura et al., 1999). Because so little is actually known about how households adjust to premature adult death, our approach is to estimate the effects of adult mortality on particular household-level outcomes with as few restrictions on the data as possible.

Difference-in-differences model

We take a counterfactual framework approach in which each household has an outcome, either with or without treatment. The treatment group contains households experiencing at least one working-age adult death (D), and the comparison group is comprised of households not experiencing working-age adult deaths (N). Ideally, we would like to measure the impact of the working-age adult deaths on the same households under the same circumstances. However, this is not possible because a household can not be simultaneously in both the treatment and control groups.

One way to obtain unbiased estimates of working-age adult death is to rely on difference-in-differences (DID) estimation. To get the difference-in-differences estimator, we take the difference in one outcome before (t=0) and after (t=1) the working-age adult death within the treatment group (a reflexive estimator): $E(Y_D) = E(Y_{D1}) - E(Y_{D0})$. This estimator, however, might pick up time trends or impacts of shocks that are unrelated to the working-age adult death. To take the unrelated trends or impacts out, we also take the difference in outcomes within the control group (N) over time and then take the difference-in-differences between the two groups:

$$E() = [E(Y_{D1}) - E(Y_{D0})] - [E(Y_{N1}) - E(Y_{N0})] = E(Y_D) - E(Y_N). \quad (1)$$

We can further stratify working-age adult mortality by the gender of the deceased. We have, therefore, two treatment groups: households with the male working-age adult death (M) and with the female working-age adult death (F). We estimate the DID for each treatment group:

$$E(^{M}) = E(Y^{M}_{D}) - E(Y_N)$$

and (2)

$$E(^{F}) = E(Y^{F}_{D}) - E(Y_N).$$

In the empirical section, we present the DID for each outcome of interest.

As discussed in Section 2, about half of the deceased working-age men in our sample came from the highest per capita income quartile in 1997. Ill individuals, especially young adults, may move back to their homes in rural areas seeking terminal care. Thus, working-age adult mortality in rural Kenya cannot be considered a random shock to households. There are at least two sources of selection problems: (a) household and individual characteristics that are correlated with working-age adult mortality and (b) household characteristics that affect the likelihood of offering terminal care. Fortunately, however, any time-invariant household characteristics that are correlated with working-age adult mortality are controlled for in the process of differencing@ the household data in difference-in-difference estimators.

Estimation strategy

Although the DIDs in equation (2) control for unobserved household characteristics, there may be area-specific time-variant effects that might be correlated with both the working-age adult death and the outcome. To control for such area-specific time-variant effects, we estimate the following OLS model with village□time interaction dummies:

$$.Y_i = D_i^{M}.^{M} + D_i^{F}.^{F} + D_i^{E}.^{E} + V. + .e_i \quad (3)$$

where D_i^M and D_i^F are vectors of the number of working-age adult male and female deaths occurring between the surveys, respectively, and D_i^E is a vector of the number of elderly deaths occurring between the surveys; V is a vector of village time dummies (to control for village-specific time-variant effects over the two survey periods); and e_i is the error term.

In equation (3), we also include elderly deaths. Although our primary interest is on the effects of working-age adult mortality, the definition of working-age@ is inherently arbitrary. Elderly persons may have similar effects on their households as that of working-age adults. On the other hand, households may have had more time to anticipate the death of elderly members and shift activities to younger members than would be the case for an unexpected death of a younger adult. Omitting elderly deaths may bias estimations if there is a correlation between working-age adult deaths and elderly deaths. Therefore, we include in our models the numbers of male and female elderly who passed away between the 1997 and 2000 surveys. There are 34 and 26 households that incurred the death of at least one elderly male and elderly female, respectively.

Because the impacts of an adult death may also differ depending on the status within the household of the deceased member, we group household members into six groups as defined in Section 2: male heads, female heads/spouses, other adult males, other adult females, elderly males, and elderly females. To test for possible status-differentiated effects of adult death, we use a dummy variable for each group. Among the 46 households with male working-age deaths, 21 of the deceased were male heads, while the other 25 were other adult males. Among the 41 households with at least one female working-age adult death, 10 of the deceased were female heads/spouses, while the other 31 were other adult females.

We feel that there are no changes in household-level variables that are exogenous to the impacts of adult mortality in the household. For instance, household size and composition, which are considered to be exogenous variables in most analyses, are directly affected by adult mortality. And so are other changes in household-level variables such as assets and landownership. For this reason, no household-level variables are included in the models besides the adult mortality variables.

We estimate the effects of adult mortality on a set of household composition variables: household size, the number of male adults, female adults, boys, girls, and young children (5 years and younger). The second set of outcomes are total land cultivated and crop output. To examine the gender-specific impacts on types of crops, we dis-aggregate the land cultivated by the household into three categories: cereals, root crops, and high-value crops. The third set of outcomes are on assets (farm equipment, small animals, and cattle) and off-farm income. Lastly, we re-estimated these models with the inclusion of categorical variables for recent deaths (i.e., in 1999 and 2000). This allows us to examine if a recent death has a larger impact than a death that occurred earlier (in 1997 or 1998), which would indicate households= ability to recover over time. The recent-death variable was not significant in any of the estimated models and is not discussed further.

RESULTS

Household composition

Because the death of an adult reduces the household=s supply of labor and adversely changes its dependency ratio, surviving members may pursue a number of options to change the composition of the household.[10] Young children may be sent to relatives= homes, or productive adults may be called back or adopted into the household. Under some circumstances, the death of an adult member may cause other household members to move away, as when the death of a female spouse thought to have had AIDS may provide incentives for other potential sexual partners of the husband (who might be presumed to be HIV-positive) to leave the household. Customs in parts of Kenya and the broader east and southern Africa region provide for the

[10] For example, Ainsworth and Semali (1995) found that rural households in Kagera, Tanzania were able to maintain their household sizes and dependency ratios even after experiencing working-age adult mortality. In Chiang Mai in Thailand and Rakai in Uganda, however, descriptive analyses show that household sizes declined by about one person after a prime-age adult death (Janjaroen, 1998; Menon, et al., 1998).

widower to take the spouse=s sister or cousin as his new wife should she choose to remain in the household (Mutangadura et al., 1999; Shah et al., 2002), a custom that has become increasingly dysfunctional because of AIDS.

This section examines how Kenyan households adjust household composition to cope with working-age adult mortality. Examining how the age and gender of household members change in response to adult death may aid in the interpretation of effects on farm production and non-farm income analyzed later.

Table 4 presents changes in household composition. Households that incurred at least one working-age male death between the 1997 and 2000 surveys shrank by 0.61 member (Column C). On the other hand, there was no significant change in the size of households not incurring a working-age death (Column I). Thus, the DID indicates that household size declined by 0.64 person among households incurring the death of a working-age male compared to the control group (Column J). In contrast, household size shrunk by 0.33 persons in households incurring a working-age female death, compared to the control group, but this effect was not statistically different from zero at any conventional level of significance.

There are significant changes in the number of household members when dis-aggregated by age-gender group. Households suffering working-age adult mortality have significantly fewer adult male and female members (Column C and F). If households experiencing working-age adult mortality were unable to adjust their numbers of male and female adults at all, we should find a decline of one male and female adult members. Compared with households not affected by working-age adult mortality, households with male and female working-age adult mortality had 0.79 fewer adult males and 0.78 fewer adult females, respectively (Column J, row 2, and Column K, row 3). This indicates very partial replenishment; in most cases, households are unable or not attempting to replenish their numbers after incurring the death of an adult member.[11]

The decline in male and female adults are compensated partially by an increase in the number of boys in the household. The number of boys in the household between 1997 and 2000 increased more for households incurring working-age adult mortality than for households that did not (Column J and K). This suggests that boys might have been adopted by households with working-age adult mortality to compensate for the loss in adult family labor. By contrast, we do not find any significant increase in the number of girls in household that incurred an adult death.

Now we turn to regression analyses. Table 5 presents OLS results of equation (3). As shown in column A, the death of a working-age man reduces the size of the household by 0.79 person. It reduces the number of men in the household by almost the exact same number (Column C). In contrast, the death of a working-age woman does not reduce the size of the household significantly, but it reduces the number of women by about 0.91 person.

However, it is likely that the effects of adult death on household composition depend not only on the gender and age of the deceased person, but also on the person=s position in the household. For this reason, we use six dummy variables that indicate the deceased person=s position in the households, as discussed earlier. Changes in household size, shown in Column B, are the sum of the changes in the other columns. For example, the death of a working-age male head-of-household reduces the household size by about 1.53 persons (Column B). Looking across the row, it can be seen that the death of a working-age male head is mainly caused by a 1.19 reduction in the number of adult men (Column D) and a 0.59 reduction in the number of adult women (Column F). The changes in the number of boys, girls, and young children are not significantly different from zero. While the drop in the number of adult men by roughly one is largely explained by the death of the male head himself, the decline in the number of adult women may initially

[11] We also examine changes in household composition when we exclude deceased household members from the 1997 household composition. If households are able to attract a new adult after the household incurs a death, and the deceased member is not counted, then we should see a significant increase in resident members compared to households not experiencing working-age adult mortality. The changes in the numbers of living male and female adult members are not statistically different between the two types of households.

seem puzzling. One possible explanation is that the widow may be unable to retain her rights to the deceased husband=s land which may force her to leave the homestead (Mutangadura et al., 1999; Rugalema, 1999). However, of the 22 households who lost their male heads-of-households, we found 21 wives of deceased heads still living in their households in 2000.

Another explanation is that older daughters may be more likely to leave home in times of financial stress such as after the death of the head-of-household. Of the 22 households who lost their male heads-of-household, 72.6 percent of the daughters left their households, in contrast to only 41.1 percent among households not affected by adult mortality. Of the daughters who left their household in the death-stricken families, marriage accounted for 62.5 percent of them according to the survey respondents. Thus it seems that the 0.59 reduction in the number of women in households incurring the death of their male head-of-household can be largely attributed to daughters getting married.

The death of a working-age female spouse/head reduces the size of the household by over two persons (Table 5, Column B). It reduces the number of women by about one person (Column F), which is directly attributable to the female head/spouse=s death. Additionally, her death reduces the number of boys and girls in the household each by roughly 0.6 persons, although the estimated coefficient on girls is more precisely estimated. After the death of a mother, young children may be sent to relatives= homes or schools where they might receive better care than can be provided by a now-single working father. We find that in households in which the core female member died, 9 of the 31 resident boys and girls (aged 7 to 16) in 1997 left the household by 2000; of these five went to attend school and the rest were to live with relatives or other households. In contrast, the death of another adult female is associated with an increase in the number of boys in the household, most likely to help out with household activities formerly handled by the deceased woman. This indicates, as might be expected, that the effects of adult mortality depend not only on the age and gender of the deceased, but also the position of the individual in the household.

The death of another adult male (i.e., a working-age man other than the self-reported head-of-household) reduces the number of men by only 0.45 person (Column D), suggesting that slightly less than half of the households are able to draw back another man to cope with the death of another adult male. However, this effect is significant only at the 10 percent level. Further investigation of such cases indicates that these households incurring the death of a non-head male member are more likely to retain other older sons, who may be productive agricultural workers in the household. Among households incurring adult mortality, just over 73 percent of adult sons remained in the household between the 1997 and 2000 surveys compared with 54.2 percent in households not incurring adult mortality. In contrast, the death of another adult female decreases the number of women in the household by 0.81 (column F), indicating that it is more difficult to replace female household members. These households appear to adjust by adding boys to their family (Column H). Examining households incurring the death of another adult female, we find that young male relatives (nephews of the head-of-household or spouse) are the main source of adjustment. Nephews comprise 31.8 percent of boys aged 6 to 14 in households incurring the death of a non-spouse female adult, compared to only 18.8 percent among households not afflicted by adult mortality.

In contrast to working-age adult 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 be progressively absorbed by other household members. The results in Table 5 indicate that the death of an elderly male or female reduces the number of adult male and female members by about one person, respectively (rows D and F). However, the death of an elderly male tends to increase with the number of boys in the household. Some tasks performed by elderly males may be assumed by boys absorbed into the household from the extended family. Aside from the reduction in women accounted for by the death of the elderly woman herself, we observe no statistically significant changes in the number of other household members.

In general, the results in this sub-section indicate that the effects of adult death on household size and composition are sensitive to the age, sex, and position of the deceased. The most severe changes in household size occur when the death is a male or female household head, which are associated with a loss of 1.5 and 2.1 members, respectively. This supports the conventional wisdom that households incurring a working-age adult death have fewer economically active members to care for the needs of a proportionally greater number of dependents and to manage farm production. However, we find that the death of other

adult members has either no statistically significant effects on the size of the household because it is able to partially or fully adjust by drawing back other members to the household, or, in the case of elderly female death, the household may not attempt to adjust its composition.

Farm production

This sub-section estimates the effect of working-age adult mortality on cultivated area and crop production. Households suffering adult mortality may experience at least three sources of shocks on crop production. First, a decline in adult members may cause binding labor constraints. Results in the previous section indicate that labor shocks might be especially severe in cases involving the death of the head-of-household or spouse, which in both cases lead to a greater-than-one person decline in household size, as shown in Table 5. Barnett and Blaikie (1992) followed roughly 140 households in several Ugandan villages over time and showed how reductions in family farm labor affect farm production. Some of the loss of family labor may be replaced by hired labor but this usually means that some portion of the harvest must be used to pay for it. Second, losses in crop husbandry and management skills in the deceased person may further hinder crop production, and may lead to shifts in crop mix away from management-intensive crops. Women in Kenya, as in most parts of Eastern and Southern Africa, are primarily responsible for the household=s food crop cultivation, while typical cash crops@ such as coffee, tea, sugarcane, and export-oriented horticultural products are primarily mens= activities (Davison, 1988; Francis, 1998). Depending on who manages the plots, intra-household resource allocation across plots may be different (Udry, 1996). Third, cash income formerly earned by deceased family members to finance cash inputs is no longer available, which might induce less intensive production practices or a shift to crops requiring less fertilizer or other purchased inputs.

Cultivated land

The results of difference-in-differences in Table 6, columns J and K, suggest that the death of a working-age adult is not significantly associated with a reduction in the *total* cropped area. However, when we dis-aggregate cultivated land into three crop categories B cereals, root crops, and high-value crops B we find a significant gender difference in the change in area devoted to high-value crops.[12] Among households without any working-age adult death, the area devoted to high-value crops between 1997 and 2000 significantly increased by 1.14 acres. Yet among households incurring a working-age male death, the area devoted to high-value crops increased only by 0.24 acres. The difference between the two groups (DID) is -0.90 acres, which is statistically significant at 10 percent (t-ratio=1.95). Because men usually manage the cultivation of cash crops, the lost knowledge and skills in production and marketing may force households to shift away from such crops after the death of a working-age man. The difference in cash crop area between the control group and households incurring working-age female adult mortality is not statistically different from zero.

In regression analyses, we find that the death of a female head/spouse decreases the size of cultivated land devoted to cereals by 1.19 acres (Table 7, Column D), consistent with Davison=s (1988) and Francis= (1998) characterization of the female head-of-household (or spouse) as having primary responsibility for growing the household=s food supply. The death of another adult female however, does not significantly affect cereal area cultivated. As in Table 6, the death of a working-age man decreases the size of cultivated land devoted to high-value crops by 0.66 acres (Column H). When distinctions are made between the male head-of-household and other adult males, the greater adverse impact of the death of the male head on high-value crop area becomes apparent (Column H). Interestingly, the death of another working-age adult male actually increases the amount of land devoted to cereals by 0.76 acres (t-ratio=1.49). Thus, households seem to convert land that was formerly devoted to high-value crops to cereals. The median net return to an acre of land was 5,325 Ksh for cereals, 6,387 Ksh for root crops, and 14,400 Ksh for high-value crops. Thus by switching from high-value crops to cereals after the death of a working-age man, households lost about 9,075 Ksh per acre (about US$121) in net revenue.[13]

[12] See notes in Table 6 for the list of crops in each category.

[13] All monetary values in this paper are expressed in constant 2000 Kenyan shillings.

Crop production

Ideally, we would like to compare the productivity of a specific crop on a specific plot before and after adult mortality. However, this turns out to be a difficult task, at least in our situation, because many households switched crops after experiencing adult mortality. Measuring the impact of only those households who did not switch crop choice may underestimate the impact of adult mortality on the productivity of a specific crop, because those who switched crops could be the hardest hit and least able to maintain their preferred crop mix. Thus we do not estimate the household-crop fixed effects models. Instead, we simply estimate changes in the value of total crop output and the value of total crop output per acre in between the two surveys.[14]

We first present descriptive information of the gross value of total crop output in the last four rows in Table 6. Largely because of more favorable weather in the 1999/2000 crop season, the gross value of total crop output was higher in real value (the 1997 nominal prices are inflated into the 2000 real prices) than for the 1996/97 season, even among households experiencing male and female working-age adult mortality. However, their increase in the gross value of total crop output is much smaller than it is for households without any working-age adult mortality (Column J and K). Because of large standard errors, however, the DIDs are not statistically significant.

Among households incurring the death of a working-age woman, the gross value of total output per acre increased significantly (Table 6, Column F). This is consistent with the earlier finding that these households tended to partially shift cropped area from cereals to cash crops. However, this implies a greater dependence on the market for these households= food requirements. Households incurring the death of a working-age man experienced a decline in the value of total output per acre (Column C). However, the DIDs are not statistically significant.

The regression results in Table 8 indicate that the death of resident household heads and spouses generally adversely affects the value of total crop output and the value of total output per acre. The *gross* value of crop output decreases by 57 percent for households incurring the death of a male household head (Table 8, Column B), but this effect is significant only at the 10 percent level.[15] We do not find any statistically significant changes in the gross value of total crop output after the death of other household members. Table 8 also presents the results on the *net* value of total output, after taking account of the costs of chemical fertilizer, seed, and land preparation.[16] The results are similar to those of gross value output: the death of a household head reduces net crop output by 68 percent (Column D). This effect is statistically significant at the 5 percent level. Adverse crop output effects of similar magnitude are noted in the case of female head and spouse mortality, but these effects are imprecisely measured.

To examine how much of the decline in crop output is due to a reduction in cultivated land and how much is due to a reduction in land productivity, we then estimate the value of total output per acre. The results indicate that adult mortality does not appear to have any significant effects on either gross or net value of output per acre (Table 8, Columns E, F, G, and H), although the signs are generally as expected. Thus, the 68 percent reduction in the total net crop output after a household head=s death is primarily attributable to a reduction in cultivated area rather than less intense cultivation of the reduced area remaining under cultivation.

Why might the effects of working-age male head-of-household mortality be greater than for women on agricultural output? This might be considered inconsistent with the fact that women supply most of the labor input on smallholder family farms. Yet there are still reasons why our results may indeed be highly plausible. First, as mentioned earlier, it is primarily cash crop production that suffers most after the male head death. Because these crops typically generate greater revenue per unit of land and labor than cereal and root crops,

[14] By estimating the value of total farm output, we are unable to isolate the impacts of working-adult mortality on farm productivity because farmers reallocate crops and prices change over time. However, some price changes are predictable, and it is an important skill for farmers to adjust crop allocation according to predicted price changes. Thus, by using the value of total farm output, we are measuring the impacts of technical as well as managerial skills.

[15] The dependent variables are in log. Because five households had negative net outputs in both years, we had to exclude those households from the regression analyses where the dependent variable is in log.

[16] Hired labor costs were not included in net crop output because such information was unavailable.

the measured impacts on total crop value may be greater. Because of data limitations, we could not measure the effects of adult death on food consumption, but it is possible that these gender-differentiated effects could be very different. Second, and as explained earlier, the death of male household heads is correlated with a subsequent departure of an adult woman from the household, most commonly an older daughter. In such cases, the daughter=s departure is likely to cause additional shocks to family labor and other resources beyond the death of the male household head. Third, in most parts of Africa, including Kenya, by law and tradition only men have rights to inherit land. These gender-disparities in property rights make women especially vulnerable to losing land when their husbands die. Results in Table 6 indicate that the death of a male head-of-household results in an overall decline of 0.565 acres in cultivated area, but this effect not statistically significant, although there is a highly significant reduction in cultivation of high-value crops. When we examine the 21 cases of male head-of-household mortality between 1997 and 2000, we find eight households experiencing a -50 to -90 percent decline in cultivated area over the same period. In six cases, the area cultivated by the household changed from -50 to +50 percent, and in the remaining 7 cases, cultivated area actually increased by more than 50 percent. It is possible that some of the households experiencing a major decline in cultivated area may have experienced a loss of land rights. Loss of land rights may also partially explain why 24 households could not be re-interviewed in 2000 because they moved away or dissolved.

Note that in the regressions where the position of the deceased adult member is not distinguished between household heads and spouses vs. other adults in the household (columns A, C, E, and G), no significant effects on crop production are detected. These findings underscore the importance of carefully differentiating the gender, position, and age categories of deceased individuals when measuring the effects of adult mortality.

Assets and off-farm income

Assets

Assets can be sold to mitigate the shocks of adult mortality and other shocks. Previous studies found a large reduction in asset holdings when households experienced adult mortality (Barnett and Blaikie 1992). In this sub-section we look at changes in the values of farm equipment (e.g., animal traction equipment, sprayers), small animals, and cattle.

The results in Table 9 indicate that while the mean value of all three categories of assets declined between 1997 and 2000 for all households (Column C, F, and I), the decline was particularly acute among households experiencing working-age adult death (Columns C and F). However, because of large standard errors, only in the case of small animals (goats, sheep, and chickens) are the DIDs statistically different between households experience adult male mortality and the control group (Column J).

The regression results in Table 10 provide a similar picture of the negative effects of working-age adult death on assets. The death of a working-age man decreases the value of farm equipment by 3,686 Ksh. While this change in farm assets represents a 28.5 percent decline from mean asset levels among sampled households in 1997, the result is statistically significant only at the 10% level. The regressions examining the mortality effects of particular household members (column B) show generally adverse but not statistically significant results. The value of small animals declines by 4,003 Ksh (a 43.1 percent decline from mean 1997 levels) after the death of a working-age woman (Column C). We find similar effects in the case of working-age male death. When the results are disaggregated according to the death of particular household members (column D), the results are not statistically significant except in the case of death of other adult women. To the extent possible, households appear to be trying to hold on to productive cattle, reflected by the lack of any significant negative effects in Columns E or F, while adjusting with the sale or consumption of small stock. In fact, members in households incurring the death of a male head of household appear to gain livestock assets, which as we noted earlier, may be related to the tendency for daughters in such households to leave home, often for marriage, which frequently involves cattle payment for bride doweries.

Off-farm income
Roughly 30 percent of total household income in 1997 and 2000 was derived from off-farm activities. A reduction in the number of adults in the household suggests a possible reduction in off-farm labor. The last row in Table 9 present the changes in off-farm income between households afflicted by adult death and the control group. As expected, households incurring working-age adult mortality have relatively low levels of off-farm income in 2000. Because of large standard errors, the DIDs are not statistically significant, but the mean reductions in off-farm incomes are roughly 35-40 percent for households afflicted by adult death, compared to only 12% for household not experiencing adult mortality.

The regression results in Table 10 (column H) indicate that while the death of adults, even in the elderly categories, adversely affect non-farm incomes, only the case of male head-of-household mortality has statistically significant effects, but they are very severe. The death of a male head reduces the household=s off-farm income by 42,830 Ksh (roughly US$595), which is about 79 percent of these households= initial off-farm income in 1997. As discussed earlier, we found that roughly half of the adult males that passed away between 1997 and 2000 were in the highest income quartile, so it is not surprising to find relatively large income shocks arising from adult male mortality. Referring back to the findings in Table 4, we found that the death of a male head-of-household also reduces the number of adult women living in the household. Therefore, the effects of the male head=s death on off-farm income may partially reflect the loss of labor of other family members, not simply those of the deceased person.

Are the effects of adult mortality sensitive to initial levels of poverty?
It has been argued that the poor are less able to cope with the shocks posed by working-age adult mortality and therefore the magnitude of the effects may be sensitive to households= initial conditions (Drimie, 2002).

This is an important issue to address empirically, because of its potential implications for the targeting of scarce resources for poverty alleviation and AIDS-mitigation. To test this hypothesis, we conduct a simple test. First, we divide the sample into two groups based on the value of household productive assets according to the initial 1997 survey.[17] Then, we estimate the same set of models already reported for the two groups. Because of space limitations, we report results only for the cases of deaths of working-age male and female heads/spouses on various outcomes in Table 11.

There are clear differences across the two groups. The impacts on household size are greater among households in the top half of the 1997 asset distribution (relatively less poor) than the bottom half (poor). Among households in the upper half of asset holdings, the death of a male or female head causes a larger-than-two person decline in total household size, and a greater-than-one decline in the number of women. As discussed earlier, we found daughter getting married and leaving households, possibly for bride doweries, after a death of a male head. Thus, it is possible that daughters from relatively less poor households are getting married after a death of a male head or female head/spouse. Consistent with this hypothesis, we find a small increase in the total value of cattle in less poor households after the death of a male head, while we find a reduction in the value of cattle among the poor households, especially in the case of female head/spouse mortality.

Comparing the results in Table 10, columns A and B, we find that male head mortality has more severe effects on crop production, asset depletion, and off-farm income among poor households. Male head-of-household mortality in poor households is associated with reductions in the area under high-value crops, the net value of crop output, the total value of farm equipment, the total value of small animals, and off-farm income. All of these effects are statistically significant at the 90 percent confidence level or higher. In contrast, we do not find any significant impacts of a death of a male head among households in the top 50 percent of the asset distribution. In the case of female head/spouse mortality, there appear to be few statistically significant effects on crop cultivation or income among poor and less poor households

[17] This includes farm equipment including mechanical and animal draft power, plus the value of cattle and small animal stock.

These results provide a somewhat mixed picture about the sensitivity of the impacts of adult mortality to initial levels of household vulnerability. Households= initial level of asset poverty does appear to exacerbate the impact of male adult mortality, but not in the case of female adult mortality.

These results raise questions about the common view that loss of labor poses the major constraint on crop production among households suffering from working-age adult mortality. We find declines in the numbers of men and women after the death of male heads and female heads/spouses in the relatively poor as well as the relatively better off households. In fact, households in the top half of the asset distribution actually experienced a greater decline in family labor, especially among adult members. Yet we do not find significant losses in cultivated land (total as well as for the three types of crops) and net crop output among relatively less poor households. Possible reasons for the significant loss in crop output among relatively poor households, according to the results in Table 11, include (a) incapability of paying hired labor because of the loss in assets and off-farm income, and (b) loss of farm equipment necessary to produce high-value crops. It is also possible that less poor households are less able to acquire the knowledge to acquire inputs, credit, and crop husbandry practices that might be lost with the death of a working age adult. While some organizations have stressed that priority be put on developing labor saving agricultural technologies in light of the loss of labor caused by AIDS, these results at least suggest the need to consider how the major constraints on agricultural production may be different for different kinds of households. This may warrant a more nuanced and multifaceted approach for generating appropriate new agricultural technologies in the wake of AIDS, given the heterogeneity of small-scale farmers= resources and constraints.

CONCLUSIONS

The starting point for the design of effective programs to mitigate the impacts of adult mortality caused by AIDS is accurate information on how households are affected by, and respond to, the death of working-age members. While these issues have been extensively discussed in conceptual terms, and explored empirically in a few purposively selected areas known to be hard hit by HIV/AIDS, there is a dearth of quantitative information on the effects on farm production, non-farm income, and assets, especially using samples that allow generalization beyond a particular case study area.

Using panel data from 22 districts in rural Kenya, we have shown the characteristics of working-age adults who passed away between 1997 and 2000, and then estimated the impacts of adult mortality on household composition, farm production, asset holdings, and off-farm income.

The study highlights eight major findings: First, there are important gender differences in the incidence of adult death. About half of the deceased working-age men are in the highest per capita income quartile in the 1997 survey. This is consistent with findings from earlier studies showing a positive correlation between male HIV infection and socioeconomic status, such as education and income. Deceased working-age women were distributed more evenly through all income quartiles. The fact that we found many deceased working-age men in the highest income quartile indicates that lack of money is not likely to be a major impediment to the adoption of safer sexual behaviors, and that there is still considerable room for intensification of educational efforts to change mens= sexual behaviors and practices.

Second, the prevalence of adult mortality is concentrated in particular areas. About 39 percent of the working-age adults who passed away between the 1997 and 2000 surveys are from the Kisumu and Siaya Districts of Nyanza Province, where HIV infection rates are known to be high, even though these districts contained only 12 percent of the households in the nationwide sample. These results suggest that the Kenyan government and interested donors should intensify their safety net and education programs in this province, while maintaining prevention programs nationwide.

Third, household composition is affected in different ways depending on the gender and former position of the deceased member. Households suffering the death of a head-of-household or spouse incurred a greater-than-one person decline in the number of household members. The decline in household size was largest in cases where the female heads were afflicted, as this was associated with a significant decline in the number of other woman and older girls in the household. The passing of the male head-of-household also caused a significant decline in the number of women residing at the household. By contrast, the death of other

working-age family members is partially offset by the entry or return of other members. These findings are consistent with household coping behaviors described by qualitative studies in the literature.

Fourth, the effects of adult death on crop production are also sensitive to the gender, position, and age categorization of deceased members. For example, the death of a male household head between 16 and 59 years old is associated with a 68 percent reduction in the net value of the household=s crop production (net of major cash input costs). Effects are less dramatic for other working-age family members. The gender of the deceased adult affects the type of crop suffering a shortfall, with grain crops being adversely affected in the case of adult female mortality and cash crops@ such as coffee, tea, and sugar being most adversely affected in the case of adult male mortality. Although women provide most of the households= labor input for crop cultivation, the results suggest that the death of male household heads may more adversely affect net crop output because of (a) the observed shift from relatively high-value to low-value crops, which may result from the fact that it is primarily men who are given the specialized crop husbandry and marketing knowledge to grow these crops under outgrower and cooperative arrangements, and (b) the additional loss of labor from the departure of older daughters from the household, which occurred more frequently in households where the male head of household has died.

Fifth, households seem to cope with working-age adult mortality by selling particular types of assets, mainly small animals. This would logically result from the household=s need to raise cash for care and funeral expenses from its assets of lesser long-term productivity. The death of working-age men is also associated with a reduction in the value of farm equipment, which would appear to both contribute to the estimated short-term decline in farm production and exacerbate the households= longer-term ability to restore former production levels.

Sixth, household off-farm income appears to suffer greatly from the death of a working-age male head. Negative but statistically imprecise effects were observed in the case death of other adult members.

Seventh, there is little indication that households are able to recover quickly from the effects of adult mortality. The inclusion of categorical variables representing recent deaths (i.e., if the death occurred in 1999 or 2000) of the household head was not significant in any of the estimated models, providing little evidence of recovery over the three-year survey interval.

Lastly, when we divide the samples into two groups based on households= initial asset levels in 1997, we find negative impacts on the net value of crop production, assets, and off-farm income only in the case of male head-of-household mortality among relatively poor households. We do not find any significant effects of male head mortality on those outcomes among the upper 50% of households ranked by asset levels.

This last point seems to challenge the conventional wisdom that labor shortages are the major constraint on crop production among farm households afflicted by adult mortality. Our results suggest that statistically significant adverse effects of adult mortality on net crop output occurred only for lower 50% of households ranked by productive assets, even though these households experienced a smaller net outflow of adult labor than the relatively less poor households. The asset-poor households also experienced significant losses in off-farm income and farm equipment after incurring a male head-of-household death. These results suggest that cash income and productive assets are also hard hit among poor household afflicted by adult mortality, and that appropriate directions for new agricultural technology development programs should take into account the heterogeneity of afflicted households= resources and endowments.

The findings also indicate the need for special assistance to asset poor households incurring the death of a male head of household. The loss of income from cultivation of traditional cash crops such as coffee, tea, sugarcane, etc. was a major source of hardship for these households. By overcoming gender barriers and nurturing women farmers= participation in extension programs, cooperatives, and other fora for learning about and participating in cash crops, the shocks to agricultural income faced by widows= households could be mitigated. Government and outgrower companies could organize field sessions in which experienced farmers are recruited to help teach women about husbandry and marketing techniques for particular crops (Gillespie and Haddad, 2002). However, field schools designed for women farmers may require

complementary campaigns to legitimize these activities within local communities, especially among men who may feel that such training upsets traditional norms as to the gender-related division of labor activities.

This paper has measured only the short-run effects of adult deaths on selected aspects of rural household welfare. The full long-run effects of adult deaths on households remain unknown and are beyond the scope of this paper. In our study, for instance, we found few significant effects on household crop production or asset levels when the deceased adults were sons, daughters, and other non-head/spouse members. However, parents that incurred the death of a child years ago will have fewer members over time to assume the responsibilities of farm operations and contribute to the parents= welfare in their later years. The ability to empirically analyze such longer-term effects will become more feasible as researchers are able to track affected households over a longer time frame. However, even the short run findings of this study lend micro-level credence to the view that premature adult death in areas such as rural Kenya are indeed eroding the livelihoods of many households and that there is a need to find effective ways to mitigate working-age mortality rates and redress their effects especially on poor households.

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Table 3. Age-specific mortality rates per 1000 person-years among 15-44 years-old individuals.

	Mortality per 1000 person-years			Nationwide sample, Kenya 1997-2000		Kisumu and Siaya District sample 1997-2000	
	HIV-negative individuals, Kisesa District, Tanzania, 1994-1998	Nationwide sample, Kenya, 1997-2000	Kisumu and Siaya Districts, Kenya, 1997-2000	Number of deaths expected[a] using mortality rates in Column (A)	actual number of deaths recorded	Number of deaths expected[a] using mortality rates in Column (A)	actual number of deaths recorded
	(A)	(B)	(C)	(D)	(E)	(F)	(G)
Men							
15-24	2.9	2.0	3.8	13.1	9	1.5	2
25-34	4.8	3.8	26.4	11.4	9	0.9	5
35-44	8.6	14.6	88.7	11.2	19	1.0	10
Women							
15-24	1.9	2.1	6.2	9.0	10	0.9	3
25-34	1.6	6.7	37.4	3.3	14	0.3	7
35-44	8.2	7.6	14.0	11.9	11	1.2	2
All							
15-24	2.4	2.0	4.9	22.8	19	2.4	5
25-34	3.0	5.1	31.9	13.5	23	1.2	12
35-44	8.4	10.9	46.9	23.1	30	2.1	12

Note: [a] expected deaths computed as AMR*n*y, where AMR is adult mortality rate of HIV-negative individuals in the Tanzanian sample (column A); n is the number of individuals in the age category in the panel survey; and y is the number of years between the 1997 and 2000 surveys (y=2.75).
Sources: Urassa et al (2001), Table 2, pg 2019 for column A. Columns B, C, E, and G derived from the Tegemeo Institute/Michigan State University Agricultural Monitoring and Policy Analysis Household Surveys in 1997 and 2000.

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Table 4. Difference-in-differences in household composition by gender of deceased working-age adults.

	Households with ***Male*** working-age adult deaths ($D^M = 1$)			Households with ***Female*** working-age adult deaths ($D^F = 1$)			Households without working-age adult deaths ($D = 0$)			Difference-in-Differences ***Male*** working-age adult deaths	Difference-in-Differences ***Female*** working-age adult deaths
	X_{1997} (A)	X_{2000} (B)	$)X^M_1$ (C)	X_{1997} (D)	X_{2000} (E)	$)X^F_1$ (F)	X_{1997} (G)	X_{2000} (H)	$)X_0$ (I)	$)X^M_1!)X_0$ (J)	$)X^F_1!)X_0$ (K)
Household Composition											
Household Size	6.61	6.00	-0.61*	6.89	6.59	-0.30	6.44	6.47	0.03	-0.64*	-0.33
			(1.71)			(0.63)			(0.44)	(1.65)	(0.76)
Male Adults	1.91	1.18	-0.73**	1.76	1.62	0.14	1.58	1.64	0.06*	-0.79**	0.08
			(4.00)			(0.52)			(1.89)	(4.03)	(0.93)
Female Adults	1.70	1.75	0.05	2.14	1.46	-0.68**	1.68	1.78	0.10**	-0.05	-0.78**
			(0.24)			(2.99)			(3.45)	(0.35)	(4.10)
Boys	1.02	1.30	0.27*	0.92	1.30	0.38*	1.20	1.16	-0.04	0.31*	0.42*
			(1.86)			(1.74)			(1.21)	(1.71)	(2.09)
Girls	1.11	1.07	-0.05	1.32	1.22	-0.11	1.15	1.11	-0.03	-0.02	0.08
			(0.36)			(0.47)			(1.03)	(0.07)	(0.39)
Young Children (under 6 years old)	0.86	0.70	-0.16	0.76	1.00	0.24	0.84	0.76	-0.08**	-0.08	0.32*
			(1.02)			(1.16)			(2.46)	(0.47)	(1.67)
Relative/Non-Relative (R/NR) Boys and Girls										$X^M_1!X_0$	$X^F_1!X_0$
R/NR Boys	n.a.	0.23		n.a.	0.68		n.a.	0.29		-0.06	0.39**
										(0.64)	(3.28)
R/NR Girls)	n.a.	0.34		n.a.	0.68		n.a.	0.24		0.10	0.44**
										(1.11)	(4.22)
Number of households		44 [a]			37 [a]			1,339			

Source: Tegemeo Institute (Nairobi)/Michigan State University Agricultural Monitoring and Policy Analysis Household Surveys in 1997 and 2000.
Note: Numbers in parentheses are t-ratios. * indicates significance level at 10 %. ** indicates significance level at 5 %.
(*a*) Two households with both male and female working-age adult deaths are excluded from this table.

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Table 5. The impacts of adult mortality on household composition (OLS with villageHtime dummies) [a]

	) HH Size		) Men		) Women		) Boys		) Girls		) Young Children under 6	
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)	(L)
Working-age Adult Mortality												
Male adults	-0.794*		-0.796**		-0.138		0.212		0.001		-0.055	
	(1.97)		(4.12)		(0.69)		(1.21)		(0.01)		(0.34)	
Female adults	-0.440		-0.206		-0.907**		0.314		0.046		0.320	
	(0.95)		(0.83)		(4.56)		(1.56)		(0.23)		(1.57)	
Male heads		-1.527**		-1.193**		-0.591*		0.268		0.102		-0.091
		(3.44)		(4.96)		(2.10)		(1.15)		(0.53)		(0.40)
Female heads/		-2.131**		-0.161		-1.114**		-0.635		-0.595*		0.389
spouses		(2.95)		(0.39)		(3.20)		(1.30)		(2.00)		(1.58)
Other adult males		-0.089		-0.445*		0.295		0.176		-0.077		-0.024
		(0.14)		(1.65)		(1.15)		(0.76)		(0.36)		(0.11)
Other adult females		0.102		-0.152		-0.813**		0.542**		0.229		0.302
		(0.20)		(0.52)		(3.60)		(2.70)		(1.02)		(1.19)
Elderly Mortality												
Elderly males		-0.549		-0.914**		-0.154		0.400**		0.144		-0.055
		(1.28)		(4.48)		(0.85)		(2.16)		(0.65)		(0.28)
Elderly females		-1.215**		-0.378		-0.929**		0.253		-0.174		0.021
		(2.24)		(1.56)		(3.70)		(0.84)		(0.76)		(0.08)
Constant	1.040	1.301	0.019	0.381	0.628*	0.760*	0.244	0.055	-0.550	-0.603	0.607	0.627
	(0.78)	(1.00)	(0.05)	(1.35)	(1.47)	(2.06)	(0.62)	(0.13)	(0.85)	(0.91)	(1.01)	(1.04)
VillageHTime	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
F-test on Mortality	0.10*	0.00*	0.00*	0.00*	0.00*	0.00*	0.16	0.03*	0.97	0.23	0.27	0.40
R-squared	0.091	0.103	0.084	0.100	0.105	0.119	0.085	0.093	0.076	0.080	0.112	0.113
Number of households	1,422 Households											

Source: Tegemeo Institute (Nairobi)/Michigan State University Agricultural Monitoring and Policy Analysis Household Surveys in 1997 and 2000.
Note: * indicates significance level at 10 %. ** indicates significance level at 5 %. Numbers in parentheses are t-ratios calculated with Huber-White-robust standard errors.
(*a*) A household member is defined as a person who lives with the household at least 6 months in the past 12 months.

Table 6. Difference-in-differences in cultivated land by gender of deceased working-age adults.

	Households with ***Male*** working-age adult deaths ($D^M = 1$)			Households with ***Female*** working-age adult deaths ($D^F = 1$)			Households without working-age adult deaths ($D = 0$)			Difference-in-Differences ***Male*** working-age adult deaths	Difference-in-Differences ***Female*** working-age adult deaths
	X_{1997} (A)	X_{2000} (B)	ΔX^M_1 (C)	X_{1997} (D)	X_{2000} (E)	ΔX^F_1 (F)	X_{1997} (G)	X_{2000} (H)	ΔX_0 (I)	$\Delta X^M_1 \Delta X_0$ (J)	$\Delta X^F_1 \Delta X_0$ (K)
Cultivated Land											
Total area cultivated (acre)	3.53	4.32	0.79	4.04	4.37	0.33	4.15	5.00	0.85**	-0.06	-0.52
			(1.63)			(0.55)			(7.02)	(0.10)	(0.71)
Cereals [a] (acres)	1.67	1.72	0.05	2.62	1.90	-0.72*	2.44	2.02	-0.42**	0.47	-0.30
			(0.16)			(1.82)			(5.38)	(1.09)	(0.64)
Root crops [b] (acres)	1.00	1.49	0.49	0.85	0.71	-0.14	0.97	1.10	0.13*	0.36	-0.27
			(1.25)			(0.65)			(1.73)	(0.83)	(0.60)
High-value crops [c] (acres)	0.87	1.11	0.24	0.57	1.76	1.20**	0.74	1.88	1.14**	-0.90*	0.06
			(0.97)			(3.20)			(13.7)	(1.95)	(0.12)
Crop Production											
Total Gross Output (Ksh)	56,012	58,554	2,542	58,334	61,660	3,325	62,027	74,976	12,950**	-10,408	-9,625
			(0.17)			(0.18)			(5.02)*	(0.72)	(0.61)
Total Gross Output per Acre (Ksh/Acre)	16,591	13,472	-3,119	11,457	17,760	6,303*	16,949	19,274	2,325**	-5,444	3,978
			(0.69)			(2.34)			(2.97)	(1.24)	(0.84)
Number of households		44 [d]			37 [d]			1,339			

Source: Tegemeo Institute (Nairobi)/Michigan State University Agricultural Monitoring and Policy Analysis Household Surveys in 1997 and 2000.
Note: Numbers in parentheses are t-ratios. * indicates significance level at 10 %. ** indicates significance level at 5 %.
(*a*) Cereals include local maize, hybrid maize, beans, sorghum, millet, wheat, banana, and other minor cereals.
(*b*) Root crops include cassava, arrowroots, yams, sweet potato, and peas.
(*c*) High-value crops include coffee, tea, sugarcane, french beans, Irish potato, vegetables, and fruits.
(d) Two households with both male and female working-age adult deaths are excluded from this table.

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Table 7. The impacts of adult mortality on cultivated land.
(OLS with villageHtime dummies)

	) Total Area Cultivated		) Area under Cereals [a]		) Area under Root crops [b]		) Area under High-value crops [c]	
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)
Working-age Adult Mortality								
Male adults	-0.128		0.510		0.115		-0.753**	
	(0.29)		(1.41)		(0.35)		(2.82)	
Female adults	-0.299		-0.127		-0.294		0.122	
	(0.59)		(0.35)		(1.24)		(0.41)	
Male heads		-0.565		0.238		0.053		-0.857**
		(0.93)		(0.50)		(0.09)		(2.72)
Female heads/ spouses		-0.970		1.190*		0.014		0.206
		(0.92)		(1.72)		(0.03)		(0.40)
Other adult males		0.265		0.760		0.168		-0.664
		(0.44)		(1.49)		(0.51)		(1.63)
Other adult females		-0.183		0.103		-0.399		0.113
		(0.32)		(0.24)		(1.48)		(0.32)
Elderly								
Elderly males		0.060		0.170		0.145		-0.257
		(0.14)		(0.57)		(0.42)		(0.86)
Elderly females		1.030		0.931		0.108		-0.009
		(1.55)		(1.64)		(0.25)		(0.03)
Constant	-0.597	-0.723	-0.960	-1.13*	-0.639	-0.692	1.002*	1.097**
	(0.66)	(0.80)	(1.59)	(1.82)	(1.29)	(1.30)	(1.84)	(2.02)
VillageHTime dummies	YES	YES	YES	YES	YES	YES	YES	YES
F-test on Mortality interactions	0.22	0.70	0.36	0.24	0.43	0.66	0.02**	0.04**
	0.141	0.142	0.127	0.130	0.109	110	0.158	0.158
Number of observations	1,420 Households							

Source: Tegemeo Institute (Nairobi)/Michigan State University Agricultural Monitoring and Policy Analysis Household Surveys in 1997 and 2000.
Note: Numbers in parentheses are t-ratios calculated with Huber-White-robust standard errors. * indicates significance level at 10 %. ** indicates significance level at 5 %. (*a*), (*b*), and (*c*) See the notes at the bottom of Table 6.

Table 8. The impacts of adult mortality on crop production.
(Household Fixed Effects model with villageHtime dummies)

	ln(Total Gross Output in Ksh)		*ln*(Total Net Output in Ksh)		*ln*(Total Gross Output in Ksh per Acre)		*ln*(Total Net Output in Ksh per Acre)	
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)
Working-age Adult Mortality								
Male adults	-0.155		-0.088		-0.074		-0.047	
	(0.65)		(0.38)		(0.33)		(0.22)	
Female adults	0.048		-0.181		0.287		0.058	
	(0.21)		(0.78)		(1.29)		(0.27)	
Male heads		-0.567*		-0.679*		-0.328		-0.453
		(1.67)		(2.01)		(1.01)		(1.45)
Female heads/ spouses		-0.101		-0.461		0.270		-0.045
		(0.20)		(0.93)		(0.57)		(0.10)
Other adult males		0.224		0.415		0.159		0.298
		(0.69)		(1.33)		(0.51)		(1.03)
Other adult females		0.039		-0.167		0.262		0.041
		(0.15)		(0.64)		(1.04)		(0.17)
Elderly								
Elderly males		0.194		0.285		0.134		0.263
		(0.77)		(1.12)		(0.56)		(1.12)
Elderly females		0.387		0.544*		0.177		0.334
		(1.12)		(1.67)		(0.54)		(1.11)
Constant	10.20**	10.20**	10.03**	10.03**	9.144**	9.144**	8.985**	8.985**
	(361.9)	(362.1)	(365.3)	(366.2)	(341.0)	(340.7)	(355.2)	(355.4)
VillageHTime dummies	YES	YES	YES	YES	YES	YES	YES	YES
F-test on Mortality interactions	0.80	0.48	0.68	0.12	0.42	0.60	0.94	0.50
Number of observation	1,422		1,417		1,422		1,417	

Source: Tegemeo Institute (Nairobi)/Michigan State University Agricultural Monitoring and Policy Analysis Household Surveys in 1997 and 2000.
Note: Numbers in parentheses are t-ratios calculated with Huber-White-robust standard errors. * indicates significance level at 10 %. ** indicates significance level at 5 %.

Table 9. Difference-in-differences in assets and off-farm income by gender of deceased working-age adults.

	Households with ***Male*** working-age adult deaths ($D^M = 1$)			Households with ***Female*** working-age adult deaths ($D^F = 1$)			Households without working-age adult deaths ($D = 0$)			Difference-in-Differences	
										Male working-age adult deaths	***Female*** working-age adult deaths
	X_{1997} (A)	X_{2000} (B)	$)X^M_1$ (C)	X_{1997} (D)	X_{2000} (E)	$)X^F_1$ (F)	X_{1997} (G)	X_{2000} (H)	$)X_0$ (I)	$)X^M_1!)X_0$ (J)	$)X^F_1!)X_0$ (K)
Asset Values (Ksh)											
Farm Equipments	12,490	9,155	-3,336*	15,706	13,462	-2,244	12,340	11,380	-960*	-2,376	-1,284
			(1.86)			(0.84)			(1.64)	(0.73)	(0.36)
Small Animals [a]	11,774	5,370	-6,404**	8,644	3,681	-4,962**	7,647	5,452	-2,196**	-4,208**	-2,766
			(2.30)			(3.49)			(7.10)	(2.37)	(1.48)
Cattle	43,504	30,636	-12,868**	42,657	22,739	-19,918**	43,394	32,758	-10,636**	-2,232	-9,282
			(2.14)			(3.59)			(9.02)	(0.34)	(1.29)
Off-farm income (Ksh)											
Off-farm income	53,943	28,619	-25,324	87,157	51,734	-35,423	64,162	56,771	-7,390*	-17,934	-28,032
			(1.96)*			(1.38)			(2.75)	(1.20)	(1.64)
Number of households		44 [b]			37 [b]			1,339			

Source: Tegemeo Institute (Nairobi)/Michigan State University Agricultural Monitoring and Policy Analysis Household Surveys in 1997 and 2000.
Note: Numbers in parentheses are t-ratios. * indicates significance level at 10 %. ** indicates significance level at 5 %.
(*a*) Small animals include goats, sheep, pigs, chicken, turkey, and ducks.
(*b*) Two households with both male and female working-age adult deaths are excluded from this table.

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Table 10. The impacts of adult mortality on assets/off-farm income.
(OLS with villageHtime dummies)

	)(Values of farm equipment)		)(Values of small animals)		)(Values of cattle)		)(Off-farm income)	
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)
Working-age Adult Mortality								
Male adults	-3,686*		-5,140*		-1,855		-9,076	
	(1.81)		(2.02)		(0.32)		(0.66)	
Female adults	-371.8		-4,003**		-6,169		-20,544	
	(0.17)		(2.69)		(1.28)		(1.03)	
Male heads		-2,839		-3,749		10,554		-42,830*
		(1.02)		(1.35)		(1.45)		(2.22)
Female heads/spouses		-1,362		-3,942		-8,805		-22,592
		(0.45)		(0.91)		(1.28)		(0.49)
Other adult males		-4,583*		-6,466		-13,156		21,592
		(1.66)		(1.38)		(1.55)		(1.23)
Other adult females		-17.39		-3,839**		4,712		-17,722
		(0.01)		(2.60)		(0.79)		(0.82)
Elderly Mortality								
Elderly males		-2,143		-1,888		716.9		-30,708
		(0.44)		(0.94)		(0.09)		(1.62)
Elderly females		-2,484		356.7		-4,049		-25,904
		(0.85)		(0.26)		(0.63)		(0.94)
Constant	172.0	693.1	1,053	1,692	-9,530	-9,555	-134,237**	122,972**
	(0.20)	(0.34)	(0.55)	(0.83)	(0.96)	(0.96)	(3.00)	(2.90)
VillageHTime	YES	YES	YES	YES	YES	YES	YES	YES
F-test on Mortality	0.19	0.44	0.00*	0.00*	0.41	0.11	0.46	0.12
R-squared	0.126	0.127	0.133	0.134	0.162	0.162	0.140	0.146
Number of households	1,422 Households							

Source: Tegemeo Institute (Nairobi)/Michigan State University Agricultural Monitoring and Policy Analysis Household Surveys in 1997 and 2000.
Note: * indicates significance level at 10 %. Numbers in parentheses are t-ratios calculated with Huber-White-robust standard errors.

Table 11. The differential impacts of adult mortality by 1997 household asset levels.

	Male head mortality		Female head/spouse mortality	
	bottom half	top half	bottom half	top half
Household Composition				
) Household Size	-0.882	-2.011**	-1.620**	-2.880**
	(1.28)	(2.59)	(2.09)	(2.50)
) Men	-1.268**	-0.945**	-0.391	1.097
	(3.42)	(2.30)	(0.62)	(1.22)
) Women	-0.042	-1.176*	-0.810**	-1.810**
	(0.15)	(1.80)	(3.47)	(4.32)
) Boys	0.629**	-0.790	-0.377	-0.556
	(2.10)	(1.60)	(0.55)	(0.49)
) Girls	-0.201	0.516*	-0.523	-1.470**
	(0.73)	(1.85)	(1.52)	(3.47)
) Children under 6	-0.023	0.386	0.482	-0.149
	(0.07)	(0.63)	(1.42)	(0.30)
Cultivated Land				
) Total Area Cultivated	-0.217	0.340	-1.103	-0.008
	(0.21)	(0.41)	(0.75)	(0.01)
) Area under Cereals	-0.024	0.547	-1.055	-1.023
	(0.04)	(0.76)	(1.13)	(0.95)
) Area under Cash Crops	-0.794**	0.728	-0.014	0.340
	(2.74)	(1.36)	(0.02)	(0.38)
Crop Production				
) *ln*(Gross Value Output)	-0.566	0.365	-0.225	-0.948
	(1.55)	(0.83)	(0.43)	(1.37)
) *ln*(Net Value Output)	-0.772*	0.158	-0.423	-0.157
	(1.72)	(0.29)	(0.66)	(0.18)
Assets/Off-farm Income				
) Total Value of Farm Assets	-2,423**	7225	-7,501	-7,042
	(3.22)	(0.76)	(1.23)	(0.71)
) Total Value of Small Animals	-4,152*	1,582	-1,766	-424.6
	(1.85)	(0.18)	(0.66)	(0.09)
) Total Value of Cattle	-10,310	11,038	-17,228**	140.6
	(1.44)	(0.70)	(3.73)	(0.01)
) Off-farm Income	-45,716*	-42,131	31,547	-153,476
	(1.70)	(0.96)	(1.60)	(1.22)
Number of observations	687		735	

Source: Tegemeo Institute (Nairobi)/Michigan State University Agricultural Monitoring and Policy Analysis Household Surveys in 1997 and 2000.
Note: * indicates significance level at 10 %. ** indicates significance level at 5 %. Numbers in parentheses are t-ratios calculated with Huber-White-robust standard errors.

Table A1. Descriptive Statistics.

	Mean	Standard Deviations
Adult Death Variables		
Working-age male adults	0.032	0.177
Working-age female adults	0.029	0.176
Working-age male heads	0.015	0.123
Working-age female heads/spouses	0.007	0.084
Working-age other males	0.017	0.129
Working-age other females	0.022	0.155
Elderly males	0.029	0.167
Elderly females	0.013	0.121
Dependent Variables		
) Household size	-0.004	2.574
) Number of men	0.034	1.301
) Number of women	0.081	1.162
) Number of boys	-0.020	1.196
) Number of girls	-0.034	1.162
) Number of children under 6	-0.071	1.144
) *ln* (Total area cultivated in acre)	0.105	0.567
) *ln* (Area cultivated for cereals)	-0.207	0.717
) *ln* (Area cultivated for root crops)	0.128	0.678
) *ln* (Area cultivated for high-value crops)	0.401	0.701
) *ln* (Total gross output in Ksh)	0.254	1.602
) *ln* (Total net output in Ksh)	0.407	1.511
) *ln* (Total gross output per acre)	0.129	1.463
) *ln* (Total net output per acre)	0.267	1.416
) Values of farm assets	-838.7	29,462
) Values of small animals	-2,197	17,355
) Values of cattle	-17,420	123,567
) Off-farm income in Ksh	-11,464	116,788