Staff Paper

MEASURING THE IMPACTS OF PRIME-AGE ADULT DEATH ON RURAL HOUSEHOLDS IN KENYA

Takashi Yamano and T. S. Jayne

Staff Paper 2002-26 **October, 2002**

Department of Agricultural Economics
MICHIGAN STATE UNIVERSITY
East Lansing, Michigan 48824

MEASURING THE IMPACTS OF PRIME-AGE ADULT DEATH ON RURAL HOUSEHOLDS IN KENYA

Staff Paper 2002-26
by
Takashi Yamano and T. S. Jayne[1]
Corresponding Author: T.S. Jayne, jayne@msu.edu
51 pages

Abstract

Using a two-year panel of 1,422 Kenyan households surveyed in 1997 and 2000, we measure how prime-age adult mortality affects rural households' size and composition, agricultural production, asset levels, and off-farm income. First, the paper uses adult mortality rates from available data on an HIV-negative sample from neighboring Tanzania to predict the number of deaths that might have been expected in the absence of HIV, and compares this to the number of deaths actually recorded over the survey interval in the Kenyan sample. Based on this procedure, only a quarter of the prime-age female deaths in the 25-34 age range and about half of the male deaths in the 35-44 year age range age range could have been predicted on the basis of the HIV-negative Tanzanian adult mortality rates. In the Nyanza area, the discrepancies were even larger over a broader number of age/sex ranges. This provides a strong indication that AIDS accounts for a large proportion of the recorded deaths for these age/sex categories, particularly in the Nyanza area.

Next, using a household fixed-effects model that controls for time-varying effects, 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 death 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 household head 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 prime-age male head. 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 prime-age family members is partially offset by an inflow of other individuals into the family. Other prime-age family members' mortality has less dramatic effects on the households' agricultural production, assets, and off-farm income. Lastly, there is little indication that households are able to recover quickly from the effects of prime-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.

The paper concludes by discussing the implications of these findings for agricultural research and extension programs as well as for safety net programs designed to cushion the impacts of prime-age adult death.

---

[1] Yamano is Research Fellow, Graduate Research Institute for Policy Studies, Tokyo. Jayne is Professor, International Development, Michigan State University, East Lansing.

JEL classification code: O12; J10; Q12

Key words: HIV/AIDS, adult death, agricultural production, Kenya

Acknowledgements: Support for this research has been provided by the Kenya Mission of the United States Agency for International Development under the Tegemeo Agricultural Monitoring and Policy Analysis Project. Support was also provided by the Food Security II Cooperative Agreement (PCE-A-00-97-00044-00) between AID/Global Bureau, Office of Agriculture and Food Security, and the Department of Agricultural Economics at Michigan State University. The Agriculture, Natural Resources and Rural Enterprise Division, Office of Sustainable Development, Bureau for Africa, USAID (AFR/SD/ANRE) also supported this work. The authors thank Kathleen Beegle, Gretchen Birbeck, Amy Damon, Yoko Kijima, Mattias Lundberg, Kaoru Nabeshima, Jennifer Olson, Keijiro Otsuka, James Shaffer, John Strauss, Michael Weber, and Kim Witte for comments on an earlier draft of the paper.

1. INTRODUCTION

Development planners increasingly 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 15-54 year age cohort have risen dramatically since the onset of HIV/AIDS. The estimated life expectancy in Sub-Saharan Africa is now 47, down by five years since 1993, and an estimated 15 years shorter than it would have been in the absence of AIDS (UNAIDS/WHO, 2001). One report estimates that deaths caused by HIV/AIDS in the ten most affected African countries will reduce the labor force by 20 percent or more by 2020 (FAO, 2001). There is widespread agreement that this unprecedented humanitarian disaster will have pervasive economic and food security effects.

A number of studies have modeled the impact of HIV/AIDS on economic growth (e.g., Bloom and Mahal, 1997; Cuddington and Hancock, 1995; Cuddington, 1993). 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 households respond to HIV/AIDS and the subsequent effects on agricultural production, non-farm income, and other key indicators of welfare.

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 prime-age 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; Lundberg, Over, and Mujinja, 2000; Tibaijuka, 1997). 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 prime-age adult mortality more generally, given the substantial AIDS-related increase over the last two decades in the proportion of African households suffering from prime-age adult mortality. While only a certain proportion of prime-age 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; Kahn et al., 1999; UNAIDS/WHO, 1998). Moreover, a growing emphasis among development planners on understanding the dynamics of poverty requires a better understanding of the effects of prime-age 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 prime-age adult mortality 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 household fixed-effects models of changes in outcomes. We focus on "reduced form" specifications in which as little structure as possible is put on household behavior, because so little is currently known about the complex and dynamic responses by households to adult mortality (Whiteside, 2002).

The findings of this study highlight the importance of dis-aggregating the effects of prime-age 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 relates these results to available epidemiological information on the connection between prime-age mortality and AIDS. Section 4 presents the estimation procedure and variables used in the analysis. 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.

2. DATA

(a) 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 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), could not be contacted (45 cases), and refused to participate in the survey (five households). Among these 78 households that could not be re-interviewed, we obviously lack data on adult mortality. It is possible that the prevalence of prime-age mortality was higher among these households than in the panel sample. A study from Kisesa, Tanzania, for instance, found that after the death of a prime-age male household head, 42.5 percent of households had dissolved (remaining members moved away) within one year after the death (Urassa et al., 2001). If these 78 households experienced higher mortality rates than the average, the prevalence of adult mortality in this paper would be underestimated. Therefore, the results in this paper should be treated as the measured impact of prime-age adult mortality among households remaining intact after experiencing the death in the household.

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,[4] 6,856 members were identified again in the 2000 survey. Among those 6,856 individuals, 145 passed away before the 2000 survey.

The 2000 survey encountered 2,357 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 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. Nine persons died because of accidents or violence, and are excluded from the analysis. Of the remaining 151 cases attributed by respondents to disease, 76 individuals were in the conventional "prime age" categories of sexual activity (15-49 years for women and 20-54 years for men) according to World Health Organization (WHO). The other 75 cases of mortality involved individuals older than these age ranges. Adult mortality information for this panel sample is summarized in Table 1.

(b) Meaning of "prime age"

Studies measuring HIV prevalence focus primarily on age categories of prime sexual activity. In Kenya, according to the National AIDS and STE Control Program (NASCOP, 2001), the peak ages for AIDS cases are 25 to 29 for women and 30 to 34 for men.[5] Roughly 75% of

AIDS cases occur in adults between 20 and 45. However, a significant proportion of AIDS cases in men occur in the 45 to 54 age range and in women in the 15-19 age range. For these reasons, we define "prime age" as 15 to 45 years for women and 15 to 54 years for men.

However, standard age ranges of prime sexual activity is not perfectly correlated with the ages of prime economic productivity. Many men and women reach their period of peak economic contribution to the household after age 55, which would suggest that limiting the age ranges over which we assess the effects of prime-age adult mortality on economic outcomes may produce downwardly biased findings. While it is possible to specify models that examine the separate effects of mortality within finely-disaggregated age/sex ranges, degree of freedom problems prohibit this approach. Thus, to examine the sensitivity of the results to the definition of "prime age," we run alternate regressions based on 15-59 year age ranges for both men and women in addition to those based on the standard age ranges specified above.

3. RELATIONSHIP BETWEEN ADULT MORTALITY AND HIV/AIDS

To what extent can disease-related prime-age mortality be attributed to HIV/AIDS? Epidemiological studies from various Eastern and Southern Africa sites indicate that the link is typically strong for particular age-sex categories. Kahn et al. (1999) find that AIDS and pulmonary tuberculosis, which is strongly co-factored with AIDS, accounted for 80 percent of all communicable disease-related deaths within the 15-49 year age group between 1992 and 1995 in the rural north-east of South Africa. In small towns in Uganda, where HIV rates are around 20 percent, 75 percent of adult death is due to AIDS (UNAIDS/WHO, 1998). In Kagera, Tanzania, Ainsworth and Semali (1998) find that AIDS is the leading cause of death among women aged 15 to 39. In Kisea, Tanzania, where HIV prevalence was seven percent among adults aged 15-44 years during the mid 1990s, Urassa et al. (2001) find that mortality rates were almost 20 times higher among HIV-positive individuals than HIV-negative people (73.1 vs. 3.7 deaths per 1000 person years).

In the period between the two Kenyan surveys in 1997 and 2000, five percent of sampled households had at least one prime-age adult death (Table 1). Households in the Kisumu and Siaya districts in Nyanza province suffered the most prime-age adult deaths. Of the 177 sampled households in Kisumu and Siaya districts, 28 households (16 percent) had at least one prime-age adult death between the 1997 and 2000 surveys. Nyanza Province has the highest rates of HIV prevalence in the country (UNAIDS/WHO, 2000).

Table 1 also shows the numbers of adult deaths among men over 54 and women over 49. 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 prime-age ranges. The average age of all adult deaths in Kisumu and Siaya districts is 42 years old, which is far lower than all the other districts, where the mean age at death for all adults was 58 years. Because sexually active adults are more likely to suffer from HIV, it appears likely that the high mortality rate among prime-age adults in Kisumu and Siaya is partially, if not primarily, due to AIDS.

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,[6] and that men (and women) with higher education and income are likely to travel more.[7] 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 prime age men and women who passed away since the 1997 survey. The deceased women were much younger than deceased men at the time of their death. The average age for deceased women was 30.1 years, while it was 37.9 years for men. A high percentage (48.7 percent) of deceased prime-age men were found in the highest per-capita income quartile in 1997, while only 16.2 percent of other prime-age men who were still alive at the second survey were found in the same quartile. About half of the deceased prime-age men (48.7 percent) were household heads. The average years of schooling was 7.4 years among those men. More than half of deceased prime-age women (59.8 percent) were daughters of their household heads. They had 6.2 years of schooling and did not coalesce within any particular income group.

To obtain a rough estimate of the percentage of prime-age deaths in our sample due to AIDS, we draw upon Urassa et al.'s (2001) study showing adult mortality rates among individuals known to be HIV-negative through blood testing in Kisesa District in Tanzania from 1994-1998, and compare these age- and sex-differentiated mortality rates with those obtained in the Kenyan sample from 1997-2000. In the absence of AIDS in Kenya, one might expect to see adult mortality rates similar to those observed among the HIV-negative sample in Tanzania. However, several caveats are in order. First, the mortality rates among the HIV-negative group in the Urassa et al sample overestimate the mortality rates that would have occurred if AIDS did not exist, because AIDS has pervasive community-level effects that indirectly raise adult mortality rates even among HIV-negative individuals. Secondly, overall living standards in Kisesa District, Tanzania, particularly relating to health, may be lower than the mean level in our Kenyan sample. For both these reasons, adult mortality rates among the HIV-negative group in Tanzania are likely to overestimate what might be expected in an HIV-negative Kenyan population. Therefore, this procedure is likely to provide a conservative estimate of the number of prime-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 either the overall Kenya sample or 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 actually 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.

4. METHOD FOR ESTIMATING THE EFFECTS OF PRIME-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 prime-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 our main purpose is to empirically examine the effects of adult mortality on particular household-level outcomes, our approach is to place as few restrictions on the data as possible.

(A) 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 prime-age adult death (D), and the comparison group is comprised of households not experiencing prime-age adult deaths (N). Ideally, we would like to measure the impact of the prime-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 prime-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 prime-age adult death within the treatment group (a reflexive estimator): $E(\Delta Y_D) = E(Y_{D1}) - E(Y_{D0})$. This estimator, however, might pick up time trends or impacts of shocks that are unrelated to the prime-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:

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

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

$$E(\delta^M) = E(\Delta Y^M{}_D) - E(\Delta Y_N) \text{ and}$$
$$E(\delta^F) = E(\Delta Y^F{}_D) - E(\Delta Y_N). \qquad (2)$$

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

As discussed in Section 2, about half of the deceased prime-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, prime-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 prime-age adult mortality and (b) household characteristics that affect the likelihood of offering terminal care. Fortunately, however, the time-invariant group characteristics that are correlated with the prime-age adult mortality are controlled for in difference-in-difference estimators because we take a difference among the same group over time.

(B) Estimation Strategy

Although the DIDs in equation (2) control for group-specific characteristics and the average change in outcomes over time, there may be other area-specific time-variant effects that might be correlated with both the prime-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:

$$\Delta Y_i = D_i^M \delta^M + D_i^F \delta^F + D_i^E \delta^E + V\beta + \Delta e_i \qquad (3)$$

where D_i^M and D_i^F are vectors of the number of prime-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 Δe_i is the error term.

In equation (3), we also include elderly deaths. Although our primary interest is on the effects of prime-age adult mortality, the definition of “prime-age” is inherently arbitrary. Elderly persons may have similar effects on their households as that of prime-age adults. On the other hand, households may have had more time to 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 prime-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 40 and 34 households that incurred the death of at least one elderly male and elderly female, respectively.

The impacts of the death of a prime-age adult may also differ depending on the status within the household of the deceased member. Some members are also more central to the household’s existence than others. W might conceive of household heads and spouses as “core members” of the household, and other prime-age adults as “non-core” members. Core members are more likely to play the primary role in the social cohesion of the household for as long as it exists, make the major decisions on behalf of the household, and have accumulated knowledge and skills needed for the survival of the household. For instance, 94 and 93 percent of the individuals identified as household heads and spouses in the 2000 survey were residing on the household premises at least six months in both 1997 and 2000, as opposed to 78 and 81 percent for sons and daughters, respectively, and only 55 percent for other household members (relatives and non-relatives). To test for possible status-differentiated effects of adult death, we develop dummy variables that separate the effects of death between household heads and spouse (“core” members), and other prime-age members (i.e., adult sons, daughters, other relatives, and non-relatives). Among the 39 households with male prime-age deaths, 16 of the deceased were heads of household, while the other 23 were other "non-core" adults (usually younger brothers or cousins of the household head or spouse). Among the 37 households with at least one female prime-age adult death, 7 of the deceased were heads or spouses, while 30 were other adult females.

We feel that there are no other plausible time-variant household-level variables that are not endogenous to the impacts of adult mortality in the household; for this reason, no household-level variables are included in the models besides the adult death 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 total land cultivated into three categories: cereals, root crops, and high-value crops. The third set of outcomes are on assets (farm equipments, 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.

5. RESULTS

(A) 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.[8] Small 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 a core adult member may cause other household members to move away, as when the death of a spouse thought to have had AIDS may provide incentives for other female 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 widower to take the spouse's sister or cousin as his new wife should she choose to remain in the household (Matangadura 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 prime-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 prime-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 (+0.03) in the size of households not incurring a prime-age death (Column I). Thus, the DID indicates that household size declined by 0.64 person among households incurring the death of a prime-age male compared to the control group (Column J). In contrast, household size shrunk by 0.33 persons in households incurring a prime-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 prime-age adult mortality have significantly fewer adult male and female members (Column C and F). If households experiencing prime-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 prime-age adult mortality, households with male and female prime-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.[9]

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 prime-age adult mortality than for households that did not (Column J and K). This suggests that boys might have been adopted by households with prime-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 prime-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), indicating no substitution. In contrast, the death of a prime-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 that person's position in the household. For this reason, we stratify household members into core members (head or spouse) and non-core members (sons, daughters, relatives, and non-relatives) to explicitly examine the specific effects of different age-gender-status combinations on household composition in Columns B, D, F, H, J, and L. We also include numbers of deceased elderly. Changes in household size, shown in Column B, are the sum of the changes in the other columns. For example, the death of a prime-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 male prime-age head of household is mainly caused by a -1.19 change in the number of adult men (Column D) and a -0.59 change 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 seem puzzling. One potential explanation, commonly discussed in the literature, is that in patrilineal societies that characterize most of the areas in this survey, the widow may lose her rights to the deceased husband's land and be forced to return to her parents' family (Matangadura et al., 1999; Rugalema et al., 1999). However, of the 22 households who lost their male heads-of-household, we found 21 wives still living in their households in 2000.

Another explanation is that older daughters may be married off for bride doweries in times of financial stress such as after the death of the head-of-household. Traditionally, the family of the bride acquires cattle and/or other assets as bride payment. Of the 22 households who lost their male heads-of-household, 72.6 percent of the daughters over 16 years of age left their households, in contrast to only 41.1 percent among all other households. Of these daughters who left their household in the death-stricken families, marriage accounted for 62.5 percent of them according to the survey respondents. Consistent with this explanation and as discussed further later, households afflicted by male head-of-household mortality had a significantly higher value of cattle assets in 2000 than in 1997. Thus it seems that the 0.59 reduction in the number of women in households incurring the death of their male head-of-household may partially reflect a coping strategy to accumulate assets through marrying off daughters.

The death of a prime-age female core member 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 core female's death. Additionally, her death reduces the number of younger 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 boys and girls (aged 7 to 16) residents in 1997 left the household by 2000; of these five were to attend school and the rest were to live with relatives or other households. In contrast, the death of a non-core female adult 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 now-deceased non-core female adult. This indicates, as might be expected, that the effects of adult death do not depend only on the age and gender of the deceased, but also the position of the individual in the household.

The death of a non-core male member 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 a male adult to cope with the death of a non-core male member. We also find that these households are more likely to retain older sons, who are likely to be productive agricultural workers, in the household. Among afflicted households, 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 a non-spouse prime-age woman decreases the number of women in the household by 0.81, 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 a non-spouse female adult, we find that relative boys (nephews of the head-of-household or spouse) are the main source of adjustment. Nephews comprise 31.8 percent of boys aged 6 to 16 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 prime-age adult mortality, which generally occurs suddenly and 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. However, the death of an elderly male is positively associated 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.

The results in this sub-section indicate that households in rural Kenya are not able to offset their loss of core adult members. The death of members who are most likely to be the foundation of the household, i.e., the head or spouse, decreases the size of household by more than one person. On the other hand, households are able to partially compensate for the loss of labor of non-core adults, either through attracting new members or delaying the departure of older children from the household. These results indicate that the effects of adult mortality are sensitive to the position of the deceased within the household.

(B) Farm Production

This sub-section estimates the effect of prime-age adult mortality on cultivated area and crop production. Households suffering adult mortality may experience at least three sources of shocks on farm 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, column K, suggest that the death of a prime-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 – cereals, root crops, and high-value crops – we find a significant gender difference in the change over time in land size devoted to high-value crops.[10] Among households without any prime-age adult death, the land size devoted to high-value crops between 1997 and 2000 significantly increased by 1.14 acres. Yet among households incurring a prime-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 prime-age man. The difference in cash crop area between the control group and households incurring prime-age female adult mortality is not statistically different from zero.

In regression analyses, we find that the death of a core prime-age woman decreases the size of cultivated land devoted to cereals by 1.89 acres (Table 7, Column D), consistent with Davison's (1988) and Francis' (1998) characterization of the female head-of-household as having primary responsibility for growing the household's food supply. The death of a non-core woman however, does not significantly affect cereal area cultivated. As in Table 6, the death of a prime-age man decreases the size of cultivated land devoted to high-value crops by 0.83 acres (Column G). When distinctions are made between the male head-of-household and other adult males, the greater adverse impact of the death of the household head on high-value crop area becomes apparent (Column H). Interestingly, a prime-age male death actually increases the amount of land devoted to cereals by 0.72 acres (t-ratio=1.78). 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 prime-age man, households lost about 9,075 Ksh per acre (about US$121) in net revenue.[11]

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 total farm output and total farm output per acre in between the two surveys.

We first present descriptive information on gross crop output in Table 6. Largely because of more favorable weather in the 1999/2000 crop season, gross crop output was higher than for the 1996/97 season, even among households experiencing male and female prime-age adult mortality. However, their increase in crop output is much smaller than it is for households without any prime-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 prime-age woman, 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 prime-age man experienced a decline in total output per acre (Column C). However, the DIDs are not statistically significant.

The regression results in Table 8 indicate that the death of core-member adults (household heads and spouses) generally adversely affects crop output and output per acre, by between 40 and 80 percent. However, none of these effects are statistically different from zero even at the 10 percent level. To examine the robustness of these findings, we redefined the category of "prime age" from 15-49 years for women and from 15-54 years for men, to 15-59 years for both sexes. As explained in Section 2, the rationale for this is to approximate more closely the age ranges of prime economic contribution to the household rather than the age ranges typically reported for vulnerability to sexually transmitted diseases. After modifying these age ranges, 8 men and 6 women changed from the elderly to the prime age categories.

When using the alternative age ranges, the results change somewhat. The *gross* value of crop output decreases significantly by 57 percent for households incurring the death of a male household head (Table A2, column B).[12] Similar effects are found on the total *net* value of output, after taking account of the costs of chemical fertilizer, seed, and land preparation.[13] The death of a household head reduces net crop output by 68 percent (Column D). Adverse crop output effects of similar magnitude are noted in the case of female head and spouse mortality, but these effects are imprecisely measured. We do not find any statistically significant adverse effects on crop output after the death of other household members.

Why might the effects of prime-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 provide a higher value of output than cereal and root crops, the measured impacts on crop value may be greater. Because of data limitations, we could not measure the effects of adult death on food consumption; these age/gender/position effects could be very different.

Secondly, as discussed earlier, the death of the male head-of-household tends to cause older daughters to leave the household as well. Because these daughters most likely contributed to the household's agricultural production, the measured reduction in agricultural production in response to the male household head's death also incorporates the effect of a loss in the daughter's agricultural labor as well.

Thirdly, 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 (Gillespie and Haddad 2002; Matangadura et al., 1999; Barnett et al., 1995). Loss of land rights, in addition to the loss of agricultural labor, may account for the observed reduction in cropped area for households losing a prime-age male head of household, although there is not strong evidence of this from our results, which show that there is no significant changes in the amount of cultivated land in households incurring the death of a male household head. Our findings indicate that the most important sources of significant decline in crop output in response to male household head mortality are (1) shifting from high value to low value crops, which may reflect a loss in specialized knowledge about crop husbandry or marketing for particular cash crops; (2) a loss in labor not only from the deceased but also from other family members who leave, which appears to affect crop choice and intensity of cultivation more so than total area under cultivation.

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. This appears to be because of households' greater ability to offset the loss of non-core adults through attracting new members. These findings underscore the importance of carefully differentiating the gender, position, and age categories of deceased individuals when measuring the effects of adult mortality. Moreover, we find that the effects of prime age mortality can be sensitive to how prime age is defined.[14]

(C) 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 I), the decline was particularly acute among households experiencing prime-age adult death (Columns C and F). However, because of large standard errors, only in the case of small animals (goats, sheep, and chickens) were the DIDs statistically different between households experience adult male and female mortality and the control group. The value of small animals declined by 5,784 Ksh and 6,419 Ksh among households with the death of a prime-age man and women, respectively. By contrast, the value of small animals declined by 2,238 Ksh among households without any prime-age adult deaths. The difference between the two (DID) is 3,546 Ksh, a 30 percent reduction from the initial level in 1997.

The regression results in Table 10 provide a similar picture of the negative effects of prime-age adult death on assets. The death of a prime-age man decreases the value of farm equipment by 3,552 Ksh (a 28.5 percent reduction). By contrast, the surviving husband appears less likely to sell off farm equipment after the death of an adult woman. The sale of farm equipment after the husband's death may partially reflect men's greater use of such equipment in crop cultivation patterns. His death also induces a sell-off or consumption of small animals over time, although this effect is imprecisely measured. The value of small animals declines by 4,319 Ksh (43.1 percent) after the death of a prime-age woman (Column C). 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 coping with the prime-age adult deaths by selling or consuming small stock. In fact, members in households incurring the death of a male head of household appear to gain livestock assets, possibly due to bride doweries after daughters marry.

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 two rows in Table 9 present the changes in off-farm income between households afflicted by adult death and the control group. As expected, households with the prime-age adult death 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 indicate that only the death of a male head-of-household has significant negative effects on off-farm income. The death of a head reduces the off-farm income by 43,081 Ksh (roughly US$595), which is about 79 percent of the initial off-farm income among households who experienced the death of prime-age man. 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.

6. CONCLUSIONS

The starting point for the design of effective programs to mitigate the impacts of adult deaths caused by AIDS is accurate information on how households are affected by, and respond to, the death of prime-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 prime-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 seven major findings: First, there are important gender differences in the prevalence of adult death. About half of the deceased prime-age men are in the highest per capita income quartile in the 1997 survey and they are disproportionally likely to be household heads. 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 prime-age women were distributed more evenly through all income quartiles and are most likely to be daughters in their households. The fact that we found many deceased prime-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' behaviors. Discussions with several NGO representatives in Kenya indicated that their educational programs are targeted toward low-income individuals, but these results indicate a need to target relatively high-income men as well.

Second, the prevalence of adult death is concentrated in particular areas. Of the 73 prime-age adults who passed away between the 1997 and 2000 surveys, 32 (about 44 percent) are from Nyanza Province, where HIV infection rates are known to be high. 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. This finding is in contrast to earlier findings from Tanzania. Older daughters in households afflicted by male head-of-household mortality were very likely to leave the household, often to get married, which appears to provide some financial benefits to afflicted households in the form of bride payments. The decline in household size was largest in cases of female head/spouse mortality, as this was associated with a decline in the number of younger boys and girls in the household. By contrast, the death of other prime-age family members is partially offset by the entry or return of other adult members. These findings are consistent with household coping behaviors described by qualitative studies in the literature.

Fourth, the effects of adult death on farm production are also sensitive to 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 value of the household's crop production (net of major cash input costs); effects are less dramatic for other prime-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 male prime-age mortality. Although women provide most of the households' labor input for crop cultivation, our finding is that male household heads' death has the most dramatic effect on crop production. The results indicate that there are two reasons accounting for this: (a) the shift in crop output 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 loss of labor from the departure of older daughters from the household, which seems to be most prevalent in households where the male head of household had died.

Fifth, households seem to cope with prime-age adult death 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 prime-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, households appears to suffer the greatest decline in household income from the death of a core prime-age female member (roughly $1000 per year) although this effect was imprecisely estimated. More statistically significant but less adverse effects on off-farm income (-$780 per year) are observed for households of deceased male heads.

Lastly, 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.

The findings point to the need for special assistance to households incurring the death of a relatively senior prime-age male household head. The loss of income from cultivation of cash crops such as tea, sugarcane, and horticulture was a major source of hardship for these households. The decline in cash crop income appears to result from the loss in family labor, as well as a loss in crop husbandry and marketing knowledge that prevents the continued cultivation of such crops. 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.

Non-governmental organizations providing targeted assistance to relatives of AIDS victims might prioritize households incurring the recent death of a prime-age male household head. Concessional access to credit may reduce the need for newly single female-headed households to sell off productive assets, prematurely let go of productive family members (e.g., marry off older daughters for dowery resources), or resort to dangerous activities like selling casual sex – all activities that trade off long-run welfare in order to meet immediate survival needs. Providing concessional credit to households losing a prime-age male head would, in theory, lead to decisions that reduce risky behaviors with short-run payoffs in favor of decisions more harmonious with long-run interests. However, possible moral hazard behavior of prime-age men would need to be considered carefully. In particular, to what extent would men be motivated to take greater risks in their behavior knowing that assistance would be available to their families in the event of their death?

Some longstanding traditions that formerly played a important social function, such as "widow inheritance," may spread the transmission of AIDS and appears to have become dysfunctional since the advent of the disease. Safety net strategies to provide assistance to households affected by male head-of-household mortality may help reduce the economic need for widow inheritance or even riskier behaviors such as the selling of casual sex.

There are several implications for agricultural research systems. The rising incidence of prime-age adult death has, for at least some households, increased the demand for labor-saving technologies and production systems. Farming systems that are less labor-intensive will be cushioned better from sudden adult death, other things equal. However, all other things are often not equal. For example, some crops may provide relatively high returns to land and labor in a given area but require relatively high labor input to achieve these returns. Households incurring severe labor constraints due to the death of prime age members may still be able to hire labor to maintain desired cropping patterns, so prioritizing agricultural research to aim for labor-saving technology is clearly not necessarily in the best interests of small-scale farmers, even many afflicted by prime-age mortality. But clearly other afflicted households may be highly constrained in their crop and technology choices, due to severe constraints on family labor and the ability to hire labor.[15] For this sub-set of afflicted households, improved production technologies that can achieve reasonable returns with limited labor input may become attractive. Certain types of "conservation farming" techniques, involving minimal tillage, may become increasingly attractive for labor-constrained rural households.

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 did not find any 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. Morever, there are likely to be many HIV-positive individuals in our sample, the effects of which will be felt only in future 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 credence to the relatively ominous predictions about the magnitude of economic shocks resulting from the death of prime age adults, and the pressing need to find ways to mitigate prime-age mortality rates and redress their effects on household livelihoods in developing countries.

REFERENCES

Ainsworth, M., Semali, I. 1995. The Impact of Adult Deaths on Household Composition. Mimeo. World Bank, Washington, DC.

Ainsworth, M., Semali, I.. 1998. Who Is Most Likely to Die of AIDS? Socioeconomic Correlates of Adult Deaths in Kagera Region, Tanzania, in: Ainsworth, M., Fransen, L., Over, M. (Eds.) Confronting AIDS: Evidence from the Developing World, European Commission, Brussels.

Alderman, H., Behrman, J.R., Kohler, H-P., Maluccio, J.A., Watkins, S.C. 2000. Attrition in Longitudinal Household Survey Data: Some Tests for Three Developing Country Samples. *Demographic Research* 5, 79-124.

Barnett, T., Blaikie, P. 1992. AIDS in Africa: Its Present and Future Impact. Belhaven Press, London.

Barnett, T., Tumushabe, J., Bantebya, G., Ssebuliba, R., Ngasongwa, J., Kapinga, D., Ndelike, M., Drinkwater, M., Mitti, G., Haslwimmer, M.1995. Field Report: The Social and Economic Impact of Hiv/AIDS on Farming Systems and Livelihoods in Rural Africa: Some Experience and Lessons from Uganda, Tanzania, and Zambia. *Journal of International Development* 7, 163-176.

Bloom, D.E, Mahal, A.S. 1997. Does the AIDS Epidemic Threaten Economic Growth? *Journal of Econometrics* 77, 105-124.

Buve, A., Carael, M., Hayes, R. J., Auvert, B., Ferry, B. Robinson, N.J., Angonou, S., Kanhonou, L., Laourou, M., Abaga, S., Akam, E., Zekeng, L., Chege, J., Kahindo, M., Rutenberg, N., Kaona, F., Musonda, R., Sukwa, T., Morison, L., Weiss, H.A. Laga, M.. 2001. Multicentre Study on Factors Determining Differences in Rate of Spread of Hiv in Sub-Saharan Africa: Methods and Prevalence of Hiv Infection. *AIDS* 15, suppl 4, S5-S14.

Cuddington, J.T. 1993. Further Results on the Macroeconomic Effects of AIDS: The Dualistic, Labor-surplus Economy. *World Bank Economic Review* 7, 403-417.

Cuddington, J., Hancock, J. 1995. The Macroeconomic Impact of AIDS in Malawi: A Dualistic, Labour Surplus Economy. *Journal of African Economies* 4, 1-28.

Davison, J. 1988. Who Owns What? Land Registration and Tensions in Gender Relations of Production in Kenya, in: Davison, J. (Ed.), Agriculture, Women and Land: The African Experience, Boulder, Westview, Colorado.

Deheneffe, J., Carael, M., Noumbissi, A. 1998. Socioeconomic Determinants of Sexual Behaviour and Condom Use, in: Ainsworth, M., Fransen, L., Over, M.(Eds.) Confronting AIDS: Evidence from the Developing World, European Commission, Brussels.

Filmer, D. 1998. The Economic Correlation of Sexual Behaviour: a Summary of Results from an Analysis of Dhs Data, in: Ainsworth, M., Fransen, L., Over, M.(Eds.) Confronting AIDS: Evidence from the Developing World, European Commission, Brussels.

FAO (Food and Agriculture Organization). 2001. The Impact of AIDS on Food Security. Committee on World Food Security, twenty-seventh session, Rome 28 April - 1 May 2001. Downloadable at: http://www.fao.org/docrep/meeting/003/Y0310E.htm

Francis, E. 1998. Gender and Rural Livelihoods in Kenya. *Journal of Development Studies,* 35, 72-95.

Garenne, M., Kahn, K., Tollman, S., Gear, J. 2000. Causes of Death in a Rural Area of South Africa: an International Perspective, *Journal of Tropical Pediatrics*, 46 (June), 183-190.

Gillespie, S., Haddad, L. 2002. IFPRI 2001/2002 Annual Report Essay: Food Security as a response to AIDS. International Food Policy Research Institute, Washington DC.

Janjaroen, W. 1998. The Impact of AIDS on Household Composition and Consumption in Thailand, in: Ainsworth, M., Fransen, L., Over, M.(Eds.) Confronting AIDS: Evidence from the developing world, European Commission, Brussels.

Kahn, K., Tollman, S., Garenne, M., Gear, J. 1999. Who Dies of What? Determining Cause of Death in South Africa's Rural North-east. *Tropical Medicine and International Health,* 4, 433-441.

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

Lagarde, E., Carael, M., Glynn, J.R., Kanhonou, L., Abega, S.C., Kahindo, M., Musonda, R., Auvert, B., Buve, A. 2001. Education Level Is Associated with Condom Use Within Non-spousal Partnership in Four Cities of Sub-Saharan Africa. *AIDS,* 15, 1399-1408.

Leighton, C. 1996. The Direct and Indirect Costs of HIV/AIDS, in S. Forsythe and B. Rau (eds) *AIDS in Kenya: Socioeconomic Impact and Policy Implications,* Family Heath International/AIDSCAP, Nairobi.

Lundberg, M., Over, M., Mujinja, P. 2000. Sources of Financial Assistance for Households Suffering an Adult Death in Kagera, Tanzania. *South African Journal of Economics* 68, 947-984.

Menon, R., Wawer, M.J., Konde-Lule, J.K., Sewanlambo,N.K., Li, C. 1998. The Economic Impact of Adult Mortality on Households in Rakai District, Uganda, in: Ainsworth, M., Fransen, L., Over, M.(Eds.) Confronting AIDS: Evidence from the developing world, European Commission, Brussels.

Mutangadura, G., Mukurazita, D., Jackson, H. 1999. A Review of Household and Community Responses to the HIV/AIDS Epidemic in the Rural Areas of Sub-Saharan Africa. Draft final report submitted by SAfAIDS to UNAIDS (February).

NASCOP (National AIDS and STDs Control Programme). 2001. Estimating National HIV Prevalence in Kenya from Sentiel Surveillance Data, NASCOP, Nairobi, Kenya, June report.

Nweke, F. 2002. *The Cassava Transformation.* Michigan State University Press, East Lansing.

Quigley, M., Chandramohan, D., Setel, P, Binka, F, and Rodrigues, L. 2000. Validity of Data-derived Algorithms for Ascertaining Causes of Adult Death in Two African Sites Using Verbal Autopsy. *Tropical Medicine and International Health,* 5 (1), 33-39.

Rugalema, G., with S. Weigang and J. Mbwika. 1999. HIV/AIDS and the Commercial Agricultural Sector of Kenya. Report. Food and Agriculture Organization, United Nations Development Programme, Rome.

Shah, M., Osborne, N., Mbilizi, T., Vilili, G. 2002. Impact of HIV/AIDS on Agricultural Production Systems and Rural Livelihoods in the Central Region of Malawi. CARE International in Malawi, Lilongwe.

Tibaijuka, A.K. 1997. AIDS and Economic Welfare in Peasant Agriculture: Case Studies from Kagabiro Village, Kagera Region, Tanzania. *World Development* 25, 963-975.

Udry, C. 1996. Gender, Agricultural Production, and the Theory of the Household. Journal of Political Economy 104, 1010-1046.

Urassa, M., Boerma, J.T., Isingo, R., Ngalula, J., Ng'weshemi, J., Mwaluko, G., Zaba, B. 2001. The Impact of HIV/AIDS on Mortality and Household Mobility in Rural Tanzania. *AIDS,* 15, 2017-2023.

UNAIDS/WHO. 1998. AIDS Epidemic Update (December). UNAIDS/WHO, Geneva.

UNAIDS/WHO. 2000. Kenya: Epidemiological Fact Sheets on HIV/AIDS and Sexually Transmitted Infections, UNAIDS/WHO, Geneva.

UNAIDS/WHO. 2001. AIDS Epidemic Update, UNAIDS/WHO, Geneva.

Whiteside, A. 2002. The Economics of HIV/AIDS. International AIDS Economics Network, Economics of HIV/AIDS in Developing Countries Symposium, Barcelona, Spain, 6 July 2002.

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

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 prime-age[b] adult death in 1997-2000[c] (C)	Number of deceased adults		Average age of all deceased adults (F)
				Prime-age (D)	Elderly (E)	
	- Number -	- Number -	- Number (%) -	- Number -		- Age -
Coastal	88	3	5 (6 %)	5	10	59
Eastern	233	9	8 (3 %)	8	10	59
Nyanza	262	18	30 (11 %)	32	16	43
Kisumu/Siaya	177	11	28 (16 %)	30	13	42
Kisii	85	7	2 (2 %)	2	3	51
Western	290	13	12 (4 %)	12	19	55
Central	174	7	4 (2 %)	5	6	53
Rift Valley	375	28	14 (4 %)	14	14	56
Total	1,422	78	73 (5 %)	76	75	52

Source: Tegemeo Institute (Nairobi)/Michigan State University Agricultural Monitoring and Policy Analysis Household Surveys in 1997 and 2000.

Note: (*a*) Deaths caused by accidents were not included. (*b*) Prime-age is defined as 15-49 for women and 15-54 for men. (*c*) There are three households that had more than two prime-age adult deaths. One of those three is found in Nyanza, and it had three prime-age adult deaths.

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

	Deceased Prime-age Adults		Other Prime-age Adults	
	Male (A)	Female (B)	Male (C)	Female (D)
Number of prime-age adults	39	37	3,326	3,171
Individual Characteristics				
Age (at death)	37.9	30.1	27.3	26.1
Schooling (years)	7.4	6.2	8.6	8.0
Age group (%)				
15-19	5.1	16.2	27.2	29.0
20-29	17.9	37.8	39.1	40.8
30-39	30.8	24.3	17.3	17.2
40-49	23.1	21.7	10.7	13.0
50-54	23.1	n.a.	5.7	n.a.
	100	100	100	100
Relationship to the household head (%)				
Head/Spouse	48.7	16.2	20.2	28.6
Son/Daughter	38.5	64.9	59.8	54.0
Others	12.8	18.9	20.0	17.4
	100	100	100	100
1997 Household Income Quartile (%)				
Highest	48.7	35.1	15.4	17.7
Mid-high	20.5	16.2	26.6	28.2
Mid-low	10.3	32.4	26.7	26.7
Lowest	20.5	16.3	31.3	27.4
	100	100	100	100
Year of death (%)				
1997	15.4	8.1	n.a.	n.a.
1998	28.2	37.8	n.a.	n.a.
1999	30.8	35.1	n.a.	n.a.
2000	25.6	19.0	n.a.	n.a.
	100	100		

Source: Tegemeo Institute (Nairobi)/Michigan State University Agricultural Monitoring and Policy Analysis Household Surveys in 1997 and 2000.
Note: (*a*) Prime-age is defined as 15-49 for women and 15-54 for men.

Table 3. Age-Specific Mortality Rates per 1000 person-years among persons 15-44 years

	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

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.

Note: [a] expected deaths computed as AMR*n*y, where AMR is adult mortality rate of HIV-negative individuals in the Tanzanian sample (as in 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).

Table 4. Difference-in-Differences in Household Composition by Gender of Deceased Prime-age Adults

	Households with ***Male*** prime-age adult deaths ($D^M = 1$)			Households with ***Female*** prime-age adult deaths ($D^F = 1$)			Households without prime-age adult deaths ($D = 0$)			Difference-in-Differences: ***Male*** prime-age adult deaths	Difference-in-Differences: ***Female*** prime-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)
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**	0.20
(> 17 years)			(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**
(> 17 years)			(0.24)			(2.99)			(3.45)	(0.35)	(4.10)
Boys	1.02	1.30	0.28*	0.92	1.30	0.38*	1.20	1.16	-0.04	0.32*	0.42*
(6 to 16 years)			(1.86)			(1.74)			(1.21)	(1.71)	(2.09)
Girls	1.11	1.07	-0.04	1.32	1.22	-0.10	1.15	1.11	-0.04	0.00	0.06
(6 to 16 years)			(0.36)			(0.47)			(1.03)	(0.07)	(0.39)
Young Children	0.86	0.70	-0.16	0.76	1.00	0.24	0.84	0.76	-0.08*	0.08	-0.32*
(< 6 years)			(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**
(6 to 16 years)										(0.64)	(3.28)
R/NR Girls	n.a.	0.34		n.a.	0.68		n.a.	0.24		0.10	0.44**
(6 to 16 years)										(1.11)	(4.22)
Number of households		38 [a]			34 [a]			1,349			

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 at 10 %. ** indicates significance at 5 %.
(*a*) One households with both male and female prime-age adult deaths are excluded from this table.

Table 5. The Impacts of Adult Mortality on Household Composition (OLS with village×time dummies)

	Δ HH Size		Δ Men 17 & older		Δ Women 17 & older		Δ Boys 6 to 16 years old		Δ Girls 6 to 16 years old		Δ Young Children 5 & younger	
Effect of Mortality of:	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)	(L)
Prime Age Member												
adult male	-0.794*		-0.796*		-0.138		0.212		0.001		-0.055	
	(1.97)		(4.12)		(0.69)		(1.21)		(0.01)		(0.34)	
adult female	-0.440		-0.206		-0.907*		0.314		0.046		0.320	
	(0.95)		(0.83)		(4.56)		(1.56)		(0.23)		(1.57)	
Prime Age Core Member:												
adult male head of household		-1.527*		-1.193*		-0.591*		0.268		0.102		-0.091
		(3.44)		(4.96)		(2.10)		(1.15)		(0.53)		(0.40)
adult female head or spouse		-2.131*		-0.161		-1.114*		-0.635		-0.595*		0.389
		(2.95)		(0.39)		(3.20)		(1.30)		(2.00)		(1.58)
Non-Core Member												
adult male, not head		-0.089		-0.445*		0.295		0.176		-0.077		-0.024
		(0.14)		(1.65)		(1.15)		(0.76)		(0.36)		(0.11)
adult female, not head or spouse		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 Member												
male		-0.549		-0.914*		-0.154		0.400*		0.144		-0.055
		(1.28)		(4.48)		(0.85)		(2.16)		(0.65)		(0.28)
female		-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)
Village×Time dummies	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
F-test on prime age 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 %. Numbers in parentheses are t-ratios calculated with Huber-White-robust standard errors.

Table 6. Difference-in-Differences in Cultivated Land and Crop Production by Gender of Deceased Prime-age Adult

	Households with ***Male*** prime-age adult deaths ($D^M = 1$)			Households with ***Female*** prime-age adult deaths ($D^F = 1$)			Households without prime-age adult deaths (D = 0)			Difference-in-Differences	
										Male prime-age adult deaths	***Female*** prime-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)	3.61	4.75	1.14*	3.98	4.41	0.43	4.15	4.98	0.83**	0.30	-0.41
			(2.09)			(0.64)			(6.93)	(0.42)	(0.53)
Cereals [a] (acres)	1.74	1.96	0.22	2.48	2.04	-0.44	2.44	2.01	-0.43**	0.65	-0.01
			(0.57)			(0.93)			(5.57)	(1.40)	(0.02)
Root crops [b] (acres)	0.96	1.64	0.68	0.94	0.74	-0.20	0.97	1.09	0.13*	0.55	-0.33
			(1.50)			(0.81)			(1.68)	(1.18)	(0.69)
High-value crops [c] (acres)	0.91	1.15	0.24	0.56	1.64	1.07**	0.74	1.88	1.14**	-0.90*	0.07
			(0.87)			(2.75)			(13.7)	(1.81)	(0.12)
Crop Production											
Total Gross Output (Ksh)	59,739	66,882	7,143	41,843	57,231	15,388	62,275	74,709	12,435**	-5,292	2,953
			(0.42)			(1.58)			(4.79)	(0.34)	(0.18)
Total Gross Output per Acre (Ksh/Acre)	17,417	14,331	-3,086	11,130	15,803	4,673**	16,910	19,260	2,350**	-5,436	2,323
			(0.59)			(2.37)			(3.02)	(1.15)	(0.47)
Number of households		38 [d]			34 [d]			1,349			

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*) One households with both male and female prime-age adult deaths are excluded from this table.

Table 7. The Impacts of Adult Mortality on Cultivated Land (OLS with village×time dummies)

Effects of Mortality of:	Δ Total Area Cultivated (A)	(B)	Δ Cereals [a] (C)	(D)	Δ Root crops [b] (E)	(F)	Δ High-value crops [c] (G)	(H)
Prime-age Adult								
male	0.303		0.721*		0.412		-0.830**	
	(0.64)		(1.78)		(1.09)		(2.75)	
female	-0.062		0.182		-0.335		0.091	
	(0.11)		(0.43)		(1.31)		(0.30)	
Prime Age Core Member								
male head of household		0.188		0.412		0.699		-0.923**
		(0.80)		(0.70)		(0.94)		(2.66)
female head or spouse		-2.241*		-1.889*		-0.396		0.044
		(1.73)		(2.00)		(0.54)		(0.09)
Prime Age Non-Core Member								
male, not head		0.370		0.931*		0.211		-0.773*
		(0.61)		(1.77)		(0.62)		(1.79)
female, not head or spouse		0.193		0.397		-0.321		0.117
		(0.31)		(0.88)		(1.19)		(0.35)
Elderly								
male		-0.302		0.104		-0.099		-0.307
		(0.73)		(0.37)		(0.32)		(1.14)
female		0.856		0.655		0.231		-0.030
		(1.41)		(1.39)		(0.69)		(0.10)
Constant	-0.619	-0.610	-0.988	-1.105*	-0.635	-0.621	1.004*	1.117**
	(0.50)	(0.67)	(1.58)	(1.74)	(1.28)	(1.21)	(1.86)	(2.07)
Village×Time dummies	YES	YES	YES	YES	YES	YES	YES	YES
Joint significance test (F stat)								
on PA mortality interactions	0.21	0.89	1.72	2.18*	1.42	0.75	3.80**	2.43*
R-squared	0.141	0.140	0.127	0.130	0.110	0.110	0.155	0.155
Number of observations	1,422 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*) 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.

Table 8. The Impacts of Adult Mortality on Crop Production (Household Fixed Effects model with village×time dummies)

Effect of Mortality of:	*ln*(Total Gross Output, Ksh)		*ln*(Total Net Output, Ksh)		*ln*(Total Gross Output per Acre)		*ln*(Total Net Output per Acre)	
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)
Prime-age Adult								
male	0.074		0.152		0.016		0.035	
	(0.29)		(0.60)		(0.07)		(0.15)	
female	-0.012		-0.110		0.188		0.083	
	(0.05)		(0.46)		(0.81)		(0.37)	
Core Prime Age Member								
male head of household		-0.304		-0.471		-0.291		-0.511
		(0.77)		(1.18)		(0.77)		(1.39)
female head or spouse		-0.799		-0.875		0.031		-0.063
		(1.12)		(1.31)		(0.06)		(0.10)
Non-Core Prime Age Member								
male, not head		0.334		0.543		0.231		0.382
		(1.01)		(1.70)		(0.73)		(1.30)
female, not head or spouse		0.048		-0.062		0.172		0.044
		(0.18)		(0.24)		(0.69)		(0.19)
Elderly Members								
male		-0.023		0.047		0.047		0.153
		(0.10)		(1.12)		(0.21)		(0.72)
female		0.441		0.468		0.278		0.312
		(1.46)		(1.62)		(0.97)		(1.17)
Constant	10.20**	10.20**	10.03**	10.03**	9.144**	9.144**	8.985**	8.985**
	(361.9)	(362.0)	(365.3)	(365.8)	(341.0)	(340.6)	(355.2)	(355.4)
Village×Time dummies	YES	YES	YES	YES	YES	YES	YES	YES
Joint significance test(F-stat)								
on PA mortality interactions	0.04	0.75	0.28	1.54	0.33	0.43	0.08	0.96
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 Prime-age Adults

	Households with ***Male*** prime-age adult deaths ($D^M = 1$)			Households with ***Female*** prime-age adult deaths ($D^F = 1$)			Households without prime-age adult deaths (D = 0)			Difference-in-Differences	
										Male prime-age adult deaths	***Female*** prime-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)
Asset Values (Ksh)											
Farm Equipment	13,004	10,264	-2,741	12,808	10,224	-2,584	12,402	11,418	984.3*	-1,756	-1,600
			(1.39)			(0.89)			(1.69)	(0.50)	(0.43)
Small Animals [a]	11,372	5,588	-5,784**	9,977	3,558	-6,419**	7,680	5,442	-2,238**	-3,546**	-4,181**
			(1.94)			(3.17)			(7.24)	(1.86)	(2.12)
Cattle	45,806	34,176	-11,629*	45,857	24,653	-21,204**	43,249	32,560	-10,689*	-939.9	-10,514
			(1.78)			(3.57)			(9.02)	(0.13)	(1.42)
Off-farm income (Ksh)	51,925	30,427	-21,498	92,795	53,643	-39,152	64,135	56,584	-7,550**	-13,947	-31,601*
			(1.51)			(1.45)			(2.83)	(0.87)	(1.80)
Number of households		38 [b]			34 [b]			1,349			

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 prime-age adult deaths are excluded from this table.

Table 10. The Impacts of Adult Mortality on Assets/Off-farm Income(OLS with village×time dummies)

Effect of Mortality of:	Δ(Values of farm assets)		Δ(Values of small animals)		Δ(Values of cattle)		Δ(Off-farm income)	
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)
Prime-age Adult								
male	-3,552		-3,508		2,068		-5,263	
	(1.54)		(1.30)		(0.32)		(0.35)	
female	-432.2		-4,319**		-5,888		-23,298	
	(0.19)		(2.68)		(1.15)		(1.09)	
Core Prime Age Member								
male head of household		-1,671		-73.12		17,288**		-43,081*
		(0.49)		(0.03)		(2.03)		(1.86)
female head or spouse		-1,700		-7,589		-9,339		-74,505
		(0.30)		(0.95)		(0.93)		(0.87)
Non-Core Prime Age Member								
male, not head of household		-4,977*		-5,986		-8,562		19,999
		(1.75)		(1.26)		(0.97)		(1.11)
female, not head or spouse		-110.7		-3,480**		-4,263		-14,920
		(0.04)		(2.43)		(0.76)		(0.73)
Elderly Member								
male		-2,622		-3,512*		-1,220		-30,047*
		(0.62)		(1.86)		(0.17)		(1.81)
female elderly		1,974		485.7		-3,840		-13,116
		(0.85)		(0.35)		(0.72)		(0.58)
Constant	177.5	922.2	1,082	2,238	-9,556	-8,911	-134,986*	-124,619**
	(0.20)	(0.51)	(0.57)	(1.17)	(0.96)	(0.90)	(3.01)	(2.92)
Village×Time	YES	YES	YES	YES	YES	YES	YES	YES
F-test on PA Mortality	1.20	0.82	5.01**	2.80*	0.69	1.70	0.68	1.44
R-squared	0.126	0.127	0.130	0.134	0.160	0.162	0.140	0.147
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 A1. Descriptive Statistics

	Mean	Standard Deviations
Adult Death Variables		
Male prime-age adult	0.027	0.163
Female prime-age adult	0.026	0.167
Male prime-age head	0.011	0.106
Female prime-age head or spouse	0.004	0.059
Male prime-age non-head	0.016	0.126
Female prime-age non-head or spouse	0.023	0.158
Male elderly	0.034	0.182
Female elderly	0.018	0.139
Dependent Variables		
Δ Household size	-0.004	2.574
Δ Number of men	0.034	1.301
Δ Number of women	0.081	1.162
Δ Number of boys	-0.020	1.196
Δ Number of girls	-0.034	1.162
Δ Number of children under 6	-0.071	1.144
Δ Total area cultivated in acre	1.047	7.473
Δ Area cultivated for food crops	-0.412	2.823
Δ Area cultivated for root crops	0.135	2.795
Δ Area cultivated for high-value crops	1.109	2.995
Δ *ln* (Total gross output in Ksh)	0.254	1.602
Δ *ln* (Total net output in Ksh)	0.407	1.511
Δ *ln* (Total gross output per acre)	0.129	1.463
Δ *ln* (Total net output per acre)	0.267	1.416
Δ Values of farm assets	-838.7	29,462
Δ Values of small animals	-2,197	17,355
Δ Values of cattle	-17,420	123,567
Δ Off-farm income in Ksh	-11,464	116,788

Source: Tegemeo Institute (Nairobi)/Michigan State University Agricultural Monitoring and Policy Analysis Household Surveys in 1997 and 2000.

Table A2. The Impacts of Adult Mortality on Crop Production (Household Fixed Effects model with village×time dummies), with Prime Age Being Defined as 16-59 Years of Age.

	ln(Total Gross Output Ksh)		*ln*(Total Net Output Ksh)		*ln*(Total Gross Output per Acre)		*ln*(Total Net Output per Acre)	
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)
Prime-age Adult								
male	-0.155		-0.088		-0.074		-0.047	
	(0.65)		(0.38)		(0.33)		(0.22)	
female	0.048		-0.181		0.287		0.058	
	(0.21)		(0.78)		(1.29)		(0.27)	
Core Prime Age Member								
male head of household		-0.567*		-0.679**		-0.328		-0.453
		(1.67)		(2.01)		(1.01)		(1.45)
female head or spouse		-0.101		-0.461		0.270		-0.045
		(0.20)		(0.93)		(0.57)		(0.10)
Non-Core Prime Age Member								
male, not head		0.224		0.415		0.159		0.298
		(0.69)		(1.33)		(0.51)		(1.03)
female, not head or spouse		0.039		-0.167		0.262		0.041
		(0.15)		(0.64)		(1.04)		(0.17)
Elderly Members								
male		0.194		0.285		0.134		0.263
		(0.77)		(1.12)		(0.56)		(1.12)
female		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)
Village×Time dummies	YES	YES	YES	YES	YES	YES	YES	YES
Joint significance test(F-stat)								
on PA mortality interactions	0.8	0.48	0.68	0.12	0.42	0.6	0.94	0.5
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 absolute t-ratios calculated with Huber-White-robust standard errors.
* indicates significance level at 10 %. ** indicates significance level at 5 %.

ENDNOTES

1. These surveys were designed and implemented under the Tegemeo Agricultural Marketing and Policy Analysis (TAMPA) Project, a joint collaboration between Egerton University/Tegemeo Institute, Michigan State University, and the Kenya Agricultural Research Institute, with financial support 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 than those who were re-interviewed. We suspect that some of those who were not re-interviewed were pastoral households. By using three large longitudinal data sets from Bolivia, Kenya, and South Africa, Alderman et al. (2000) found that attrition does not significantly affect the estimated coefficients in regression analyses, even though characteristics of re-interviewed households or individuals may be statistically different from those who were lost between surveys.

4. We define a household member as a person who has lived on the household compound for more than six of the past 12 months.

5. NASCOP conducts regular HIV surveillance at numerous sites around the country, which is then used to estimate the number of HIV-infected people in the entire country.

6. 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. Filmer (1998) also found a positive relationship between education and the probability of having a non-regular partner in Kenya, based on Demographic and Health Survey data in 1993. The positive relationship, however, was only statistically significant among women, not among men. He also found a positive relationship between education and the probability of using a condom with a non-regular partner.

7. 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).

8. 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 prime-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).

9. 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 prime-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.

10. See notes in Table 6 for the list of crops in each category.

11. All monetary values in this paper are expressed in constant 2000 Kenyan shillings.

12. 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.

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

14.In the remaining sections, however, there were no major differences in the results when the alternate prime age ranges were used in the models.

15. The rising incidence of prime-age death in rural Eastern and Southern Africa may be partially accounting for increased cultivation of labor-saving crops such as cassava and sweet potato (Nweke, 2002) although other factors are also clearly driving this shift as well. But this is a double-edged sword – while cassava is less labor-intensive than crops such as maize, it is also less nutritious.