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ESSAYS ON DISEASE-RELATED WORKING-AGE ADULT MORTALITY: EVIDENCE FROM RURAL KENYA

By

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ABSTRACT

ESSAYS ON DISEASE-RELATED WORKING-AGE ADULT MORTALITY: EVIDENCE FROM RURAL KENYA

By

Lilian Wambui Kirimi

The onset of HIV/AIDS has led to a remarkable increase in working-age adult mortality. Using a nationally representative panel data of rural Kenyan farm households surveyed between 1997 and 2007, the first essay of this dissertation examines whether the relationship between socioeconomic characteristics and adult mortality has changed over this period. Hazard analysis is applied to a 10-year period data of 5,755 working-age adults. There is a downward trend in the risk of working-age adult mortality across the observation period, with the decline being faster for men than women. In the early stages of the HIV/AIDS epidemic, wealthier, more educated individuals, those who were mobile and spent extended periods of time away from home were more likely to die of HIV/AIDS-related diseases. A comparison between the findings within the 10-year period and the early stages reveals that the relationship has changed in a number of ways. First, the hazard of death varies only slightly by wealth status and there is a weak significant shift toward an inverse relationship between asset value and mortality in some periods. Second, the hazard of death is converging among men of all education levels. Third, the risk and spread of HIV/AIDS is no longer related to mobility and spending time away from home. Fourth, relative remoteness and isolation from the initial epicenter

of HIV/AIDS is no longer associated with lower HIV infection and hazard of death. These changes suggest that over time, mortality risks are converging among groups that could in the past be clearly distinguished with regard to the likelihood HIV infection and AIDS-related mortality.

Essay Two determines the dynamics of the impacts of adult death on household composition, cultivated land, value of crop output, household asset base and income. I use panel data over a 7-year time period and a statistical model borrowed from the program evaluation literature that exploits a counterfactual strategy, taking into account the impacts of death across both time and households. In contrast to the Essay 1, in which the individual is the unit of observation, the unit of observation in Essay 2 is the household. Findings indicate that: (i) small negative impacts of adult mortality begin to emerge in the period preceding death, presumably due to pre-death morbidity; (ii) there are substantial and significant negative impacts observed in the year of death, and in most cases, these impacts are larger compared to those in other years before and after death; (iii) impacts are not just a one-time post-death adjustment but rather they persist over time; (iv) negative effects are larger in the period closest to the death event, signifying some recovery over time for some outcomes; (v) contrary to the conventional wisdom that afflicted households will shift to labor-saving crops such as roots and tubers, there is weak evidence of a such a shift but a modest shift away from capital-intensive high-value crops; (vi) sale of small animals and participation in off-farm activities are important coping strategies for afflicted households; and (vii) impacts of adult mortality differ by the gender and position of the deceased adult.

DEDICATION

To my husband, Kirimi Sindi

And our daughters Kendi and Gakii,

who cheered me on along the way.

And to my mom, Bilha Njoki Muigai,

who prayerfully and eagerly waited for

the completion of this work.

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Through it all, God's grace has been sufficient and to Him be the glory!

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in the region became newly infected, while 2.0 million adults and children died of AIDS(UNAIDS, 2006).

According to the 2006 Report on the Global AIDS Epidemic (UNAIDS, 2006), 1.3 million people in Kenya were living with HIV/AIDS by the end of 2005, 740,000 of whom were women with ages 15-49. The HIV prevalence rate was 6.1% among adults in the 15-49 age range. The majority of new infections occur among the youth, especially for young women aged 15-24 and young men under the age of 30. The number of deaths due to AIDS was estimated to be 140,000 while there were about 1.1 million children who lost their mother, father, or both parents to AIDS by the end of 2005.

Until recently, HIV/AIDS was mainly regarded as a health issue. However, the epidemic is now being considered as one with profound economic, political, and social impacts. It is also recognized that certain aspects of the disease including stigma, rapid spread of infection, and heightened working-age adult morbidity and mortality, pose major problems for governance, development and economic growth (Barnett and Whiteside, 2002; FAO, 1994). The increased mortality of working-age adults in sub-Saharan countries due to the AIDS epidemic is associated with potentially severe consequences for surviving household members and the community at large (Ainsworth and Dayton, 2000; Ngom and Clark, 2003).

While there are other more prevalent diseases in Africa, the characteristics of HIV/AIDS suggest that its economic and demographic impact will be profound. In the absence of the AIDS epidemic, working-age deaths are relatively rare in Africa, about six deaths per 1,000 persons per year for ages 15-50. In an area with high levels of HIV infection, working-age mortality rates can double, triple, or quadruple (World Bank, 1993

Chapter 1

INTRODUCTION

Working-age adult deaths historically have been relatively rare in Africa. However, in eastern and southern sub-Saharan Africa, the working-age adult mortality rates have more than doubled since 1980 (UNAIDS, 2003). There is overwhelming evidence that the dramatic rise in disease-related adult mortality is predominantly a result of HIV/AIDS, especially within the 15-45 year old range. According to the 2006 UNDP's Human Development Report (UNDP, 2006), the life expectancy in sub-Saharan Africa is 46 years, which is 32 years less than the average life expectancy in countries of advanced human development, and 20 years less than it would have been without HIV/AIDS. The onset of HIV/AIDS has changed the pattern of mortality dramatically. As Topouzis (1998) points out, it is not just a matter of mortality decline being reversed. In the past, declines in mortality occurred at the infant and child levels and resulted in a marked increase in life expectancy. However, in the era of HIV/AIDS, life expectancy is declining dramatically due to young adult mortality.

HIV/AIDS emerged in the early 1980s and has continued to spread all over the world with alarmingly high prevalence and incidence rates. Africa and particularly Sub-Saharan Africa continues to bear the brunt of the scourge. In 2006, an estimated 38.6 million people worldwide were living with HIV at the end of 2005, 4.1 million became newly infected with HIV and 2.8 million lost their lives to AIDS (UNAIDS, 2006). Sub-Saharan Africa is home to just over 10% of the world's population but has more than 60% (about 24.5 million) of all people living with HIV. An estimated 2.7 million people cited in Beegle, 1997). Because HIV in Africa is transmitted primarily through heterosexual contact, the epidemic is having a dramatic impact on the mortality of men and women in their working, earning and childbearing years. As a result, HIV/AIDS has reduced life expectancy by nearly 15 years in some countries. It is because it is poised to destroy 2-5% of the productive population each year over the next 20 years that HIV/AIDS is top priority for development agencies (Engel, 2002).

This analysis looks at the characteristics associated with working-age adult mortality and the economic impacts of adult mortality more generally, realizing that much of the mortality observed in our data is due to HIV/AIDS. While all working-age adult deaths cannot be attributed to AIDS, we know that AIDS is a leading cause of working-age mortality. Efforts by development planners to deal with the heightened prime-age adult mortality require accurate knowledge of the characteristics of those most likely to die in their prime age, and the effects of mortality on household behavior and welfare.

Increases in adult mortality have led to a sustained focus on economic impacts and mitigation strategies among policy makers and development practitioners. As a result, there have been a number of studies directed at understanding the characteristics of individuals dying of HIV/AIDS and the economic impacts of HIV/AIDS on households' welfare. Although these studies have generated some useful and interesting results, much of the evidence is based on case studies, cross-sectional surveys, sector-specific research, or surveys of specific risk groups, including medical and clinical studies (Nyaga et al, 2004). These types of studies cannot adequately measure the effects of mortality and are not representative of how it affects the population in a wider sense.

Another drawback of these impact studies is that they tend to focus on very short-term impacts, usually up to two years after death. However, we would expect short-term effects to be different from long term-effects. This essay uses data over a 7-year time period to understand the longer-term effects of death, effects which may be large and different from those experienced during the period immediately following a death. In addition, I examine the temporal pattern of the effects of death in the years after the occurrence of death, which accounts for the likelihood that adult death is not associated with just a one-time or permanent adjustment in household outcomes. As a result, this study uncovers the dynamics in household welfare and responses as a result of prime-age death.

In this regard, this study addresses the following questions. First, what are the characteristics associated with working-age adult mortality in Kenya and is there evidence of shifts over time of socioeconomic characteristics of persons who are afflicted by death? In particular, are individuals who are relatively less wealthy, with lower education, and without a formal job or business activity more likely to die in their working-age period than their counterparts? Second, how does disease-related adult death affect rural farm households, how severe and persistent are these effects, and what is the ability of afflicted households to respond to impacts of mortality? Effects of mortality on household demographic structure, agricultural production, assets and off-farm income will be examined. Insights into death effects on rural agriculture are particularly important since a shock in this sector can affect the Kenyan economy as a whole. This is because agriculture is vital for domestic production, exports, employment and foreign currency earnings.

Answers to questions addressed in this study will contribute to the growing empirical literature and inform responses on mitigation measures. Understanding the determinants of adult mortality is an essential step towards curtailing the spread of HIV/AIDS. Knowledge of impacts of adult mortality and household coping strategies is vital in generating the best responses toward the epidemic. Such information can improve targeting and effectiveness of prevention activities, and inform the design of programs to help afflicted and affected households and communities deal with the impacts of the disease. The study will use nationwide panel data on rural households surveyed between 1997 and 2004. The national coverage of the data set will overcome the non-representativeness problem that plagues past case-studies, while its panel structure will make possible the use of methods that control for problems such as unobserved heterogeneity (which are not possible with cross-section data).

This dissertation is organized as follows. The second chapter addresses the question of socioeconomic characteristics of adults afflicted by disease-related death, and whether the relationship between these socioeconomic characteristics and adult mortality has changed over time as the disease has progressed. Chapter 3 examines the dynamics of the impacts of adult death on household composition, cultivated land (total and by crop types), value of crop output, household asset base (cattle, small animals and farm equipment) and income. Each essay contains a section on conclusions and policy recommendations.

Chapter 2

CHARACTERISTICS ASSOCIATED WITH WORKING-AGE ADULT MORTALITY IN RURAL KENYA

2.1. Introduction

Prime-age adult mortality rates in eastern and southern sub-Saharan Africa have more than doubled since 1980 (UNAIDS, 2003). There is overwhelming evidence that the dramatic rise in disease-related adult mortality is predominantly a result of HIV/AIDS (Ainsworth and Dayton, 2000; Ngom and Clark, 2003). Using data from the earlier part of the period covered in this analysis, Yamano and Jayne (2004) applied an ecological approach to estimate the portion of deaths attributed to AIDS. They found that AIDS accounted for a large proportion of the recorded deaths for particular age/sex categories, particularly in the Nyanza area. This essay looks at the characteristics associated with working-age adult mortality, realizing that much of the mortality observed in our data especially within the 15-45 year range, is due to HIV/AIDS.

HIV/AIDS has been typically viewed as an urban epidemic. However, there is concern that over time, prevalence rates have continued to rise in rural areas through migration, trade and strengthened rural-urban linkages. In the early stages of the HIV/AIDS epidemic, studies in Eastern and Central Africa showed that a positive correlation existed between HIV infection and socioeconomic status indicators namely education, income, wealth and occupation. Infection and mortality rates were higher among the urban, wealthy and educated (Ainsworth and Semali, 1998; Nyaga et al, 2004). Ainsworth and Semali (1998) present a summary of eleven studies, which show that HIV infection is positively correlated with indicators of socioeconomic status such as schooling, income, wealth and occupation even in rural areas. The accepted explanation has been that men with higher education and income find it easier to attract casual sexual partners, and that men and women with higher education and income are likely to travel more. These studies covered the early periods of the epidemic. However, as the disease has progressed, there are reasons for expecting that this positive relationship between socioeconomic status and HIV contraction, and consequently adult mortality, may have changed. This may probably be due to greater availability and access to information about HIV/AIDS.

In addition, later in the development of the epidemic, an emerging strand of the social science literature on HIV/AIDS in Africa stresses the relationship between poverty, risky sexual behavior, and subsequent contraction of the disease (e.g. Gillespie and Kadiyala, 2005; Poku, 2001; Desmond, 2001). For example, health factors correlated with poverty reduce individuals' immune response and raise the probability of contraction with HIV-positive partners (Stillwaggon, 2005). Some policy makers have increasingly recognized poverty as an important social pathway contributing to the spread of the disease and working-age adult mortality, particularly among women. It has been argued that women unable to sustain themselves through wage labor or agriculture are more likely to resort to risky sexual behavior for survival (Bryceson and Fonseca, 2006). According to this perspective, poverty predisposes certain groups to risk of infection. As a result, a common programmatic response to AIDS has been the provision of income-earning activities to targeted groups, in the hope that this may reduce risky behaviors that spread AIDS. In spite of growing perceptions that the spread of HIV (and subsequent mortality) in eastern and southern Africa is increasingly associated with poverty, we know of no statistical evidence using nationally representative survey data that would support this conclusion.

This study seeks to determine the socioeconomic characteristics of individuals who are subsequently afflicted by working-age adult mortality. Also, it examines whether over time, the relationship between socioeconomic status and adult mortality has changed as HIV/AIDS (a leading cause of prime-age mortality) has progressed. The study uses a nationwide longitudinal data of 5,755 working-age individuals in 1,500 small-scale farm households in rural Kenya surveyed across a ten-year time period, to determine the hazard of death and how this relates to socioeconomic characteristics of individuals who are afflicted by death. Because sampled households were surveyed five times over a ten-year period, from 1997 to 2007, this study provides a unique opportunity to assess potential shifts in the socioeconomic correlates of disease-related adult mortality over time.

The essay first examines the spatial relationship between disease-related prime-age mortality in our survey data and lagged provincial HIV prevalence rates as reported by the Kenyan government; the strong correlation found indicates that the disease-related mortality observed in our survey data largely reflects the growing influence of AIDS in mortality rates. Next, we construct various indicators of household and individual poverty status and use these in hazard models of disease-related mortality to assess potential changes in the relationship over time between socioeconomic characteristics and subsequent death of working-age adults. The study covers a ten-year period and thus includes a period in which AIDS-related mortality has acutely heightened. Therefore, it is now possible to capture more of the dynamics of adjustment in socioeconomic characteristics over a longer period of time. We use inverse probability weighting procedures to control for potential attrition bias.

The study contributes to literature and practice in various ways. It adds to our understanding of the relationship between adult mortality and socioeconomic characteristics. This is in turn important for understanding behavior and designing mitigation policy. Working-age adults comprise most members of the society who are economically productive and responsible for the support of children and elderly dependents. Hence, there is need to determine socioeconomic characteristics of individuals afflicted by adult morbidity and mortality in order to avert potential adverse effects on individual and household welfare. Knowledge of the mechanisms that are behind mortality trends and variations is essential for the prediction of the course of the epidemic. The study informs the ongoing debate on the relationship between poverty, risky sexual behavior, and subsequent contraction HIV/AIDS and adult mortality in Africa.

While not all working-age adult deaths can be attributed to AIDS, high HIV infection rates in Sub-Saharan Africa are producing dramatic increases in the mortality of working-age adults (Ngom and Clark, 2003). Campaigns to prevent the spread of HIV/AIDS require accurate knowledge of the characteristics of those most likely to contract the disease. Therefore, understanding the determinants of individuals' risk of infection and death is an essential step towards curtailing the spread of this disease. Such information can improve targeting and effectiveness of prevention activities, and inform the design of programs to help affected households and communities deal with the impacts of the disease. Also, given that HIV/AIDS epidemics are heterogeneous across and within countries (in terms of intensity, pace and impact), the study will in particular provide guidance on AIDS prevention and mitigation strategies in Kenya.

The remainder of this chapter is organized as follows. Section 2.2 presents findings from previous studies and the contribution of my study. Section 2.3 describes the data and addresses the issue of attrition bias which is potentially an important problem in analysis of longitudinal survey data. Section 2.4 presents the methodology. Results are discussed in section 2.5 and section 2.6 presents conclusions of the chapter and policy implications.

2.2. Previous research on adult mortality, HIV/AIDS and socioeconomic factors

A well established pattern in the literature is that people with high education, high income, and a higher status occupation experience a lower risk of death. One possible explanation is the "access to health care" argument. If better-educated or richer people have better access to health care, and if health care has a major effect on morbidity and mortality, then it follows that education or wealth will be positively correlated with health status (Deaton, 2002). Further, income provides nutrition, housing, clean water, and sanitation and thus protects individuals from hunger and infectious diseases. Education protects health by enhancing a person's efficiency as a producer of health, conferring advantage in access to health information or through the establishment of a more patient and forward looking behavior (Grossman, 1972).

An individual's probability of dying is primarily a function of gender, age, health, genetic endowment, and the environment, all of which determine the risk of falling victim to illness or accident. These factors work together and are influenced by a complex and ever changing set of social and historical determinants (INDEPTH, 2002). HIV/AIDS has changed the landscape of adult mortality and its socioeconomic correlates. The impact of HIV/AIDS on an individual's probability of dying is complex, and depends on many factors such as gender, mode of infection, number of infections, age at infection, immune competence, overall health, and access to treatment (Ngom and Clark, 2003). The HIV/AIDS epidemic in Sub-Saharan Africa is primarily one of heterosexual transmission. Consequently, the epidemic is having a dramatic impact on the mortality of men and women in their prime childbearing and earning years. Mortality rates of adults aged 15–50 have increased dramatically in areas affected by the epidemic. In addition, the number and gender-age composition of the infected sub-population is in turn strongly influenced by population-specific behavioral factors such as sexual networking preferences (Ngom and Clark, 2003).

Analysis of the socioeconomic characteristics associated with working-age adult mortality using micro data has been previously uncommon, since mortality has been a rare event for the middle-aged and for children past the age of five years (Duleep, 1986). However, the onset of HIV/AIDS in Sub-Saharan Africa in the 1980s has led to a substantial increase in working-age adult mortality and as a result, has made this a subject of interest among researchers.

In response to the AIDS epidemic, the initial focus of analysts and policymakers was to understand the characteristics of those who were infected and died of AIDS.

Analysts and health practitioners argued that information on background characteristics of those most likely to be infected and those who have died could: i) improve targeting and effectiveness of prevention activities, and ii) affect the economic impact of the AIDS epidemic on households and the economy, including the distribution of skills in the labor force and the demand and ability to pay for curative medical care.

Past studies in sub-Saharan Africa that followed this line of inquiry generally found a positive relationship between HIV-related deaths and socioeconomic status – as measured by education, income, and occupation (Ainsworth and Semali, 1998; Kapiga et al, 1994). The explanation for this finding was that the ability to support multiple partners may rise with income and that men and women with more education and higher incomes are probably more likely to travel and thus have more opportunities for casual sexual contacts. However, Ntozi et al (1997) found that in Uganda, those with primary education are more likely to die of AIDS than those with post-primary education. They argue that that the more educated have greater access to AIDS prevention facilities such as condoms and information than those with primary education.

In terms of occupation, people of other occupations were more likely to die of AIDS than farmers (Ntozi et al, 1997); executives had higher HIV infection rates than foremen and casual laborers (Over, 1992); the epidemic was disproportionately striking groups with higher levels of productive skills and human capital (Ndongko, 1996).

Other studies report that women are more vulnerable to AIDS than men in Africa (Anarfi, 1995; Berkley et al, 1990, Ntozi et al, 1997 and Ryder et al, 1990). Women's vulnerability to HIV/AIDS may be due to a complex interplay of biological, social, and behavioral conditions. Women often have vulnerable employment status, lower incomes, and least entitlements to or ownership of assets and savings, and may resort to transactional sex for survival. As a result, they may be more economically dependent on their partners and less empowered to protect themselves against HIV infection (Greig and Koopman, 2003). It is also argued that there is more efficient transmission of HIV virus from men to women than the reverse, and sexual behavior favors men having more sexual partners. In sub-Saharan Africa, the highest rate of HIV infection is among sexually active young women, less than 35 years old. The 15-24-year-old women are more likely to be infected than men in the same age group, and men are infected at a later age (Topouzis, 1994). Thus, although the typical female advantage of lower mortality has been smaller in developing compared to developed countries, this may have been eroded more recently in Africa, due to the differential gender impact of HIV/AIDS.

Mixed results emerge with respect to marital status and type of marriage union but generally people in polygamous marriages are more likely to die of AIDS than those in monogamous marriages (Ankrah et al, 1992; Allen et al, 1991; Kapiga et al, 1994; Nunn, 1989). The institution of marriage is believed to play a beneficial role in mitigating one's risk of exposure to HIV. Since the transmission of HIV in the population is mainly through sexual activity, avoiding infection depends on risk-avoiding behavior. Consistently, empirical results show that excess mortality is concentrated in not-yet married adults aged 20-39 among both men and women (Yamauchi, 2007). In most cases, widows may have no legal rights to land and property (due to customary inheritance laws or the difficulties of enforcing existing remedial legislation) after their husbands' death. Their incomes may be too low and thus impoverishment may force them as well as single women to engage in occasional sex for money or earn a living as commercial sex workers (Topouzis, 1998).

HIV/AIDS was initially primarily prevalent in urban areas. However, it has spread to rural areas due to factors like migration, trade, refugee movements, urbanization, strengthened rural-urban linkages, improved transport and relatively high incomes that enhance mobility, as well as economic and socio-cultural factors that promote an increasing number of people who maintain strong footholds in rural areas and commute between urban and rural areas on a regular basis. Restricted access to health facilities and fewer institutions delivering HIV/AIDS information has also been cited as a factor (Topouzis, 1998). Consequently, all these factors have been suggested as important in spreading HIV/AIDS and contributing to working-age adult mortality in rural areas.

Another focus of analysts and policymakers has led to a set of studies on patterns and determinants of sexual behavior rather than the characteristics associated with HIV infection and working-age adult mortality. These patterns are seen as one of the primary determinants of the spread of HIV, and researchers have sought to determine the socioeconomic correlates of sexual behavior. This was based on the recognition that socioeconomic status may affect the probability of HIV infection through differences in sexual behavior, condom use and visits to voluntary counseling and testing centers (Deheneffe et al, 1998; de Walque, 2002). These studies provide strong empirical evidence of great heterogeneity in sexual behavior within and across countries, with some individuals having a great many more sexual partners than others. The probability of having had a non-regular partner is often unrelated to asset ownership, but when the relationship is significant it tends to be negative for women and positive for men. The probability of using a condom with a non-regular partner tends to be positively associated with education for both men and women. These studies consistently find that condom use and visits to voluntary counseling and testing centers have been more widespread among educated individuals. This finding implies that the positive correlation between HIV infection and education is likely to reverse itself in the longer run.

Indeed some reversal has been shown to occur (de Walque, 2002). In Uganda, de Walque investigates the hypothesis that the ability to process information is one channel through which education affects health outcomes. He does this by examining the effectiveness of an information campaign aimed at preventing the HIV/AIDS epidemic. He finds that during the early years of the epidemic in 1990, there was no robust relation between HIV/AIDS and education. However, in 2000, education was found to lower the risk of being HIV positive among young individuals. He suggests that as soon as information on existence and modes of transmission of HIV is available, more educated individuals modify their behavior more strongly. Also, he argues that if there indeed was an initial positive correlation between income and risk of contracting HIV, then the subsequent decline in prevalence is more likely to be due to education than to income[1]. This is because more educated people have better access to information about existence, transmission and prevention modes of HIV/AIDS epidemic. Education enables individuals to avoid infection by using condoms or a combination of HIV testing and reciprocal fidelity, and enables them to mitigate consequences of the disease through better nutrition and health care. In addition, as educated people have invested in their

[1] Unlike most cases of health conditions, malnutrition for example, it is not very expensive- at least in monetary terms- to avoid being infected by HIV/AIDS.

future by going through a longer education process, they may feel that they have more to lose if their life expectancy is drastically shortened by AIDS.

Additionally, more recent studies have found that wealth and income continue to be strongly and positively related to HIV prevalence and risky behaviors (Central Bureau of Statistics (CBS), Kenya, 2004; Shelton et al, 2005; Annim & Awusabo-Asare, 2006). Risky behaviors such as unsafe sex, frequent changes of sexual partners or multiple concurrent partnerships are key factors in driving the AIDS epidemic. Such behaviors have been found to be positively related to wealth and income for a number of reasons. First, wealth and income promote such partnerships because they are associated with mobility, time, and resources necessary to maintain concurrent partnerships. Second, wealth and income are very closely linked with social interaction, and therefore they might increase the number of opportunities for such partnerships to develop. Third, this relationship could arise partly because household wealth and income may relate to urban residence, and HIV rates are higher in urban areas. Hence, urbanization may mean higher income and wealth for the household but not necessarily improved health status. Fourth, perhaps wealth and income accord individuals status in the society and simply enable them, and especially men to have more sexual partners (Shelton et al, 2005). Individuals with more education and therefore more human capital will have better employment and higher earnings. Hence, education and occupation may also be strongly positively related to HIV prevalence just like income and wealth for similar reasons. In general, individuals that are relatively wealthier, richer, or more educated (especially males) put themselves or their health at risk through use of their resources in sexual networking. However, as the disease has progressed, this positive relationship between socioeconomic status and

HIV contraction, and consequently adult mortality, may have changed, probably due to greater availability and access to information on HIV/AIDS.

This study aims to extend existing research on the socioeconomic characteristics of working-age adult mortality. The study makes four contributions to the literature on this topic. First, most studies to date investigating the socio-economic attributes of AIDS-related adult mortality in Africa are based on relatively small samples like in case studies of areas with high HIV prevalence rates (e.g., Kagera, Tanzania and Rakai, Uganda) and of high-risk groups such as commercial sex workers and truck drivers. Thus, the generalizability of these results to the general population may be limited, and only partial evidence can be obtained from such studies. My study is based on a large-scale nationwide set of household surveys over a 10-year time period.

Second, the longitudinal nature of the data provides the opportunity to assess whether the socio-economic correlates of disease-related adult mortality have changed over time. Most studies report results from cross-sectional analysis and those that use panel data are limited to the early period of the epidemic. This study will use a 10-year panel to address the question of whether the positive relationship between working-age adult mortality/HIV infection and indicators of socioeconomic status reverses in the longer run, as frequently contended.

Third, past studies that have focused on sexual behavior do not provide adequate information with regard to the individual characteristics associated with AIDS-related adult mortality because sexual behavior is just one of the variables through which socioeconomic indicators influence mortality. The analysis undertaken in this study aims in part at addressing some limitations of past studies.

Lastly, some analysis at the macro level (e.g., Deheneffe et al, 1998, across 12 countries/sites) is too large-scale and presumes homogeneity of institutional or community features thought to be crucial in imparting variance in sexual behavior. On the other hand, the purely individual-level survey reveals little about the institutional and cultural environment surrounding the household. This study improves on past research by combining measures of socioeconomic characteristics at the individual, household and community levels.

2.3. Data

The study uses nationwide data set of Kenyan rural households collected in 1997, 2000, 2002, 2004 and 2007. The sampling frame for the surveys was prepared in consultation with the Central Bureau of Statistics, although its agricultural sample frame was unavailable. First, 24 districts were purposively chosen to represent the broad range of agro-ecological zones (AEZs) and agricultural production systems in Kenya. Next, all non-urban divisions were assigned to one or more AEZs based on secondary data. Third, proportionally to population across AEZs, divisions were chosen purposively from each AEZ. Fourth, within each division, villages and households within selected villages were randomly selected. A total of 1,578 households were chosen from 24 districts. Forty households from two pastoral districts were excluded since they differed considerably from households in other zones and had high rates of attrition. Also, thirty-eight households whose landholding was larger than 20 acres were excluded from the survey, in order to focus on small-scale households. As a result, this study is based on 1500 households from the 1997 survey. Out of these households, 1,406 households (93.7%) were re-interviewed in 2000, 1,245 households (83% of the original 1,500 households in the 1997 survey) in 2002, 1,356 households (90.4%) in 2004 and 1308 households (87.2%) in 2007 (Table 2-1). The household attrition rate between 1997 and 2007 was 12.8 percent. Note that over 100 households that dropped out of the sample in 2002 were re-interviewed in 2004, indicating that attrition rates are influenced by whether enumerators were able to find eligible household members. A relatively high rate of household attrition is found in Nyanza and Rift Valley provinces. Differences in attrition rates across regions could be due to greater household dissolution and relocation in some areas (which could be influenced by AIDS) or by differences in the quality of enumerator and supervisor teams (an issue examined below) or both.

According to household respondents, the individuals who left their households after the 1997 survey departed for various reasons including: search for employment, attending school, marriage, death, divorce/separation, moved away to live on their own or with other relatives, and moving back to the households they lived in prior to 1997. Working-age individuals lost to follow-up include those that were in households that were not relocated and reinterviewed after the 1997 survey. Household attrition is attributed to the following reasons: household moved away or dissolved, no one was at home or available to be interviewed, or a household refused to participate in the survey.

There is a great deal of fluidity in household composition, with many working-age individuals moving into and out of their rural households over time. Of the 5,755 working-age individuals (15-59 years) who were in the original 1997 sample, 13.1% had left the households between 1997 and 2000, 23.4 percent by 2002 survey, 37.0 percent by 2004 survey, and 53.3 percent by 2007 survey, for reasons other than death.

This study focuses on adults 15-59 years old who were resident in the sampled households at the time of the initial survey in 1997. We continued to track the whereabouts of individuals who left their households after 1997 and were able, therefore, to calculate mortality rates based on a consistently defined sample over the 10-year period. A panel data survey spanning a 10-year period provides 22,654 person-years of follow-up generated from 5,755 adults. In this study, the main outcome measure is time from study entry to death. For the calculation of person-time, the starting point was the beginning of the study period, while the end-points were the time of death or end of observation, defined as the end of the study period, or the time of the prior survey before the whereabouts of the individual became unavailable. The outcome in each survey interval was yes if the person died of disease related causes and no, otherwise.

The data provide multiple years of observation for each individual and a survival outcome at the end of the survey interval. In a person-period dataset, each person has one row of data for each discrete time-period, each containing: (i) a variable, which labels the time-period to which each row of the person-period dataset refers; (ii) another variable, which records whether an individual died in the particular discrete time-period in question; (iii) a set of other variables that influence the likelihood of death.

Hazard analysis is performed on this dataset, where some of the individuals died of disease-related causes during the ten year period. However, the majority of the adults are considered as "censored" observations, since they were alive at the end of the observation period and we have no further information about them.

Individuals joining their households after 1997 are excluded from the analysis. It has been noted in the literature that many people afflicted by HIV/AIDS returned to their rural homes to receive terminal care and to die (Kitange et al, 1996). Therefore, including individuals who joined their households after the 1997 survey in the analysis may lead to an overestimation of working-age adult mortality. Table 2-1 presents mortality rates within the 15-59 year age group computed two ways, first based on individuals who were residents at the beginning of each survey, and second, based on the inclusion of newly arriving members after each survey. Indeed, we find that mortality rates are higher (3.8 vs. 3.5 persons per 1000 person years) when including members joining their homes after the prior survey.

Table 2-2 presents initial individual- and household-level characteristics (based on the 1997 survey) of individuals by attrition status. Individuals who "attrited" were slightly younger and had more years of education. However, there is no considerable difference between attrited and non-attrited individuals in terms of months spent at home in 1997, and the age and education of heads of households in which they resided. Generally, the percentage of men and women attriting each year is very similar, except in 2007 when more men than women attrited. A larger percentage of individuals who attrited comprises of sons and daughters compared to heads/spouses or other members of the household. A negligible proportion of female household heads attrited while attrition rates among individuals from polygamous households are lower than those of monogamous ones. Households with larger landholdings, more income, and more wealth showed greater rates of attrition. Therefore, there appears to be differences between individuals who remained in the survey and those who attrited. These differences will be investigated further through probit re-interview models.

Table 2-1 Households and adults interviewed, and working-age adult mortality rates, 1997-2007

	Original 1997 survey	Reinterviewed households and working-age adults who remained in the households, among those in 1997 survey (number and percent)[1]			
		2000	**2002**	**2004**	**2007**
Households	1500	1406 (93.7)	1245 (83.0)	1356 (90.4)	1308 (87.2)
Adults (15-59 years)	5755	5002 (86.9)	4411 (76.6)	3625 (63.0)	2690 (46.7)

		Reinterviewed households among those in 1997 survey (Number and percent)			
Province	**1997**	**2000**	**2002**	**2004**	**2007**
Coast	91	90 (98.9)	73 (80.2)	88 (96.7)	84 (92.3)
Eastern	242	232 (95.9)	218 (90.0)	226 (93.4)	219 (90.5)
Nyanza	280	258 (92.1)	220 (78.6)	246 (87.8)	240 (85.7)
Western	303	284 (93.7)	258 (85.1)	273 (90.1)	259 (85.5)
Central	181	173 (95.6)	169 (93.3)	169 (93.4)	167 (92.3)
Rift Valley	403	369 (91.6)	307 (76.1)	354 (87.8)	339 (84.1)

	Mortality rate for adults (15-59 years)[2]				
Province	**1997-2000**	**2000-2002**	**2002-2004**	**2004-2007**	**Average**
Coast	5.2	3.9	2.6	3.0	3.7
Eastern	3.3	1.8	2.4	2.5	2.5
Nyanza					
Kisii	3.4	1.2	2.3	1.5	2.1
Kisumu/Siaya	20.0	5.5	9.7	6.4	10.4
Western	4.5	2.7	3.0	3.1	3.3
Central	3.0	1.8	3.1	2.1	2.5
Rift Valley	2.9	1.3	2.3	3.1	2.4
Total	5.2	2.3	3.4	3.2	3.5

	Mortality rate for adults (15-59 years)[3]				
Province	**1997-2000**	**2000-2002**	**2002-2004**	**2004-2007**	**Average**
Coast	4.3	3.4	2.7	3.0	3.4
Eastern	2.9	2.0	2.8	2.6	2.6
Nyanza					
Kisii	3.5	1.2	2.3	1.5	2.1
Kisumu/Siaya	18.1	5.5	12.9	8.0	11.1
Western	3.9	2.4	5.1	2.7	3.5
Central	3.0	2.6	5.1	2.7	3.3
Rift Valley	2.7	1.3	3.1	3.3	2.6
Total	4.7	2.4	4.7	3.3	3.8

Source: Tegemeo Institute (Nairobi)/Michigan State University Agricultural Monitoring and Policy Analysis Household Surveys in 1997, 2000, 2002, 2004, and 2007.

Notes:

[1] Excludes pastoralist districts

[2] Working-age adult mortality is per 1000 working-age person years; this is for adults (15-59 years) who were listed in the demographic roster at the beginning of each period.

[3] This includes adults (15-59 years) who joined the household after the previous survey; some of these died within the period.

Table 2-2 Individual and household level characteristics of working-age adults by attrition status

	Attrited in 2000, contained in 1997 sample	Attrited in 2002, contained in 1997 and 2000 samples	Attrited in 2004, contained in 1997, 2000 and 2002 samples	Attrited in 2007, contained in 1997, 2000, 2002 and 2004 samples	Did not attrit, remained in household for all 5 survey years
Age (mean of all adults)	29.5	31.3	24.1	24.5	34.5
Age of household head (mean)	48.6	43.0	44.5	43.1	44.6
Months at home (mean of all adults)	10.0	11.0	10.0	10.0	11.0
Education (mean years of all adults)	7.4	7.5	7.8	7.6	6.9
Education of household head (mean)	7.2	7.8	7.2	8.0	7.7
Female (%)	48.9	50.1	51.3	43.3	52.0
Male (%)	51.1	49.9	48.7	56.7	48.0
Relationship to household head					
Head/spouse	25.2	45.5	7.3	13.8	65.1
Son/daughter	74.8	39.4	69.4	70.0	32.1
Others	0.0	15.1	23.4	16.3	2.8
Has formal job (%)	13.1	13.0	10.6	8.9	13.7
No formal job (%)	86.9	87.0	89.4	91.1	86.3
Has informal activity (%)	12.5	22.2	10.9	10.2	22.2
No informal activity (%)	87.5	77.8	89.1	89.8	77.7
Female household head (%)	0.1	3.2	0.5	0.6	3.8
Other female (Not heads) (%)	99.9	96.8	99.5	99.4	96.2
Monogamous household (%)	87.8	93.0	95.2	92.6	93.5
Polygamous household (%)	12.2	7.0	4.8	7.4	6.5
Land holding (mean acres)	8.6	5.7	6.6	6.7	5.9
Household income ('000 Ksh., mean)	145.0	125.0	132.4	142.6	122.3
Asset value ('000 Ksh, mean)	180.1	102.9	114.1	134.4	99.3
Income quartile (%)					
Lowest	25.1	30.3	26.0	22.6	23.6
Mid-low	25.4	25.8	21.5	24.6	26.7
Mid-high	20.1	22.3	25.2	25.6	26.9
Highest	29.5	21.5	27.3	27.3	22.8
Asset value quartile (%)					
Lowest	31.7	28.4	21.3	23.8	24.0
Mid-low	20.7	25.6	23.8	25.2	26.8
Mid-high	17.4	20.9	27.7	28.3	26.3
Highest	30.1	25.1	27.2	22.7	22.9
Number of individuals	753	716	1142	806	2338

Source: Tegemeo Institute (Nairobi)/Michigan State University Agricultural Monitoring and Policy Analysis Household Surveys in 1997, 2000, 2002, 2004, and 2007.

2.4. Methodology

2.4.1 Working-age adult mortality model

Based on cited literature, there is mixed evidence about the correlation between adult mortality and socioeconomic status. On the one hand, morbidity and mortality rates are inversely related to indicators of socioeconomic status such as income, wealth, education, or occupation. Conversely, in the era of HIV/AIDS, individuals who are relatively wealthier, richer, more educated or in more prestigious occupations may have higher mortality risks. This is because they tend to put their health at risk through use of their resources in sexual networking. Therefore, the impact of variables like education, income, occupation and wealth on adult mortality is ambiguous. Even over time, their influence will depend on the extent to which their potential perverse effects on health serve to counteract the expansive or protective effects.

The econometric model for the relationship between mortality and socioeconomic characteristics can be written as:

$$P(WAM_i) = f(IC_i, HC_i, CC_i) \tag{2.1}$$

where WAM_i is a binary variable equal to 1 if individual i died of disease-related causes; IC, HC and CC represent a set of covariates measured at the individual, household and community levels, respectively, for individual i.

2.4.2 Empirical analysis

In this essay, the probability of death (death hazard) is estimated using hazard analysis. Hazard models (also referred to as duration or survival models) focus on the timing of a change in state or a transition from one category to another such as from unemployment to employment, a change in marital status, or as in this essay, a change in the survival status. The dependent variable is usually the length of time that elapses from the start of the initial state until its end or until measurement is taken and the observation is censored. This study focuses on transitions from life to death, and the effects of various explanatory variables such as individual, household and community characteristics on the probability of such transitions.

Duration analysis has its origins in what is called survival analysis, where the duration of interest is survival time of a subject. In this case, the objective is to determine how various treatments or socioeconomic characteristics affect survival times. Recent treatments of duration analysis tend to focus on the hazard function, where it is not only the duration of the event, per se, that is interesting, but also the likelihood that the event will end in "the next period", given that it has lasted as long as it has. The hazard function allows us to approximate the probability of exiting the initial state within a short interval, conditional on having survived up to the starting time of the interval (or given that the state has been occupied for some length of time *t)* (Wooldridge, 2002).

Three equivalent functions are used to describe the distribution of survival time: the survivor function, the probability density function, and the hazard function. These functions can be derived from each other mathematically. The survivor function (also called survival function) is defined as:

$$\begin{aligned} S(t) &= \Pr(\text{time before failure is at least t}) \\ &= \Pr(T > t) \qquad (2.2) \end{aligned}$$

where T is the length of time a subject lives and t is a realization of T. The survivor function depicts the probability (Pr) that failure has not occurred at time t. It is the probability of "surviving" past time t. By definition of the cumulative distribution function (cdf) of any random variable, the survivor functions are related to cdfs such that

$$\begin{aligned} S(t) &= 1 - \Pr(T \le t) \\ &= 1 - F(t) \end{aligned} \tag{2.3}$$

where F(t) denotes the cdf.

The probability density function for survival times is defined in the usual way for a density of a continuous random variable:

$$f(t) = \lim_{\Delta t \to 0} \frac{\Pr\{\text{failure in period } (t, t + \Delta t)\}}{\Delta t} \tag{2.4}$$

Hazard functions describe the conditional failure rate or the probability of failure during a very small interval, given survival up to the beginning of the intermission. The hazard rate is defined as:

$$h(t) = \lim_{\Delta t \to 0} \frac{\Pr(t \le T \le t + \Delta t | T \ge t)}{\Delta t}$$

$$h(t) = \lim_{\Delta t \to 0} \frac{\Pr\{\text{subject with survival to time t fails in the period } (t,\ t + \Delta t)\}}{\Delta t} \tag{2.5}$$

It is the probability of leaving the initial state in the interval $(t, t + \Delta t)$ given survival up until time t. Thus $h(t)$ gives the instantaneous conditional probability of death immediately after t, given survival until time t. The hazard function can be expressed in terms density and cdf of survival time:

$$h(t) = \frac{f(t)}{1 - F(t)} = \frac{f(t)}{S(t)} \tag{2.6}$$

These conditional probabilities, the $h(t)$s, are the fundamentals of discrete-time hazard models.

The event of interest in this study is disease-related death. Individuals who do not die are considered censored by the end of the observation period. The presence of the censored cases suggests that the time-to-event is probably longer than the period of observation. In order to obtain an unbiased estimate of the time-to-event, the censored cases cannot be ignored. They are included in the analysis so that they can contribute whatever information they contain.

Hazard models explicitly account for time and recognize that an individual's risk of dying changes over the course of time. They adjust for changes in individuals' risk of death in different time periods. This is necessary since some individuals die within the first survey period while others do so in subsequent survey periods, and yet others are still alive at the end of the observation period. Hazard models can incorporate time-varying covariates and utilize time-series data by including annual observations as time-varying covariates. These models also make use of much more data since they can be constructed as binary logit models with each person-period as a separate observation. Therefore, each individual contributes multiple years of observation. In this case, we have multi-period logit models that can be interpreted as hazard models, and this is the approach followed in this study. The dependent variable in a multi-period logit model is constructed such that it is equal to one only in the survey interval in which an individual dies.

A hazard probability that describes the "risk of dying" in each time-period can be estimated. Hazard probability is the (conditional) probability that an individual will die in a particular time-period, given that he/she has "survived" up until this period. I estimate a discrete-time hazard model since the death event is observed at discrete times, i.e., between two surveys or equivalently, within a survey interval. Discrete-time analysis is an extension of the basic logistic regression analysis. It uses logit analysis to examine the occurrence and timing of events. Let h_{it} be the hazard (or the probability) that an individual i dies in survey interval t, given that he's still alive at the beginning of that interval.

Since the hazards are probabilities, they can be reparameterized so that they have a logistic dependence on time periods and the predictors (Cox, 1972):

$$h_{it} = \frac{1}{1 + e^{-(\alpha_1 D_{1it} + \alpha_2 D_{2it} + \alpha_3 D_{3it} + \alpha_4 D_{4it} + \beta X_{it})}} \quad (2.7)$$

where $D_{1i}, D_{2i}, D_{3i}, and\ D_{4i}$ are a sequence of dummy variables indexing the four survey periods in the study namely: 1997-2000, 2000-2002, 2002-2004, and 2004-2007. The survey-period dummies are defined for each person as follows: D_{1it} is equal to one when $t = 1$, and equal to zero when t takes any other value (2 through 4). The model does not contain an overall intercept, but has multiple intercepts, one per survey-period, as represented by the parameters, α_1 to α_4. The variable X_{it} denotes a person-level vector of the individual (IC), household (HH) and community characteristics (CC). This is shown here as a vector of time-varying variables but could also represent time-invariant variables.

Taking the logistic transformations of both sides of the equation (2.7) gives:

$$\ln\left(\frac{h_{it}}{1 - h_{it}}\right) = \left[\alpha_1 D_{1it} + \alpha_2 D_{2it} + \alpha_3 D_{3it} + \alpha_4 D_{4it}\right] + \beta X_{it} \quad (2.8)$$

Therefore, the probability that an individual will die is related to predictors by the above standard logistic regression model.

The parameters α_1 to α_4 represent the baseline logit hazard function or the baseline level of hazard in each time period. It shows the survey-period to survey-period hazard function for the entire sample, assuming a homogenous population in which individuals are not distinguished by the values of any of the explanatory variables (Singer and Willett, 1993). These parameters describe the overall profile of risk of death over time and represent the main effect of a single predictor, time. The vector of slope parameters, β describes the main effects of the explanatory variables on the baseline hazard function. These parameters are associated with shifts in the baseline hazard function.

The above model (2.8) incorporates a proportional odds or proportionality assumption that the effect of the individual, household and community characteristics on the log-odds of death is the same in every time period. It postulates that the entire family of logit-hazard profiles represented by all possible values of the explanatory variables shares a common shape, and is mutually parallel, and is shifted only vertically for different values of the explanatory variables (Singer and Willet, 1993). This assumption does not allow the effect of the variables to vary over time, and so the variables have a time-invariant effect. This applies even in the case of time-varying variables. The assumption can be relaxed by estimating the model shown in equation (2.4):

$$\ln\left(\frac{h_{it}}{1-h_{it}}\right) = [\alpha_1 D_{1it} + \alpha_2 D_{2it} + \alpha_3 D_{3it} + \alpha_4 D_{4it}] + \beta_1 (D_{1it} \times X_{it}) + \beta_2 (D_{2it} \times X_{it}) + \beta_3 (D_{3it} \times X_{it}) + \beta_4 (D_{4it} \times X_{it}) \quad (2.9)$$

To examine whether the effect of any variable varies over time, we include the interaction between indicators of time and the variable in the hazard model. This interaction implies that the effect of the variable on the hazard profile varies from survey-period to survey-period. The model enables us to investigate whether and how the effects of the various characteristics on the hazard of death vary across the 10-year observation period.

2.4.3 Model variables

Individual characteristics

Individual characteristics include age, years of education, months residing at home, and whether the adult is a household head/spouse or not. Age is a time-varying variable and is defined as an individual's age at the beginning of each survey period. It is entered in liner and quadratic terms in order to detect potential non-linearities of age on the hazard of death. Education is entered as a continuous variable after specification tests rejected non-linearities in years of education. The number of months over the past year that a person resided at home is included as a continuous variable.

Household characteristics

The vector of household characteristics includes: acres of land owned, value of assets (productive assets and farm animals), and binary variables for security of land tenure and whether the household is monogamous. Tenure security is defined as the household head having a title deed or well-recognized right over a parcel of land. The relationship between mortality, household assets, and landholding size may be non-linear. However, specification tests rejected the non-linearity hypotheses and therefore only linear terms of these variables are used in the reported regressions.

Community characteristics

Community variables include distance to the tarmac road and fertilizer store, which act as proxies for the extent of interaction among local residents and contact with people from other areas.

2.4.4 Correcting for potential attrition bias

It is possible that the AIDS epidemic contributes to sample attrition in the data used, resulting in selection bias. Characteristics of individuals that have attrited and those remaining in the sample are explored using probit reinterview models. To control for possible attrition bias, the inverse probability weighting method is used as outlined below.

Re-interview model

We control for possible attrition bias using the inverse probability weighting method (IPW). The IPW method assumes that the probability of being re-interviewed (non-attrition) as a function of observable information is the same as the probability of being reinterviewed as a function of observables, plus unobservables that are only observed for non-attrited observations (Wooldridge, 2002). Thus, the IPW method works well if observations on observed variables are strong predictors of non-attrition and if observations on unobserved variables are not strong predictors of non-attrition. Following Yamano and Jayne (2005), the re-interview model can be written as:

$$P(R_{iht} = 1) = f(HC_{1997}, ET_{iht}, PD) \qquad (2.10)$$

where R_{iht} is equal to 1 if an individual i remained in household h which was re-interviewed at time t, conditional on the individual being in the household in the previous time period and on the household being interviewed in the previous period, and zero otherwise. The function f is specified as the standard normal cumulative distribution. The set of explanatory variables includes individual and household characteristics in the 1997 survey (HC_{1997}), binary variables for enumeration teams (ET_{iht}), and provinces (PD). Team dummies account for potential differences across enumeration teams in the amount of effort put into locating households in follow-up interviews. This procedure identifies statistical differences in the attributes of re-interviewed vs. attrited individuals. Stratified by gender, a set of probit models are run to determine an individual's probability of reinterview during each of the follow-up surveys.

Equation (2.10) is estimated with probit for attrition by gender between the 1997 and 2000 surveys, obtaining predicted probability, P_{2000}; between 2000 and 2002 to obtain the predicted probability, P_{2002}; between 2002 and 2004 to obtain the predicted probability, P_{2004} and; between 2004 and 2007 to obtain the predicted probability, P_{2007}. For observations in the 2000 survey, the inverse probability weight is $R_{2000} = 1/P_{2000}$. But for the observations in the 2002 surveys, the inverse probability weight is R_{2000}, a product of $1/P_{2000}$ and $1/P_{2002}$ because these observations survived attrition twice. It follows then that for observations in 2004, the inverse probability weight R_{2004} is a product of $1/P_{2000}$, $1/P_{2002}$ and $1/P_{2004}$, while R_{2007} is a product of $1/P_{2000}$, $1/P_{2002}$, $1/P_{2004}$, and $1/P_{2007}$. The models on working-age adult mortality described in the previous section (2.4.2) are estimated using these inverse probabilities as weights in order to correct for attrition bias.

2.5 Results

2.5.1 Descriptive analysis

Basic characteristics of working-age adults who remained alive and those who died due to disease-related causes are shown in Tables 2-3, 2-4, 2-5 and 2-6, for the four survey periods: 1997-2000, 2000-2002, 2002-2004 and 2004-2007. Table 2-4 focuses on the period 2000-2002 and has a smaller set of characteristics since information on some characteristics is not available. Results are provided separately for deceased individuals who were in the demographic roster at the beginning of the period and those who came into the households anytime during the period under consideration.

Results from Table 2-3 indicate that women in the 15-59 year age-range who died tend to be younger than men. Working-age adults who joined households after 1997 and died by 2000 are younger than the mean of those in the demographic roster in 1997. Deceased working-age men have fewer years of education than those who remained alive, but women who joined households and later died are more educated than those who remained alive and the other deceased women. Most of the working-age adults in the sample have primary or secondary education, and as a result mortality is predominant among adults with these levels of education. There is little difference in the number of months spent at home among all working-age adults who were in the 1997 survey. However, deceased men and women who joined the households after 1997 have resided at home for fewer months. This may be consistent with the suggestion that such individuals return home to seek terminal care and die.

Adult daughters account for more than half of the female deaths. Among deceased men who were resident household members in 1997, most deaths relate to household heads while among those who joined, sons account for half of the deaths.

Table 2-3 Characteristics of working-age adults in 2000 who remained alive, and those who died due to illness-related causes between 1997 and 2000

		Working-age adults in 1997 survey who remained alive		Deceased working-age adults			
				Were in 1997 survey		Joined household after 1997 survey	
		Female	Male	Fem	Male	Female	Male
Age (mean) in 2000		33	32	37	42	23	35
Months residing at home		11.0	10.0	12	11	2.6	6.8
Years of education (mean)		6.8	7.9	5.7	6.8	7	7
Relationship to household							
Head/spouse		45.6	31.6	34.3	61.7	0.0	33.3
Son/daughter		45.2	57.8	51.4	27.7	70.0	50.0
Others		9.3	10.6	14.3	10.6	30.0	16.7
Education categories (%)							
No formal education		14.9	7.2	28.6	19.1	0.0	33.3
Primary		58.3	55.9	54.3	53.2	80.0	16.7
Secondary		24.2	31.2	17.1	23.4	20.0	50.0
College/university		2.6	5.8	0.0	4.3	0.0	0.0
Has formal job (%)		5.6	19.0	2.9	19.1	0.0	16.7
No formal job (%)		94.4	81.0	97.1	80.9	100.0	83.3
Has informal activity (%)		15.8	18.2	20.0	25.5	10.0	0.0
No informal activity (%)		84.2	81.8	80.0	74.5	90.0	100.0
Female household head (%)		4.2	N/A	14.3	N/A	0.0	N/A
Other female (Not heads) (%)		95.8	N/A	85.7	N/A	100.0	N/A
Monogamous household (%)		95.1	97.9	85.7	93.6	100.0	83.3
Polygamous household (%)		4.9	2.1	14.3	6.4	0.0	16.7
Land holding (mean acres)		6.6	6.4	6.2	5.7	4.4	3.5
Income quartile (%)							
Lowest		27.5	22.3	25.7	23.4	20.0	33.3
Mid-low		24.8	25.0	20.0	27.7	30.0	16.7
Mid-high		24.3	25.8	25.7	27.7	20.0	33.3
Highest		23.4	26.9	28.6	21.3	30.0	16.7
Asset value quartile (%)							
Lowest		25.6	24.2	22.9	27.7	40.0	0.0
Mid-low		25.3	24.8	34.3	17.0	20.0	33.3
Mid-high		25.1	25.1	20.0	29.8	30.0	16.7
Highest		24.1	25.9	22.9	25.5	10.0	50.0
Province							
Coast	(N)	182	232	3	3	0.0	0.0
	(%)	6.4	8.2	8.6	6.4	0.0	0.0
Eastern	(N)	478	502	3	6	0.0	0.0
	(%)	16.8	17.7	8.6	12.8	0.0	0.0
Nyanza							
Kisii	(N)	165	151	1	2	0.0	1
	(%)	5.8	5.3	2.9	4.3	0.0	16.7
Kisumu/Siaya	(N)	286	245	12	20	4	3
	%	10.1	8.7	34.3	42.6	40.0	50.0
Western	(N)	580	535	6	6	3	1
	(%)	20.4	18.9	17.1	12.8	30.0	16.7
Central	(N)	354	365	3	4	1	0.0
	(%)	12.5	12.9	8.6	8.5	10.0	0.0
Rift Valley	(N)	798	800	7	6	2	1
	(%)	28.1	28.3	20.0	12.0	20.0	16.7
Number of individuals		2843	2830	35	47	10	6

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

The sample contains few adults with formal jobs and informal/business activities, who are female household heads and from polygamous households; the same pattern in numbers is reflected in mortality levels for people with these characteristics. None of the women who died had a formal job and none of those in the 1997 survey who died had any informal/business activity.

Deceased adults who joined households after 1997 appear to be from households with less land. Men and women who remained alive and those who died don't seem to coalesce into any income quartile. With respect to asset quartiles, deceased working-age women are from poorer households compared to men. Most female deaths among those who joined households after 1997 are from the lowest asset quartile while for men, no deaths are found in this quartile. It appears that mortality rates are higher among poorer adults, especially for women.

There are apparent regional differences in working-age adult mortality. Kisumu and Siaya districts in Nyanza province have the highest percentage of both female and male mortality, followed by Western province while Coast province has the lowest adult mortality. Although Nyanza province represents about 15 percent of the working-age adults in the sample, it accounts for almost 40 percent of death cases.

Table 2.4 shows characteristics in 2002 of working-age adults who remained alive, and those who died due to disease between 2000 and 2002. Thirty-three working-age adults who were in the 2000 survey passed away. Only 4 adults who joined the households sometime after 2000 died; we report statistics for this group in Table 2-4 for completeness, but of course a sample of this size cannot be considered in any way statistically representative. Adults, who were in 2000 survey and passed away are much older, less educated, and have resided at home for fewer months than the individuals who remained in the sample. Most of the working-age adults who remained alive have primary or secondary education while those who died have either primary or no formal education. Mortality rates are higher among sons and daughters compared to heads and spouses. The sample contains few adults with formal jobs and informal/business activities, who are female household heads and from polygamous households. As a result we find fewer deaths among adults with formal jobs and informal/business activities, who are female household heads and from polygamous households. None of the women who died had any informal activity or was a household head. Adults who joined the household within the period and died did not have a formal job and were not involved in informal/business activities. There are differences in mortality rates across the provinces, with Coast province having the least number of deaths while Nyanza and Western provinces have the highest deaths within this period.

Table 2-4 Characteristics of working-age adults in 2002 who remained alive, and those who died due to illness-related causes between 2000 and 2002

		Working-age adults in 2000 survey who remained alive		Deceased working-age adults			
				Were in 2000 survey		Joined household after 2000 survey	
		Female	Male	Female	Male	Female	Male
Age (mean) in 2002		29	28	34	35	34	26
Months residing at home (mean)		8.1	7.7	3.0	3.5	4.3	0
Years of education (mean)		8	9	6	8	8	10
Relationship to household head (%)							
Head/spouse		30.4	19.5	38.9	26.7	0.0	0.0
Son/daughter		51.9	61.4	61.1	46.7	66.7	100.0
Others		17.8	19.1	0.00	26.7	33.3	0
Education categories (%)							
No formal education		10.6	5.8	22.2	13.3	33.3	0.0
Primary		56.0	51.8	61.1	60.0	33.3	0.0
Secondary		28.0	33.0	16.7	13.3	0.0	100.0
College/university		5.4	9.4	0.0	13.3	33.3	0.0
Has formal job (%)		5.8	11.4	5.6	13.3	0.0	0.0
No formal job (%)		94.2	88.6	94.4	86.7	100.0	100.0
Has informal activity (%)		13.3	17.0	0.0	6.7	0.0	0.0
No informal activity (%)		86.7	83.0	100.0	93.3	100.0	100.0
Female household head (%)		3.2	N/A	0.0	N/A	0.0	N/A
Other female (Not heads) (%)		96.8	N/A	100.0	N/A	100.0	N/A
Monogamous household (%)		94.0	95.0	94.4	93.3	100.0	100.0
Polygamous household (%)		6.0	5.0	5.6	6.7	0.0	0.0
Province							
Coast	(N)	231	229	2	2	0	0
	(%)	7.1	7.0	11.1	13.3	0.0	0.0
Eastern	(N)	543	564	3	1	1	0
	(%)	16.6	17.2	16.7	6.7	33.3	0.0
Nyanza							
Kisii	(N)	171	185	1	0	0	0
	(%)	5.2	5.7	5.6	0.0	0.0	0.0
Kisumu/Siaya	(N)	337	293	3	5	0	1
	(%)	10.3	8.9	16.7	33.3	0.0	100.0
Western	(N)	731	727	6	2	0.0	0
	(%)	22.4	22.2	33.3	13.3	0.0	0.0
Central	(N)	414	428	0	3	2	0
	(%)	12.7	13.1	0.0	20.0	66.7	0.0
Rift Valley	(N)	838	848	3	2	0	0
	(%)	25.7	25.9	16.7	13.3	0.0	0.0
Number of individuals		3265	3274	18	15	3	1

Source: Tegemeo Institute (Nairobi)/Michigan State University Agricultural Monitoring and Policy Analysis Household Surveys in 2000 and 2002.

Characteristics in 2004 of working-age adults who remained alive and those who died between 2002 and 2004 are shown in Table 2-5. Out of 65 working-age adults who died between 2002 and 2004, 52 of them were in the 2002 survey. Adults who died were older while men who came to the households after 2002 and later died, were 11 years younger than those who were in 2002 survey and passed away. There appears to be no difference in education between adults who died and those who remained alive, with most of them having either primary or secondary education. A large proportion of females who were in the 2002 survey and later died were relatives of the household head while most cases of male mortality pertained to household heads. Among the men who joined the households after the 2002 survey and died by 2004, most were sons of the household head while women were either spouses or daughters. There were no deaths among female heads of households. Unlike previous periods, we find a few deaths among those with formal jobs and informal/business activities. However, this is only among adults who were in 2002 survey. In addition, deceased adults appear to be from households with less land but men who join households and later die seem to join households with more land.

For working-age adults who were in 2002 survey, there are fewer deceased women in the poorest income quartile while a larger percentage of the men who died belong to this income quartile. For adults who joined the households after 2002 survey and later died, women appear to belong to the bottom two income and asset quartiles while men (who are principally sons) are in the top two quartiles. Once more, we find more deaths in Nyanza province than in other provinces.

Table 2-5 Characteristics of working-age adults in 2004 who remained alive and those who died due to illness-related causes between 2002 and 2004

	Working-age adults in 2002 survey who remained alive		Deceased working-age adults			
			Were in 2002 survey		Joined household after 2002 survey	
	Female	Male	Female	Male	Female	Male
Age (mean) in 2004	30	29	38	44	38	33
Months residing at home	8.1	7.4	1.9	4.0	2.4	3.0
Years of education (mean)	8	9	8	9	7	9
Relationship to household						
Head/spouse	34.1	21.3	16.1	47.6	42.9	16.7
Son/daughter	48.3	60.7	35.5	33.3	42.9	66.7
Others	17.6	18.0	48.4	19.0	14.3	16.7
Education categories (%)						
No formal education	9.3	3.4	6.5	4.8	14.3	0.0
Primary	55.3	54.6	74.2	52.4	71.4	66.7
Secondary	27.7	32.0	12.9	38.1	14.3	33.3
College/university	7.7	10.0	6.5	4.8	0.0	0.0
Has formal job (%)	9.9	15.1	3.2	9.5	0.0	0.0
No formal job (%)	90.1	84.9	96.8	90.5	100.0	100.0
Has informal activity (%)	12.0	13.8	3.2	4.8	0.0	0.0
No informal activity (%)	88.0	86.2	96.8	95.2	100.0	100.0
Female household head (%)	4.8	N/A	0.0	N/A	0.0	N/A
Other female (%)	95.2	N/A	100.0	N/A	100.0	N/A
Monogamous household (%)	93.7	94.8	93.5	100.0	85.7	66.7
Polygamous household (%)	6.3	5.2	6.5	0.0	14.3	33.3
Land holding (mean acres)	4.80	4.81	2.67	2.65	2.12	4.85
Income quartile (%)						
Lowest	26.5	23.4	19.4	33.3	28.6	16.7
Mid-low	24.5	25.7	25.8	23.8	42.9	0.0
Mid-high	24.5	25.4	22.6	28.6	28.6	33.3
Highest	24.5	25.5	32.3	14.3	0.0	50.0
Asset value quartile (%)						
Lowest	25.5	24.5	25.8	23.8	14.3	33.3
Mid-low	24.9	25.2	12.9	42.9	42.9	0.0
Mid-high	25.5	24.4	32.3	14.3	14.3	50.0
Highest	24.5	25.9	29.0	19.0	28.6	16.7
Province						
Coast (N)	205	204	1	2	0	0
(%)	7.5	7.3	3.2	9.5	0.0	0.0
Eastern (N)	470	472	3	3	0	0
(%)	17.1	16.9	9.7	14.3	0.0	0.0
Nyanza						
Kisii (N)	153	169	2	0	0	0
(%)	5.6	6.1	6.5	0.0	0.0	0.0
Kisumu/Siaya (N)	304	296	6	10	2	2
(%)	11.1	10.6	19.4	47.6	28.6	33.3
Western (N)	577	585	6	4	4	0
(%)	21.0	20.9	19.4	19.0	57.1	0.0
Central (N)	336	346	4	2	1	1
(%)	12.2	12.4	12.9	9.5	14.3	16.7
Rift Valley (N)	698	721	9	0	0	3
(%)	25.4	25.8	29.0	0.0	0.0	50.0
Number of individuals	2743	2793	31	21	7	6

Source: Tegemeo Institute (Nairobi)/Michigan State University Agricultural Monitoring and Policy Analysis Household Surveys in 2002 and 2004.

Table 2-6 shows the characteristics in 2007 of working-age adults who remained alive and those who died between 2004 and 2007. The results show that working-age adults who joined households after 2004 and died by 2007 are younger than the deceased adults who were in the 2004 survey. Among the adults in the 2004 survey, the deceased ones spent more months at home than those who did not die.[2] The former may have been too sick to participate in any activity outside the home and were receiving care at home.

Heads of households account for most deaths among individuals who were in the 2004 survey. However, among those who joined later, sons and daughters account for a larger percentage of the deaths.

Most of the working-age adults in the sample have primary or secondary education. However, we find that a slightly larger number of women deaths among those with primary or no formal education, while more deceased men have primary or secondary education.

The sample contains few adults with formal jobs and informal activities, who are female household heads and from polygamous households. The same pattern is generally reflected in the number of deaths among people with these characteristics. However, we note a slightly higher number of deaths among males with a formal job and women from polygamous households.

Adults who died appear to come from households with slightly smaller landholdings, and particularly for those who joined the household after 2004 and died by 2007.

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[2] Among deceased working-age adults who joined the households after 2004, information on months at home, as well as participation in formal employment and informal activities is missing for some of them. A dash (-) in the last 2 columns of Table 2-6 indicates that information on the variable is missing for some individuals and so no means or percentages are reported.

Table 2-6 Characteristics of working-age adults in 2007 who remained alive and those who died due to illness-related causes between 2004 and 2007

	Working-age adults in 2004 survey who remained alive		Deceased working-age adults			
			Were in 2004 survey		Joined household after 2004 survey	
	Female	Male	Femal	Male	Female	Male
Age (mean) in 2007	33	32	39	39	34	31
Months residing at home	7.9	7.3	10	10	-	-
Years of education (mean)	8	9	7	8	8	10
Relationship to household						
Head/spouse	31.9	20.4	52.5	45.2	0.0	0.0
Son/daughter	45.1	56.5	37.5	25.8	62.5	75.0
Others	23.0	23.2	10.0	29.0	37.5	25.0
Education categories (%)						
No formal education	9.0	3.9	20.0	3.2	0.0	0.0
Primary	56.2	56.3	57.5	58.1	75.0	50.0
Secondary	27.7	30.8	17.5	32.3	25.0	25.0
College/university	7.1	9.0	5.0	6.5	0.0	25.0
Has formal job (%)	9.2	14.2	10.0	29.0	-	-
No formal job (%)	90.8	85.8	90.0	71.0	-	-
Has informal activity (%)	11.5	13.4	20.0	12.9	-	-
No informal activity (%)	88.5	86.6	80.0	87.1	-	-
Female household head (%)	0.0	N/A	0.0	N/A	0.0	N/A
Other female (%)	100.0	N/A	100.0	N/A	100.0	N/A
Monogamous household (%)	93.4	94.6	85.0	100.0	100.0	100.0
Polygamous household (%)	6.6	5.4	15.0	0.0	0.0	0.0
Land holding (mean acres)	4.9	4.8	4.3	4.6	3.5	3.1
Income quartile (%)						
Lowest	26.5	23.3	27.5	35.5	37.5	0.0
Mid-low	24.4	25.7	30.0	16.1	12.5	50.0
Mid-high	24.7	25.2	22.5	29.0	25.0	25.0
Highest	24.3	25.8	20.0	19.4	25.0	25.0
Asset value quartile (%)						
Lowest	26.1	25.8	27.5	29.0	37.5	0.0
Mid-low	25.5	23.8	20.0	25.8	25.0	25.0
Mid-high	25.1	24.6	25.0	29.0	12.5	50.0
Highest	23.3	25.0	27.5	16.1	25.0	25.0
Province						
Coast (N)	288	261	2	3	0	1
(%)	8.4	7.5	5.0	9.7	0.0	25.0
Eastern (N)	548	527	6	2	2	1
(%)	16.1	15.1	15.0	6.5	25.0	25.0
Nyanza						
Kisii	229	209	1	1	0	0
	6.7	6.0	2.5	3.2	0.0	0.0
Kisumu/Siaya	376	386	8	7	1	0
(	11.0	11.1	20.0	22.6	12.5	0.0
Western (N)	673	696	8	6	3	0
(%)	19.3	19.9	20.0	19.4	37.5	0.0
Central (N)	380	404	4	3	1	0
(%)	11.1	11.6	10.0	9.7	12.5	0.0
Rift Valley (N)	919	1006	11	9	1	2
(%)	26.9	28.8	27.5	29.9	12.5	50.0
Number of individuals	3413	3489	40	31	8	4

Source: Tegemeo Institute /Michigan State University Agricultural Monitoring and Policy Analysis Surveys in 2004 and 2007. A dash (-) indicates information is missing for some individuals.

A slightly higher percentage of deceased men and women who were in 2004 are in the bottom two income and asset quartiles. Unlike in previous years, we find more deaths in Rift Valley province compared to Nyanza province.

Mortality by gender and age

Figure 2-1 presents percentage of deaths within age-group by gender. It reveals that there are age/cohort and gender differences in mortality. In the earlier stages of the life-cycle, there are more deaths among women than men but the trend reverses in later years. Percentage of deaths among women rises and is generally greater for men up to age group, 30-34 years. From 35-39 years age-group, this percentage declines and is less than that for men particularly for the age-groups 50-54 and 55-59. The differences in percentage of deaths between men and women are more pronounced for the age-groups 20-24, 30-34, 35-39 and 50-54, with the largest gap in the 20-24 age group. Therefore, age is a critical factor in working-age adult mortality. Data in 2004 and 2007 report cause of death by type of disease but in the other surveys, it is reported as 'disease'. Based on these surveys, the five leading causes of death among women are malaria, HIV/AIDS, TB, meningitis and cancer while among men they are malaria, TB, HIV/AIDS, cancer and stroke/heart disease.

In general, three broad categories of explanations have been suggested for gender differences in ill-health: biological, reporting differences and differences in behavior (Strauss et al, 1993). Biological explanations relate to genes and hormones. With respect to health reporting behavior, women are likely to report more health problems. It is commonly argued that women are more complete and detailed than men in any interview, including a clinical setting (Verbrugge, 1985). Strauss et al (1993) point out that behavioral choices have a significant effect on gender differences in health for various reasons. Child-bearing may affect physical functioning of women through maternal depletion and particularly where health facilities are poor and fertility rates high. Gender-based occupational and time allocation decisions may cause women and men to face different types and levels of stress. This leads to different levels of health between men and women.

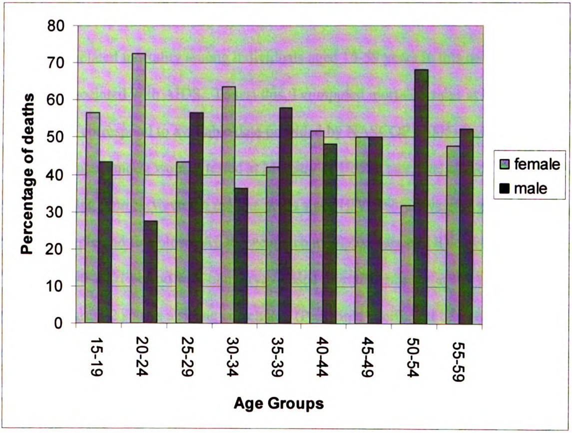

Figure 2-1 Percentage of disease-related deaths within age groups by gender, for the period 1997-2007

Source: Tegemeo Institute (Nairobi)/Michigan State University Agricultural Monitoring and Policy Analysis Household Surveys in 1997, 2000, 2002, 2004 and 2007.

Different activities with respect to smoking, drinking and sexual behavior may also lead to gender differential in health. It is also possible that women and men have different access to health care arising from household choices. In this sample of working-age adults, the pattern of deaths by age-group and gender reflects that which has been reported for HIV/AIDS, where mortality is higher among relatively younger women and slightly older men.

Correlation between HIV prevalence rates and mortality rates from survey data

Before reporting the main results, it is important to establish the extent to which the disease-related mortality among individuals aged 15-59 years in this nationwide survey is associated with AIDS. To test this, I computed mortality rates at the province-level, which correspond to available data provided by NASCOP (2005) on HIV prevalence rates among women tested at Ministry of Health antenatal clinics. Taking into account the lag time between the median years since HIV sero-conversion in an HIV positive sample and full-blown AIDS, we match available data on HIV prevalence rates from the 1990-2001 period with our survey-based mortality rates over the 1997-2007 period. Figure 2-2 shows a strong correlation (Pearson's coefficient of 0.69), providing reasonably solid evidence that the disease-related mortality in our data is to a large extent picking up the effects of HIV-related mortality.

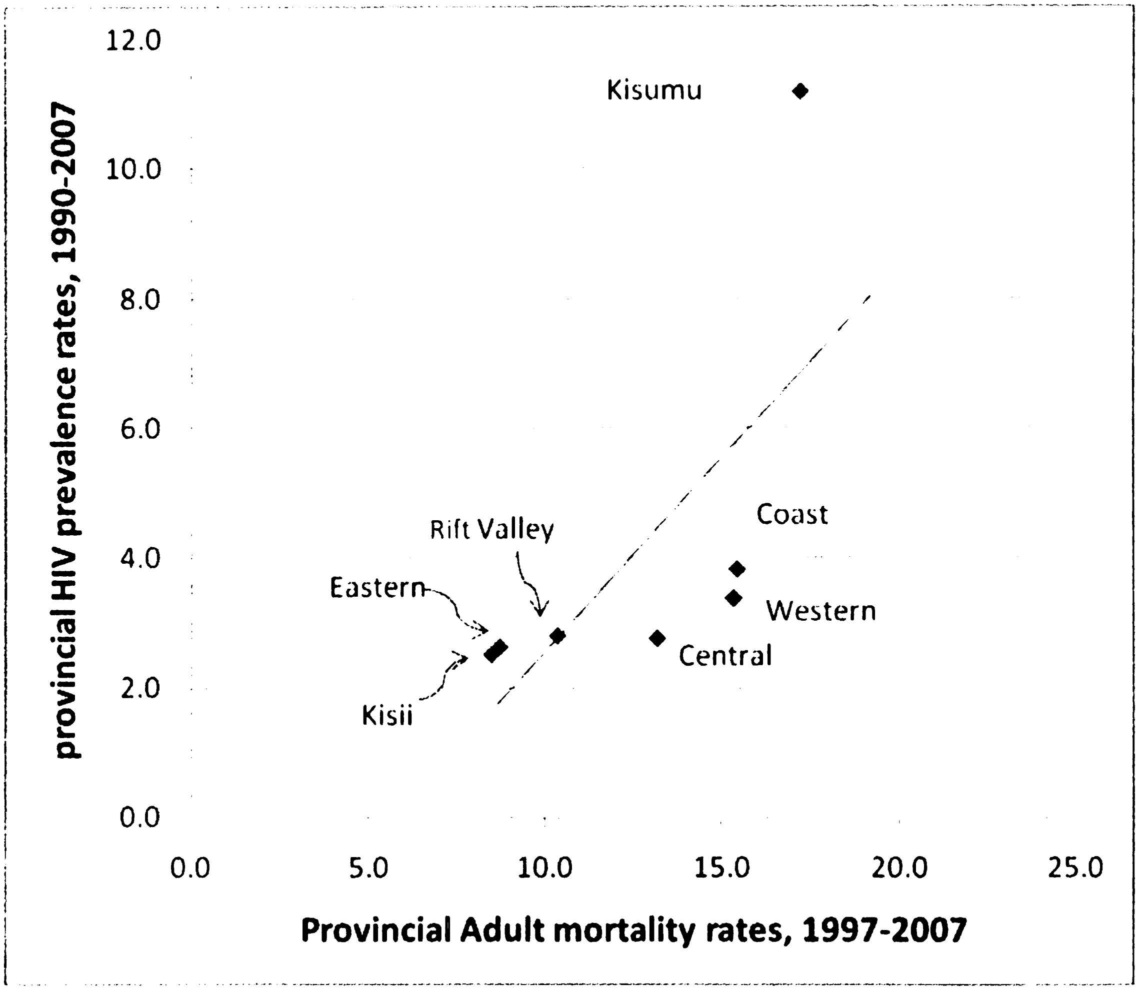

Figure 2-2 Provincial adult mortality rates from household survey data (1997-2007) and HIV prevalence rates (1990-2001)

2.5.2 Factors influencing re-interview

Results in Table 2-7 are based on equation (2.10) in section 2.4.3. Findings show that household heads and spouses are more likely to be re-interviewed than unmarried working-age adults. Age has a non-linear effect on probability of re-interview for all model specifications. At young age ranges, the probability of reinterview declines with age, but then increases beyond the ages of 42 and 41 for males and females, respectively (based on results in columns 9 and 10). Older individuals are more likely to be re-interviewed compared to younger individuals. In all specifications, the probability of re-interview decreases with years of education but the results are statistically significant only in the cases of men in the 2000 and 2002 surveys.

While men with formal jobs are more likely to be reinterviewed (columns 7 and 9), women are less likely to be reinterviewed (column 10). Generally, individuals who spend more time at home are more likely to be reinterviewed. The results also show that in general, adults in households with more children are more likely to be reinterviewed. The effect of household wealth on reinterview is generally negative, often statistically significant in the case of females. However, the effect is rather small. Holding other factors constant, women from households at the 25th and 75th percentile of the assets distribution, are nearly equally likely to be re-interviewed. The probability of re-interview for the two groups are, respectively, 0.895 vs. 0.894 in 2000, 0.839 vs. 0.835 in 2007, and 0.847 vs. 0.846 in the case of the pooled model. Security of land tenure is positively related to reinterview (columns 2, 3, 4, 9 and 10) but amount of land owned is negatively related to reinterview for males in the 2000 survey only (column 1). Adult women from polygamous households are less likely to be reinterviewed (columns 2, 8 and 10), possibly because lack of adequate economic resources in such large households maybe forcing young women to move out in search of better opportunities or even get married. However, we find mixed results in the case of men. Men from polygamous households were less likely to be reinterviewed the 2000 survey, but more likely to be reinterviewed in 2004.

Generally, there is evidence of joint significance of team dummies as well as individual and household characteristics, implying that these categories of variables are strong predictors of reinterview. Community characteristics are, however, jointly significant in a few of the specifications.

The implication of the findings in Table 2-7 is that attrition bias is a problem in this data set and there is need to control for attrition while using estimating the hazard models of working-age adult mortality.

Table 2-7 Probit models for individual-level reinterview by gender and survey periods

	Dependent variable =1 if									
	Individual reinterviewed in 2000, and is in 1997 sample		Individual reinterviewed in 2002, and is in 1997 and 2000 samples		Individual reinterviewed in 2004, and is in 1997, 2000 and 2002 samples		Individual reinterviewed in 2007, and is in 1997, 2000, 2002 & 2004 samples		Pooled model	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Individual characteristics in 1997										
Head/spouse(=1)	0.126**	0.190**	-0.032	0.028	0.415**	0.441**	0.503**	0.451**	0.204**	0.232**
	(6.62)	(10.62)	(1.22)	(1.25)	(13.28)	(13.89)	(11.36)	(10.96)	(14.35)	(17.53)
Age	-0.013**	-0.014**	-0.008*	-0.009*	-0.043**	-0.012*	-0.041**	-0.011+	-0.021**	-0.009**
	(4.13)	(4.26)	(2.09)	(2.19)	(7.27)	(1.98)	(5.32)	(1.67)	(9.35)	(4.03)
Age squared	1.2e-04**	1.3e-04**	9.6e-05+	1.1e-04+	5.1e-04**	1.9e-04*	5.2e-04**	1.7e-04+	2.5e-04**	1.1e-04**
	(2.76)	(2.85)	(1.86)	(1.93)	(5.55)	(1.99)	(4.42)	(1.72)	(7.43)	(3.31)
Years of education	0.004*	-0.000	-0.004+	-0.002	-0.001	-0.004	-0.006	-0.001	-0.000	-0.002
	(2.00)	(0.13)	(1.85)	(0.95)	(0.28)	(1.13)	(1.24)	(0.18)	(0.21)	(1.37)
Formal job (=1)	0.018	-0.033	0.027	-0.026	-0.017	-0.031	0.107**	-0.088	0.029*	-0.033+
	(0.96)	(1.19)	(1.38)	(0.79)	(0.55)	(0.66)	(2.76)	(1.58)	(2.37)	(1.75)
Informal activity (=1)	0.027	0.019	-0.024	-0.028	-0.002	-0.044	0.047	-0.003	0.009	-0.011
	(1.52)	(1.11)	(1.28)	(1.46)	(0.07)	(1.36)	(1.24)	(0.08)	(0.70)	(0.89)
Months at home	0.005**	0.001	0.003	0.008**	-0.001	0.001	0.009*	0.004	0.004**	0.003+
	(2.99)	(0.35)	(1.51)	(2.77)	(0.25)	(0.27)	(2.41)	(0.86)	(3.54)	(1.92)

Table 2-7 continued

	Dependent variable =1 if									
	Individual reinterviewed in 2000, and is in 1997 sample		Individual reinterviewed in 2002, and is in 1997 and 2000 samples		Individual reinterviewed in 2004, and is in 1997, 2000 and 2002 samples		Individual reinterviewed in 2007, and is in 1997, 2000, 2002 & 2004 samples		Pooled model	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Household characteristics in 1997										
Girls less than 6 years (number)	0.013	-0.008	-0.000	-0.008	0.008	0.026+	0.024	0.004	0.007	-0.000
	(1.27)	(0.97)	(0.05)	(0.89)	(0.51)	(1.80)	(1.17)	(0.30)	(1.04)	(0.08)
Girls 6-14 years (number)	-0.008	-0.009	0.009	0.014*	-0.014	-0.005	0.010	0.004	0.000	0.001
	(1.32)	(1.55)	(1.32)	(1.97)	(1.53)	(0.57)	(0.87)	(0.44)	(0.09)	(0.16)
Boys less than 6 years (number)	-0.009	-0.001	0.012	0.012	0.019	0.004	-0.025	-0.008	0.002	0.004
	(1.01)	(0.14)	(1.28)	(1.26)	(1.46)	(0.31)	(1.50)	(0.58)	(0.30)	(0.72)
Boys 6-14 years (number)	0.002	-0.002	0.031**	0.021**	0.005	0.005	0.031*	0.014	0.017**	0.010*
	(0.25)	(0.34)	(4.43)	(3.14)	(0.50)	(0.54)	(2.57)	(1.43)	(4.10)	(2.45)
Total assets	-7.19e-09	-1.5e-08*	5.52e-08*	8.273e-09	-2.48e-08	1.461e-08	1.148e-08	-6.3e-08*	-1.16e-09	-1.4e-08+
	(0.67)	(2.03)	(2.32)	(0.68)	(1.04)	(0.57)	(0.40)	(2.20)	(0.11)	(1.92)
Land tenure (=1)	0.023	0.040*	0.035+	0.051*	0.014	-0.006	0.023	0.015	0.026*	0.032*
	(1.17)	(2.02)	(1.74)	(2.36)	(0.45)	(0.21)	(0.60)	(0.44)	(2.00)	(2.46)
Landholding (acres)	-0.001*	-0.001	0.001	0.000	0.002	0.000	0.000	0.001	0.000	0.000
	(2.22)	(1.21)	(0.70)	(0.52)	(1.54)	(0.44)	(0.36)	(0.68)	(0.08)	(0.53)

Table 2-7 continued

	Dependent variable =1 if									
	Individual reinterviewed in 2000, and is in 1997 sample		Individual reinterviewed in 2002, and is in 1997 and 2000 samples		Individual reinterviewed in 2004, and is in 1997, 2000 and 2002 samples		Individual reinterviewed in 2007, and is in 1997, 2000, 2002 & 2004 samples		Pooled model	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Polygamous household (=1)	-0.075**	-0.130**	-0.043	-0.037	0.077*	-0.015	0.031	- 0.171**	-0.015	- 0.086**
	(2.62)	(4.95)	(1.32)	(1.26)	(1.96)	(0.36)	(0.59)	(3.51)	(0.79)	(4.84)
Community characteristics										
Distance to tarmac road	-0.001	-0.001*	0.000	-0.000	-0.001	-0.002	0.000	-0.000	-0.000	-0.001*
	(0.90)	(2.33)	(0.38)	(0.33)	(0.97)	(1.47)	(0.09)	(0.30)	(0.24)	(2.00)
Distance to fertilizer store	0.001	-0.001	0.003**	0.002*	0.000	-0.000	-0.002*	-0.002*	0.000	-0.000
	(1.01)	(1.30)	(3.44)	(2.26)	(0.11)	(0.03)	(2.01)	(1.97)	(1.05)	(0.42)
Team dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Province dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Table 2-7 continued

	Dependent variable =1 if									
	Individual reinterviewed in 2000, and is in 1997 sample		Individual reinterviewed in 2002, and is in 1997 and 2000 samples		Individual reinterviewed in 2004, and is in 1997, 2000 and 2002 samples		Individual reinterviewed in 2007, and is in 1997, 2000, 2002 & 2004 samples		Pooled model	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Chi-square joint test for[a]:										
Team Effects	10.22	9.53	4.99	0.72	6.72	245.83	357.96	276.65	84.96	62.29
	(0.017)	(0.023)	(0.082)	(0.699)	(0.081)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Individual characteristics	77.93	127.32	32.27	22.55	279.10	393.64	293.45	318.61	359.24	547.50
	(0.000)	(0.000)	(0.000)	(0.002)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Household characteristics	20.94	45.40	35.48	26.73	10.25	5.03	11.79	23.90	24.34	48.29
	(0.007)	(0.000)	(0.000)	(0.001)	(0.248)	(0.755)	(0.161)	(0.002)	(0.002)	(0.000)
Community characteristics	1.50	7.49	13.26	5.12	0.96	2.29	4.29	4.61	1.10	4.65
	(0.473)	(0.014)	(0.001)	(0.078)	(0.620)	(0.318)	(0.117)	(0.099)	(0.576)	(0.098)
Observations	2877	2878	2492	2510	2135	2151	1579	1565	9083	9104

Source: Tegemeo Institute (Nairobi)/Michigan State University Agricultural Monitoring and Policy Analysis Household Surveys in 1997, 2000, 2002, 2004 and 2007.

Notes:

Estimated coefficients are marginal changes in probability; z statistics in parentheses

** indicates 1% significance level; * indicates 5% significance level; + indicates 10% significance level

Team and province dummies included in the models but not reported.

[a] p-values in parentheses; Team effects are significant at 10% except for reinterview of females in year 2002.

Individual characteristics are significant at 1% and household characteristics are significant at 1% except for male and female reinterview in 2004 and for males in 2007. Community characteristics are significant at 10% in five of the specification

2.5.3 Results from hazard analysis

During the 10-year study period, 22,654 person-years were generated from 5,755 adults aged 15-59 years. There were 216 deaths and the crude mortality rate was 9.53 per 1000 person-years, 9.19 for males and 9.87 for females. This section presents results from three different discrete-time hazard models for the observation period 1997 to 2007.

Initial discrete-time hazard model

The results of the initial hazard model are shown in Table 2-8. This model contains survey-period dummy variables as the only explanatory variables and therefore describes the overall temporal profile of risk. Columns 1 and 2 show the parameter estimates while the corresponding marginal effects are shown in columns 3 and 4. The parameter estimates in columns 1 and 2 describe the shape of the fitted whole-sample hazard function, for men and women, respectively. If the risk of death were not related to time, these estimates would be equal and the hazard function would be flat. Results show that the parameter estimates of the later periods are smaller than those of the earlier periods for men, implying that men's overall risk of death declines over time. In the case of women, the hazard decreases in the second period, rises in the third period and then declines in the fourth period. Wald tests on the specifications for men (chi2 (3)=11.31, p value=0.0101) and women (chi2 (3)=8.87, p value=0.0310) indicate that we reject the null hypothesis that the parameter estimates are equal. Therefore, the overall risk of death is different in each survey period for both men and women in this sample. In general, there is a downward trend in the probability of working-age adult mortality across the observation period. However, mortality risk decreases faster for men than women. This is consistent with decreases in AIDS-related deaths and HIV prevalence rates in Kenya, which can be attributed to positive changes in sexual behaviour and significant progress in treatment programs. Demographic health surveys indicate that both age at first sex and use of condoms are rising, and the percentage of adults with multiple partners is falling (Cheluget et al, 2006).

The risk of dying in each survey period can be recovered using equation (2.7) (page 24). For example, in period 1 where $D_1 = 1$ and D_2 through D_4 are equal to zero, the hazard probability for men can be obtained as:

$$h_1 = \frac{1}{1+e^{-(-4.004462\times 1)}} = 0.0179 .$$

The fitted hazard value of 0.0179 indicates that among this sample of working-age adult men, there is a 1.79% risk of dying of disease-related causes between the 1997 and 2000 surveys. Similar calculations lead to the estimates of the discrete per period hazards for men and women reported in columns 5 and 6, respectively.

Table 2-8 Parameter estimates, marginal effects and hazard probabilities for the initial baseline hazard model for the period 1997-2007

	Parameter estimates		Marginal effects		Per period hazard probabilities	
Survey period	Male	Female	Male	Female	Male	Female
	(1)	(2)	(3)	(4)	(5)	(6)
1997-2000	-4.019***	-4.209***	-0.025***	-0.027***	0.0179	0.0118
	(0.194)	(0.196)	(0.003)	(0.003)		
2000-2002	-4.696***	-5.209***	-0.029***	-0.034***	0.0093	0.0044
	(0.348)	(0.304)	(0.003)	(0.003)		
2002-2004	-4.758***	-4.386***	-0.029***	-0.028***	0.0087	0.0100
	(0.279)	(0.254)	(0.004)	(0.003)		
2004-2007	-5.212***	-4.755***	-0.033***	-0.030***	0.0056	0.0069
	(0.344)	(0.231)	(0.004)	(0.003)		
Observations	11311	11343	11311	11343		

Source: Tegemeo Institute (Nairobi)/Michigan State University Agricultural Monitoring and Policy Analysis Household Surveys in 1997, 2000, 2002, 2004, and 2007.
Notes: Standard errors are in parentheses; *** indicates 1 percent significance level; ** indicates 5 per cent significance level;* indicates 10 percent significance level

Discrete-time hazard model with time-invariant effects

The main effects of the individual, household and community characteristics, in addition to the main effect of time, are shown in Table 2-9. The reported estimates are marginal effects. These models are specified such that the effect of each explanatory variable is the same in all survey-periods and therefore, the variables have a time-invariant effect. This applies even in the case of time-varying variables. For instance, although the values of the variables *age* and *age squared* vary from survey-period to survey-period, their effects are constrained to be the same in all periods under the proportionality assumption.

Time-invariant effects reported in column 1 of Table 2-9 indicate that in every survey-period, men's mortality hazard is unrelated to their age, even when age is specified as five-year age group dummies for the 15-59 age-range (results not reported here). This may be consistent with an AIDS' flattening of the normal adult mortality schedule as suggested by Weinreb (2004). Also, in each period, male heads of households have greater hazard of death compared to non-head male adults. Perhaps this may be attributed to the fact that heads are much older than the non-heads, a factor that may increase the probability that they are infected by the HIV virus, particularly if they engage in extramarital relationships.

More educated men are less likely to die in each survey period. This is because more educated people have better access to information about existence, transmission and prevention modes of HIV/AIDS epidemic. Education enables individuals to avoid infection by using condoms or a combination of HIV testing and reciprocal fidelity, and

Table 2-9 Results of time-invariant hazard models of working-age adult mortality in rural Kenya, 1997-2007

	Male	Female
Explanatory variables	(1)	(2)
1997-2000 period (=1)	-0.024***	-0.072***
	(0.008)	(0.017)
2000-2002 period (=1)	-0.032***	-0.092***
	(0.010)	(0.023)
2002-2004 period (=1)	-0.028***	-0.077***
	(0.009)	(0.020)
2004-2007 period (=1)	-0.027***	-0.087***
	(0.009)	(0.024)
Head/spouse (=1)	0.0080**	-0.0041**
	(0.0038)	(0.0018)
Age	0.0005	0.0015***
	(0.0004)	(0.0005)
Age squared	-4.57e-06	-1.64e-05***
	(4.34e-06)	(5.74e-06)
Years of education	-0.0003*	-0.0002
	(0.0002)	(0.0002)
Months at home	-0.0003**	0.0003
	(0.0002)	(0.0005)
Monogamous household (=1)	-0.0005	0.0049**
	(0.0026)	(0.0020)
Land tenure (=1)	-0.0001	0.0042*
	(0.0019)	(0.0024)
Land owned (acres)	5.84e-05	-1.46e-04*
	(6.85e-05)	(8.27e-05)
Assets	-2.24e-06	-7.78e-07
	(2.98e-06)	(1.88e-06)
Distance to fertilizer store (km)	0.0004	-0.0003
	(0.0005)	(0.0008)
Distance to tarmac road (km)	-0.0008	-0.0008
	(0.0007)	(0.0011)
Observations	11311	11343

Source: Tegemeo Institute (Nairobi)/Michigan State University Agricultural Monitoring and Policy Analysis Household Surveys in 1997, 2000, 2002, 2004, and 2007.

Notes: Standard errors are in parentheses; *** indicates 1 percent significance level; ** indicates 5 percent significance level;* indicates 10 percent significance level enables them to mitigate consequences of the disease through better nutrition and health care (Deheneffe et al, 1998; de Walque, 2002).

The number of months an adult man spends at home is negatively related to mortality hazard. It has been hypothesized in the literature that spending more time away from home is associated with higher risks of death due to disruption of family and spousal or sexual relationships, as well as the existence of more social interactions and opportunities for risky multiple sexual partnerships.

Landholding size and the value of productive farm assets (including livestock assets) are important indicators of a household's wealth. Results show that there is no significant relationship between amount of land owned, household assets and male mortality hazard. It has been argued that wealthier men are more likely to be infected by HIV because their greater resources provide access to more sexual partners (Shelton et al, 2005; Annim & Awusabo-Asare, 2006). However, their wealth may confer an advantage once they are infected. It enables them to alleviate the consequences of the disease through better nutrition and health care and access to ARV treatment. The sum effect may lead to a situation where wealth does not influence the probability of death, thus flattening the wealth-mortality gradient.

The distance variables are not significantly related to men's risk of death. This finding may imply that the disease is no longer concentrated along the main highways and points of contact with travellers but has permeated throughout rural areas.

In column 2, we find that in every survey period, women who are heads or spouses are less likely to die compared to the non-head adult women. This maybe because women who are not household heads tend to be younger; and it is the younger women in their 20s who face greater risks of HIV/AIDS. This finding is in contrast with the case for men and may be linked to the following explanations. First, men tend to marry younger women, with the older men having higher chances of being infected by the HIV virus. Thus, the presence of cross-generational sexual relationships implies that the risk of dying is greater among younger women and relatively older men. Moreover, this may be due to gender differences in sexual behaviors. For example, having multiple sexual partners and extramarital liaisons is more dominant among men than women, possibly because the society tends to somewhat condone such behaviour among men but not women. Also, while women are likely to acknowledge their risk of infection, men tend to downplay their vulnerability (Parikh, 2007). This leads to a greater risk of infection and death among male heads in contrast to women heads/spouses.

Age has a non-linear effect on women's mortality hazard. The linear term in age is positive while the quadratic term is negative. Therefore, the risk of death among adult women first increases with age and later declines after a certain age. This suggests that mortality is higher among women in the middle of the 15-59 age distribution. This age-mortality pattern is expected given that majority of new HIV/AIDS infections in Kenya occur among the youth, especially for young women aged 15-24 (UNAIDS, 2006). It is also consistent with the UNAIDS (2003) report which indicates that the risk of death from AIDS is highest in the mid-30s to early 40s.

Adult women residing in monogamous households have higher probability of death in each time period, a finding that appears surprising and counterintuitive. Transmission of HIV in Kenya is mainly through sexual activity, and so avoiding infection depends on risk-avoiding behaviour. Therefore, in theory, marriage could reduce the risk of HIV infection and HIV-related mortality risk by promoting monogamous relationships. However, research shows that married women's greatest risk of HIV infection is their husbands' extramarital sexual activities (Parikh, 2007). Based on a study in Uganda, Parikh suggests that social and economic contexts surrounding men's extramarital sexuality may increase marital HIV risk. First, she points out that HIV prevention efforts have worked to change the landscape of social morality in ways that present new obstacles to HIV prevention. There has been widespread circulation of social, religious, and public health messages that present infidelity and polygamy as risky, immoral, backward, and dishonorable. This has heightened men's personal motivations and avenues for sexual secrecy (to avoid public scorn and domestic conflict) and denial that an extramarital relationship increases risk for HIV. Parikh finds that although all participants in the Ugandan study recognized the health risks of extramarital relations, they were more concerned about the risk of getting a bad public reputation by being caught in sexual scandals, rather than the distant, unforeseen effects of contracting HIV. As a result, men have used strategies such as secrecy to manage sexual relationships that were considered as socially immoral in order to minimize risks to their reputations.

Secondly, Parikh echoes what other studies (e.g., Brockerhoff and Biddlecom, 1999) have found. Urbanization, education, and changing labor markets have created new forms of men's labor-related migration, providing opportunities for extramarital relationships. It has also been widely recognized that women tend to have much older husbands, a factor that may increase the probability that their husbands are infected and weaken their bargaining power within the marriage. In addition, women who are more economically dependent on their husbands are less empowered to protect themselves against HIV infection (Greig and Koopman, 2003; Parikh, 2007). Thus, the risk posed by their husbands' extramarital relationships is exacerbated by the fact that women cannot negotiate condom use or inquire about their husbands' extramarital activities. Taking these arguments into consideration, the finding that women in monogamous marriages in this Kenyan sample are more likely to die of disease-related causes maybe plausible.

Another surprising result is that women residing in households with secure land tenure have greater hazards of death in each time period. While the model results cannot explain the reasons behind this finding, a plausible line of conjecture is as follows. In Kenya, as in many countries in the region, economic necessity demands that a high proportion of rural men migrate elsewhere in search of employment. If households have secure land tenure[3], men usually leave the women behind in the countryside with the responsibility of tilling the land and caring for homes and children. Generally, the male migrants remit money to their wives or bring their savings back home to supplement income from the farm. Husbands returning from the cities (where risk of HIV infection and opportunities for extramarital relationships are greater) may infect their wives. The male migrants may take up low-income jobs (e.g. guards) and so what they remit back home may not be enough to supplement farm income. Parikh, (2007) finds that younger and poorer married men who migrate tend to leave their wives in rural areas because they cannot afford to relocate with them. Due to long separation from their husbands, and insufficient income from the farm and remittances, some women may develop "residential" sexual relationships in the village (Epstein, 2003; Gillespie and Kadiyala, 2005). Therefore, economic necessity and migration of men create opportunities for

[3] Tenure security is defined as the household head having a title deed or well-recognized right over a parcel of land.

multiple sexual partnering among women, which is a major risk factor in HIV/AIDS infection for women. While these social and economic dynamics may explain the significant relationship between tenure security and the probability of death among women, these explanations are offered only as conjecture, and may be a useful topic for further research.

Discrete-time hazard model with time-varying effects

The results shown in Table 2-10 allow the effects of the explanatory variables on the mortality hazard to vary over time, from one survey-period to another. Hence, the proportionality assumption is relaxed and the variables permitted to have time-varying effects.

In the case of men (column1), education has a significant and negative effect in the first two time periods (1997-2000 and 2000-2002). Setting the education variable at the 25th vs. 90th percentile changes the probability of death from 0.0140 to 0.0072 in the first time period, and from 0.0034 to 0.0020 in the second period. However, in the later two periods (2002-2004 and 2004-2007), mortality hazard does not vary by education. Therefore, the effect of education is confined to the earlier periods. Within the 10-year period, education largely affects early but not late male mortality hazards. This suggests that education causes mortality hazards among men to be separated initially, and to converge over time. In the earlier periods, information about HIV/AIDS was less available. The majority of people had poor, incomplete or inaccurate information about the probabilities of HIV infection. Education may have been protective by conferring an advantage in accessing and processing health information including HIV/AIDS

Table 2-10 Results of time-varying hazard models of working-age adult mortality in rural Kenya, 1997-2007

	Male	Female
Explanatory variables	(1)	(2)
1997-2000 period (=1)	-0.014**	-0.044
	(0.005)	(0.028)
2000-2002 period (=1)	-0.021*	-0.046
	(0.011)	(0.031)
2002-2004 period (=1)	-0.023**	-0.038
	(0.010)	(0.025)
2004-2007 period (=1)	-0.034**	-0.017
	(0.015)	(0.010)
Head/spouse (=1)	0.006**	-0.002*
	(0.003)	(0.001)
Age	0.0003	0.001*
	(0.0003)	(0.000)
Age squared	-2.79e-06	-5.82e-06
	(3.29e-06)	(3.58e-06)
Education*1997-2000	-0.0005**	-2.05e-05
	(0.0002)	(1.71e-04)
Education*2000-2002	-0.0005*	-0.0003
	(0.0003)	(0.0003)
Education*2002-2004	0.0002	0.0002
	(0.0003)	(0.0002)
Education*2004-2007	0.0006	-0.0002
	(0.0004)	(0.0001)
Months at home*1997-2000	-0.0004**	0.0005
	(0.0002)	(0.0003)
Months at home*2000-2002	-0.0004	0.001
	(0.0003)	(0.000)
Months at home*2002-2004	4.74e-05	2.93e-05
	(2.58e-04)	(3.18e-04)
Months at home*2004-2007	0.0001	-0.0002
	(0.0003)	(0.0002)
Monogamous*1997-2000	0.0001	0.003
	(0.0029)	(0.003)
Monogamous*2000-2002	-0.0001	0.005
	(0.0050)	(0.008)
Monogamous*2002-2004	-0.003	-0.0001
	(0.002)	(0.0014)
Land tenure*1997-2000	-0.0008	0.0033
	(0.0018)	(0.0055)
Land tenure*2000-2002	0.006	0.003
	(0.009)	(0.003)
Land tenure*2002-2004	0.002	0.019
	(0.004)	(0.019)
Land tenure*2004-2007	-0.003	-0.0009
	(0.002)	(0.0018)
Land owned*1997-2000	0.0001	-3.77e-05
	(0.0001)	(4.57e-05)
Land owned*2000-2002	-0.0002	-0.0002
	(0.0003)	(0.0002)
Land owned*2002-2004	2.40e-05	-0.0001
	(1.65e-04)	(0.0001)

Table 2-10 continued

Explanatory variables	Male (1)	Female (2)
Land owned*2004-2007	0.0001	8.70e-06
	(0.0001)	(5.25e-05)
Assets*1997-2000	-9.52e-06	1.01e-07
	(8.17e-06)	(6.03e-07)
Assets*2000-2002	5.82e-07	-3.55e-05***
	(2.25e-06)	(9.00e-06)
Assets*2002-2004	-3.51e-05*	-1.67e-06
	(2.00e-05)	(3.13e-06)
Assets*2004-2007	6.96e-07	-5.62e-06
	(1.90e-06)	(5.86e-06)
Distance to fertilizer store*1997-2000	-0.0005	0.0004
	(0.0007)	(0.0003)
Distance to fertilizer store*2000-2002	-0.0001	-0.0008
	(0.0013)	(0.0006)
Distance to fertilizer store*2002-2004	0.0009	0.0002
	(0.0006)	(0.0004)
Distance to fertilizer store*2004-2007	0.0010*	0.0007*
	(0.0006)	(0.0004)
Distance to tarmac road*1997-2000	0.0000	-0.0007
	(0.0007)	(0.0009)
Distance to tarmac road*2000-2002	-0.0035	0.0007
	(0.0023)	(0.0007)
Distance to tarmac road*2002-2004	-0.0023	-0.0010
	(0.0015)	(0.0012)
Distance to tarmac road*2004-2007	0.0005	-0.0004
	(0.0010)	(0.0006)
Observations	11311	11343

Source: Tegemeo Institute (Nairobi)/Michigan State University Agricultural Monitoring and Policy Analysis Household Surveys in 1997, 2000, 2002, 2004, and 2007.

Notes: Standard errors are in parentheses; *** indicates 1 percent significance level; ** indicates 5 percent significance level;* indicates 10 percent significance level

campaign. However, as information about the disease has become more available, the education advantage is eroded and education-mortality gradient is flattened. Therefore, we see no trend in this dataset that would suggest that mortality is increasingly correlated with low education as has been found in other studies (de Walque, 2002). This finding may suggest that the public AIDS awareness campaigns have been effective in delivering AIDS messages to all regardless of their education levels.

The negative effect of months at home on the risk of death among men is limited to the 1997-2000 period. Although the direction of the effect changes in subsequent periods, there is no statistically significant relationship. This finding would be consistent with the notion of the effects of migration on social and sexual networks. Men who migrate from their rural villages to towns in search of work and so spend extended periods away from home have opportunities for multiple sexual partnering in areas where HIV/AIDS prevalence has been higher for a longer time. Therefore, they face a higher risk of HIV infection and death. Migration of men and associated time spent away from home may have served as an important initial pathway through which HIV/AIDS was spread. Patterns of return or circular migration to rural areas facilitated this spread since rural dwellers may have been socialized by the experiences of the migrants (Brockerhoff and Biddlecom, 1999). However, in later periods, migration may not be a critical factor since the disease has now spread throughout the rural areas. Consequently, over time number of months spent at home has no effect on male mortality, meaning that the hazard profiles tend to converge.

The effect of household assets on risk of death among men is different over time. In the earlier two survey-periods, assets have no effect on mortality hazard. However, in the subsequent period (2002-2004), there is a negative significant effect. Holding other factors constant, the probability of death for a man at the 25th and 75th percentiles of the assets distribution is 0.0088 and 0.0050, respectively. This negative effect does not persist for long. It fades away by the last period. Thus, the effect of assets fluctuates over time, leading to coincident hazard profiles initially, followed by divergent profiles, and again coincident ones later.

The distances of individuals' homes to tarmac roads and retail input stores are generally not significantly related to the probability of death except in the 2004-2007 period. These results may imply that the disease is no longer concentrated along the main highways, trading centres and points of contact with travellers but has permeated throughout rural areas. Indeed, overtime, the risk of death is found to be higher among men who reside in relatively remote rural areas.

Over the whole observation period, there is no statistically significant effect of amount of land owned, land tenure and whether the men reside in monogamous households or not.

For women, results in column 2 of Table 2-10 show that there is no statistically significant relationship between the variables and mortality hazard except for household assets and distance to fertilizer store. The effect of assets on female mortality fluctuates over time. First, in the 1997-2000 period, assets have no effect on mortality. Then, in the 2000-2002 period, women from relatively wealthier households are less likely to die. Holding other factors constant, the probability of death for a woman at the 25^{th} and 75^{th} percentiles of the assets distribution is 0.0068 and 0.0033, respectively. Again, there is no observed relationship between assets and risk of death in the last two periods. This pattern is similar to what we find in the case of men. Men and women in relatively wealthy households are slightly less likely to die during one of the periods. This indicates that there is some evidence of a weak but statistically significant shift over time, suggesting that poverty may be increasingly associated with adult mortality over time. This pattern is in contrast to earlier findings in the literature that it is wealthier individuals who were more likely to die. It provides some evidence that the direction of the association between wealth and mortality has shifted slightly over time among men. Overall, however, the results within the 10-year period do not support the view that poverty is becoming an increasingly important social pathway contributing to the spread of HIV/AIDS and working-age adult mortality, particularly among women.

In the earlier periods, the hazard of death among women does not differ by distance to the fertilizer store. However, over time, women residing in households farther away from towns where retail input stores are found, are more likely to die. As in the case of men, being far away from highways and points of contact with travellers/outsiders is no longer protective. This is because HIV/AIDS has permeated throughout rural areas and the risk of disease-related deaths in general and AIDS-related deaths in particular maybe even greater in the remote rural areas.

2.5.4 Conclusion and policy implications

The objectives of the study are to identify the relationships between socio-economic characteristics and rural adult mortality within the 15-59 year age range, and to examine whether these relationships have changed over time as the HIV/AIDS disease has progressed. An accurate evidence-based understanding of these relationships based on nationwide survey data can usefully guide the design of AIDS response strategies.

Hazard analysis is applied to a 10-year period data of 5,755 working-age adults in rural Kenya. The results show that in general, there is a downward trend in the risk of working-age adult mortality across the observation period, with the decline being faster for men than women. This is consistent with decreases in AIDS-related deaths and HIV prevalence rates in Kenya, which can be attributed to significant progress made in HIV/AIDS prevention and treatment programs.

A number of findings derive from the time-invariant models. First, while age is unrelated to male mortality, it has a non-linear effect on women deaths. Second, the hazard of death is greater for men who are household heads, less educated, and those who have spent more time away from their homes. Third, the risk of death is greater for women are not spouses or heads, and those residing in households that are monogamous, and those with secure land tenure. Fourth, there is no statistically significant relationship between household assets, distance to tarmac roads and retail input stores and mortality hazards for both men and women.

Results from the time-varying models indicate that within the rural areas, there have been changes in the effects of some variables on the hazard of death among men and women, over time. While more educated men are less likely to die in the first two time-periods, a lack of relationship between mortality and education in the later periods implies that the hazard of death is converging among men of all education levels. When the education variable is set at the 25th vs. 90th percentile, the probability of death changes from 0.0140 to 0.0072 and from 0.0034 to 0.0020, respectively, for the earlier two periods. Although this may indicate that the HIV/AIDS information campaigns have been effective, it is necessary to keep the efforts up. It is particularly important to focus on prevention information, since new cases of HIV infection are still being reported.

The effect of assets on male and female mortality fluctuates over time, but the pattern of fluctuations does not indicate a clear trend over the 10-year period. Findings generally show a lack of relationship between assets and mortality. However, there is a weak significant shift toward an inverse relationship between asset value and mortality in some periods. Holding other factors constant, the probability of death at the 25^{th}

percentile of the wealth distribution is 88% and 68% for a man and a woman, respectively, whereas at the 75th percentile of the wealth distribution, the probability is 50% and 33%, respectively. Therefore, the risk of death varies only slightly by household wealth. This does not support the hypothesis that over time, by predisposing people to risk of infection, poverty has become an important factor in adult mortality, although it may certainly be one of the pathways. Hence, there is need to study this issue further and to reassess the common programmatic response to AIDS which focuses on the provision of income-earning activities to targeted groups, in the hope that this may reduce risky behaviors that spread the disease. In particular, expanding the scope of research to take into account non-poverty risk factors and how they interact with poverty-related factors may be more instructive for policy and interventions.

Men who reside at home for longer periods have a lower hazard of death in the 1997-2000 period but there is no observed significant relationship in subsequent periods. This is an indication that the risk of HIV/AIDS is no longer related to mobility and spending time away from home. Also, there is a shift from a lack of relationship to a positive relationship between mortality and distance to the fertilizer store for both men and women. This may be a sign that the risk of death is increasing faster in the relatively remote localities compared to towns and trading centres within the rural areas. Therefore, there is need to ensure that the remote rural areas are not overlooked in the provision of HIV/AIDS prevention and treatment programs.

In the early stages of the HIV/AIDS epidemic wealthier, more educated individuals, those who were mobile and spent extended periods of time away from home were more likely to die of HIV/AIDS-related diseases. A comparison between the findings within the 10-year period and the early stages reveals that the relationship has changed in a number of ways. First, the hazard of death does not vary by wealth status. Second, the hazard of death is converging among men of all education levels. Third, the risk and spread of HIV/AIDS is no longer related to mobility and spending time away from home. Fourth, relative remoteness and isolation from the initial epicenter of HIV/AIDS is no longer associated with lower HIV infection and hazard of death. All these changes suggest that over time, mortality risks are converging among groups that could in the past be clearly distinguished with regard to the likelihood HIV infection and AIDS-related mortality.

Chapter 3

DYNAMICS OF THE IMPACTS OF WORKING-AGE ADULT MORBIDITY AND MORTALITY ON RURAL FARM HOUSEHOLDS IN KENYA

3.1 Introduction

There has been growing concern about the increase of working-age (WA) adult morbidity and mortality in rural Africa and its impact on farm households. This rise in mortality is attributed to the onset and spread of HIV/AIDS. The death of a working-age adult may affect the social and economic well-being of households through several mechanisms such as potential loss of labor time, farming experience (knowledge and skills), and cash income including remittances. As HIV/AIDS has progressed and its presence become more visible, more research has been undertaken to understand the impacts of adult death. However, micro-level studies on impacts of adult mortality and HIV/AIDS on rural households remain limited.

Existing panel data studies examining the impact of disease-related adult mortality on rural household responses and changes in welfare (e.g. Beegle, 2005; Yamano and Jayne, 2004; Chapoto and Jayne, 2008) show that the impacts of working-age mortality depend greatly on the gender and position of the deceased person in the household; in some cases these impacts are large and significant. However, these studies generally cover a 2-3 year time frame and are unable to measure the impacts of adult mortality beyond this relatively short time frame. One exception is a study by Beegle et al (2006) which uses a 13-year panel of individuals in Kagera, Tanzania to assess how adult mortality shocks affect both short and long-run consumption growth of surviving household members. This highly interesting study, however, is confined to a particular district known to be particularly hard-hit by HIV/AIDS, and hence it may not provide a meaningful indication of the general nationwide impacts of the disease.

In addition, some studies treat afflicted households as a homogenous group with similar recovery paths after the death shock and therefore the impact measured is for the average household and is considered to be constant regardless of the timing of the adult death. However, the full effects of mortality on household behavior and welfare may occur over many years.

This essay uses data over a 7-year time period to understand the longer-term effects of death, effects which may be large and different from those experienced during the period immediately following a death. Therefore, the essay adds to the currently sparse literature on the long-term effects of adult mortality in several ways. First, I estimate a model with longitudinal data to control for pre-death differences between afflicted and non-afflicted households that may bias estimates of the impacts of death. Second, I examine the temporal pattern of the effects of death in the years before and after the occurrence of death. This accounts for the likelihood that adult death is not associated with just a one-time or permanent adjustment in household outcomes. Third, I explore how the recovery patterns of households vary depending on the gender and position of the deceased adult. Fourth, this study uses nationwide data and hence provides estimates that are more indicative of general impacts rather than being confined to areas known to have particularly high HIV prevalence rates. Therefore, this essay addresses major knowledge gaps by assessing: the short- and longer-term impacts of adult mortality; whether household outcomes recover or decline over time; whether the gender and position of the deceased members affect the recovery path; and impacts at the national level in a country with moderately high HIV prevalence rates by East African standards. As a result, this study uncovers the dynamics in household welfare and responses as a result of prime-age death.

The potential persistence of mortality effects beyond the time of death has important implications for policy makers and development practitioners on current and future policies and intervention strategies intended to mitigate these effects. The evidence of large short-term impacts of death from previous studies has led many to argue the importance of developing appropriate mitigation measures. In hard-hit areas of Africa, if the impacts of death were found to persist over time, this would motivate even greater concern for long-term response strategies to assist afflicted households and communities, and would perhaps have important implications for the design of poverty reduction strategies.

The next section contains a review of past studies on impacts of HIV/AIDS and working-age adult mortality on rural households. Section 3.3 outlines the shortcomings of these studies, which this essay seeks to address. Section 3.4 describes the data while section 3.5 briefly discusses the progression of HIV/AIDS and the associated economic costs, and section 3.6 contains the estimation methods. Study results are presented in section 3.7 and the last section contains the conclusion and policy recommendations.

3.2 Review of literature on impacts of working-age adult death

Research on the economic impact of working-age adult death can be broadly categorized into two types i.e., macro-economic level studies that estimate impacts on economic growth and development, and microeconomic research that focuses on impacts at the household level. Most of the early empirical impact studies were at the macro-level, where simulations were done on GDP or GNP per capita, and their rates of growth under various levels of projected HIV prevalence rates. These studies depict mixed conclusions and wide variations in predictions[4]. For example, Cuddington (1993) employed a single sector, full employment Solow-type growth model to simulate impacts of HIV/AIDS on the growth of GDP and GDP per capita in Tanzania. The simulation results show that AIDS reduced the average real GDP growth rate by 0.6-0.9 percent. On the other hand, Sachs et al (2001) estimate that Sub-Saharan Africa faces a 35 percent loss in GNP due to HIV/AIDS. Most existing estimates of the macroeconomic costs of AIDS in Africa range between 0.3 and 1.5 percent reduction in the growth rate of GDP annually. However, as Bell et al (2003) argue, these estimates may greatly underestimate the impact of HIV/AIDS since they fail to account for the potential impact on human capital formation and the mechanisms through which knowledge and abilities are transmitted from one generation to the next. Young (2005) incorporates this detrimental impact on the human capital accumulation in his model. He tests for the competing effects of reduced human capital of orphaned children and lowered fertility. He finds that the fertility effect dominates, with the implication that the AIDS epidemic, could lead to improved future per capita consumption possibilities of the South African economy.

A growing interest in understanding the household-level impacts of HIV/AIDS has resulted in microeconomic research that examines how this disease affects the behavior of rural households and farming systems. Most of the early research involved

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[4] See Cuddington (1993); Cuddington and Hancock (1995); Over (1992); Sachs et al (2001);

qualitative studies and rapid appraisals, and quantitative findings based on small samples. Evidence from earlier microeconomic studies is at best anecdotal and speculative, where the impacts of AIDS are hypothesized and conjectured but hardly quantified. However, studies measuring the impacts of HIV/AIDS on rural households are now emerging, but evidence is still modest. This section reports some of the existing evidence of the impacts of adult mortality and HIV/AIDS on various aspects of the rural farm household.

Household composition

Death in a household leads to changes in household size. However, as Beegle (1997) notes, the death of an adult does not necessarily imply a reduction of household size by one adult. Instead, such a death introduces changes in household size and composition or structure, which include in- and out-migration of household members, an increase in the rate of fostering, and higher rates of remarriage for surviving spouses (World Bank, 1999; Ntozi et al, 1997). Menon and others (1998) find that the death of a working-age adult leads to an increase in dependency ratio. The dependency ratio increased from 1.2 to 1.5 as a result of an adult death from AIDS. Consequently, there was an increasing number of households where children and the elderly have less support. Changes in household structure have been shown to be part of households' coping strategies. For example, fostering spreads the impact of HIV/AIDS over several households (Bledsoe, 1994). Yamano and Jayne (2004) find that household composition is affected in different ways depending on the gender and position of the deceased in the household. Death of a household head or spouse resulted in changes in household size but the death of other working-age adults is partially compensated for by entry or return of other members. Chapoto (2006) finds that irrespective of the gender and position of the deceased individual, household size declines by less than one person, implying that households are somewhat successful in replenishing their household sizes. However, changes in household size and composition depend on initial household conditions. For instance, non-poor households are more likely than poor households to restore their size to pre-death levels, mainly by attracting young boys and girls. Therefore, a household's flexibility is a critical component in successfully responding to extreme crises such as illness and death of an adult. Without such adaptation, either through altered structures or roles, or through external assistance, families and households may become non-functioning social and productive units and ultimately dissolve (Hosegood et al, 2004). Such demographic changes may have profound short- and long-term consequences for surviving individuals by impacting on a household's labor availability and allocation. These impacts begin to emerge when an adult's labor contribution declines as he falls sick. The labor of other household members is also diverted to care giving during the period before death. The death of the sick adult implies permanent loss of one source of household labor but at the same time frees time and cash that were previously devoted to care giving. Dynamics in household composition and the attendant changes in intra-household labor allocation have implications for a farm household's wealth and asset base, income sources and crop production, as households change their demand for and supply of labor. Household composition affects consumption and time allocation or labor supply decisions, and may or may not affect farm production decisions (Singh et al 1986; Benjamin, 1992). In addition, composition influences a household's ability to insure against risk (Rosenzweig, 1988) and the preferences of its members for consumption and investment (Chiappori, 1988). Edmonds et al (2001) conclude that household composition is an important component of a household's response to changes in income.

Wealth and asset base

The loss of human capital leads directly to a loss of financial capital. Households experience financial loss as a result of medical and funeral expenses and labor diverted from economically productive activities to care giving. Financial capital effects of adult death include: liquidation of savings accounts; seeking remittances from family; sale of stores of value (jewellery, household goods); borrowing from informal sector sources such as relatives, friends, neighbors, rural cooperatives, rotating and savings club associations, rural traders and money lenders, pledging of future crops, and sale of livestock (Mutangadura et al, 1999; Stokes, 2003; Topouzis, 2000). Most of the households respond initially by disposing of assets that are reversible (e.g., savings, remittances and credit) (Topouzis and du Guerny, 1999). However, as indicated by Stokes (2003), if the effects of mortality are severe enough, households may follow with the sale of productive assets, a strategy that may be costly in the long-run. Indeed, evidence from Kenya (Yamano and Jayne, 2004) and Zambia (Chapoto, 2006) shows that households first attempt to dispose of small animals and other assets with the least impact on long-term production potential. Households tend to hold onto cattle and productive farm equipment and possibly sell them only in response to severe cash requirements after incurring a death in the family but in Zambia, the death of a male head results in a 30% decline in the value of cattle assets.

There is concern that the above mentioned coping strategies may have even greater longer-run adverse consequences on households' future welfare. For instance, it has been noted that farm households rely on remittances and non-farm income to capitalize their farm operations (Reardon et al, 1995). Unfortunately, as Donovan and others (2003) indicate, such sources of income are often at risk among AIDS-afflicted households, and particularly so for those households that were already asset poor and vulnerable to begin with. Therefore, through loss of remittances and non-farm income, the death of a household member is likely to tighten cash constraints on agricultural production. This situation is aggravated by increases in medical and funeral expenses and forgone income by surviving household members who provide care for the sick. It is also the case that if these coping strategies are not sustainable or viable in the long-run, we may observe the following: first, households may be forced to adopt other strategies, implying that the long-term impacts of death may be different from the short-run effects, and; second, the capacity of households to recover from adult death shocks even in the long-run, may be eroded. In general, as fewer households cope or even merely survive, there may be increased vulnerability to other shocks or households may pursue more damaging strategies.

Agricultural production

An adult death is associated with at least a temporary loss of labor, labor re-allocation, potential loss of farming knowledge and skills, and increased medical and funeral expenses. All of these responses may be hypothesized to affect agriculture through changes in cropping patterns, land use, area cultivated, input use, farm output and income. FAO (2003) estimates that seven million agricultural workers have died from AIDS-related sicknesses since 1985 and that another 16 million of the agricultural labor force in sub-Saharan Africa could die by 2020. Thus, the epidemic currently has and is expected to have devastating impacts on millions of rural farm households over the next two decades (UNAIDS, 2004).

Existing research has presented mixed evidence on impacts of mortality on agricultural households with respect to changes in area cultivated, cropping mix and patterns, and frequency of weeding. As a result, there is no clear direction on the best policy responses to adopt in order to mitigate the effects of adult death. For instance, using data (for 1989-1993 period) from a rapid rural assessment survey for communities in Zambia and Tanzania, and households in Uganda, Barnett (1994) and Barnett et al (1995) find mixed evidence. They find little evidence of HIV/AIDS-related impacts on agricultural production in Tanzania. However, in Uganda they find some discernible evidence where households, particularly the poorer ones, shift to subsistence crops. In Zambia, Barnett (1994) reports that farming systems that are most vulnerable to labor loss are not those greatly affected by AIDS epidemic. Also, other research such as Barnett and Blaike's (1992) study in Uganda finds no significant change in agricultural production. As Barnett et al (1995) argue, the impact of death may vary across communities and households in accordance with differences in HIV prevalence rates, population density, existing farming system and the size of the local labor market. Such factors need to be taken into account in making comparisons on such study findings.

Increasing dependency ratio and lower labor availability are hypothesized to cause households to shift from labor-intensive crops to less labor-intensive ones (which may be less nutritious or productive). It has been reported that the shift in area cultivated from maize to root tubers in most parts of Africa may be an indication of labor shortages and hence a need to shift to less labor-intensive crop systems (Barnett, 1994; FAO, 1995;

FAO, 2004). Other land use changes have been observed as a response to HIV/AIDS. In Cote d'Ivoire, households facing labor shortages have resulted to either hiring more labor or allocating some land for crop sharing (FAO, 1997). However, Barnett (1994) finds a reluctance to rent out land in Uganda and particularly among widows. This may be attributed to a lack of guarantee that the land owners can maintain the use rights to the land.

Using panel data from Kagera in Tanzania, Beegle (1997, 2005), finds that although adult male death causes temporary scaling-back of cash cropping and a fall in wage income, afflicted households do not shift towards subsistence crops. She argues that this result is consistent with the high labor-land ratios in Kagera region. Beegle's study is based on a short panel (1991-1993) and is therefore unable to assess the longer time impacts. In addition, this study does not examine changes in crop output and liquidation of assets. Yamano and Jayne (2004) also use panel data from Kenya and find that afflicted households experienced a decline in farm output compared to non-afflicted ones. However, the effect of death on crop production is sensitive to gender and position of the deceased in the household and the households' initial asset levels. Results show that households suffering death of the household head or spouse were largely unable to replace labor lost through death, whereas households suffering death of another adult were able to attract new household members. They also find that relatively better off households experienced a greater decline in family labor, especially among adult members. However, they find no evidence of significant losses in cultivated land and net crop output among these households.

Chapoto (2006) finds that the effects of prime-age adult mortality on farm production in Zambia are sensitive to the gender and position in the household of the deceased member. The death of a male head causes households to cut back the area cultivated, possibly due to the inability of households to fully replace deceased members. The area under cereals and other food crops declines as a result of death, with the most severe effects observed in the case of a male head death and there is no evidence that afflicted households are switching to labor-saving crops or that initial poverty exacerbates the impact of mortality on cultivated land. In addition, afflicted households in Zambia don't suffer declines in value of crop output except in the case of poor households experiencing a male head death. Generally, evidence from Tanzania, Rwanda, Kenya and Zambia suggests that better-off households may be able attract new members or to hire additional workers to partly compensate for the loss of adult member (Beegle, 1997; Donovan et al, 2003; Yamano and Jayne, 2004; Chapoto, 2006). These results raise questions about the view that loss of labor poses the major constraint on crop production. This issue may be addressed in part, by accounting for differences in conditioning factors (such as labor-land ratios) that vary across production regions. It has also been hypothesized that households may withdraw from time-consuming marketing activities and revert to subsistence production. As a result of the inability to add value to produce, households are likely to experience decreases in crop income flows.

Household diversification strategies

Not all costs of illness are borne by the person who is sick. In a household, ill health of an individual is likely to evoke resource adjustments by other members of the household or surviving members in case of death. Adjustments in participation across income earning activities may be expected in response to an illness shock. Morbidity lowers the sick person's productivity and often entails care time spent by another household member who may otherwise be engaged in productive work. In Indonesia there is evidence for reallocation of time from market activities and school to household care activities of adult women and older children when infants fall sick (Pitt and Rosenzweig, 1990). Kochar (1995) finds that market labor supply (wage income) is responsive to illness of a household member and concludes that farm households may be more vulnerable to demographic shocks such as sickness and death than to crop income shocks. The effects of adult mortality on agricultural production and yields will depend on several conditioning factors such as the agricultural system, labor/land ratios, labor requirements of the cropping system, farm sizes, and land tenure, which vary across production regions.

Apart from agricultural production, households pursue other income-generating activities either all year round or on a seasonal basis. Many farming households supplement their income with non-farm activities. There is evidence that non-farm earnings are an important source of household income in Africa (Reardon, 1997; Yamano and Jayne, 2004). However, these earnings are sometimes seasonal because of competition for labor from the agricultural sector during the peak seasons. Extra labor demands (e.g. due to care giving) during critical times of year such as ploughing, planting, or weeding can have disastrous impacts on farm and non-farm incomes. Studies have shown that households may be protected from idiosyncratic crop shocks when there are well functioning credit and labor markets, through compensating increases in non-farm labor supply (Eswaran and Kotwal, 1989; Morduch, 1990; Kochar, 1995).

This raises the possibility that households whose crop production and/or income may be adversely affected by morbidity and death may use market labor supply as an avenue to cope with effects of death. The importance of off-farm/labor income for Kenyan rural farm households increases the likelihood of such a response[5]. Incomes from both farm- and off-farm sources may decline as HIV infections and AIDS deaths are disproportionately concentrated in the most productive age groups (15-59). There is evidence that households and particularly female-headed ones are responding to HIV/AIDS by turning to off-farm income generating opportunities (FAO, 1995). The studies by FAO find that: (i) households that did not engage in off-farm activities did not do so because they lacked capital and (ii) households that were already engaged in some off-farm activities were better cushioned from effects of HIV/AIDS. This implies that diversification over income sources may be important in mitigating the effects of adult mortality. The study by Yamano and Jayne (2004) reports that death of a male head of household results in large reductions in off-farm income. Chapoto (2006) reports mixed but statistically insignificant impacts on off-farm income for all cases of death by gender and position in the household.

It is also often assumed in some of the theoretical literature that the negative effects of adult mortality on agricultural production, as well as losses in non-farm or self-employment income from the deceased, will force many afflicted households into poverty. However, there are mixed findings. There is evidence that the effects of working-age adult mortality on agricultural production and incomes tend to be more severe on households that were already relatively poor (Drimie, 2002). Chapoto (2006)

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[5] Nearly 30 percent of farm household income in 1997 and 2000 was derived from off-farm activities (Yamano and Jayne, 2004).

finds that the area under cereals declines most among wealthier households incurring a male head death while the impact does not differ between poor and non-poor households in case of a female head/spouse death. In addition, Lundberg et al (2000) show that among afflicted households, poorer households are less likely to receive assistance, financial and otherwise, from social networks.

3.3 Limitations of reviewed literature

The preceding review of literature on impact of adult mortality suggests some limitations in research on this topic. First, few studies use nationwide representative panel data. For instance, although case study panel data sets like the Kagera demographic and health survey have generated estimates of the impact of adult mortality and AIDS in particularly hard-hit areas, these studies lack representativeness and could produce overestimates of the impacts of the disease if they are generalized more broadly to the region or continent. Hence, their results cannot provide a comprehensive understanding of the national level impacts.

Second, most prior micro studies are unable to estimate the enduring or prolonged impact of mortality, starting from the onset of illness, death and after death short- and longer-term effects. The few existing longitudinal studies use data from the early years of the epidemic and available evidence has typically been from panels separated by only 2-3 years. In addition, some studies focus on impacts on households regardless of the timing of death. Therefore, only short-run effects are measured. Long run impacts, dynamics of recovery process, whether recovery occurs and under what conditions, are still unknown. Put differently, it is likely that less is known about the long-term impacts of adult mortality and HIV/AIDS epidemic than is generally acknowledged.

Some longitudinal research does not account for attrition, which may underestimate incidence and impact of adult mortality. Bias due to attrition may be particularly severe where there is considerable mobility arising from migration between rural and urban areas and/or dissolution of households as a result of death.

3.4 Data and attrition

The study uses a four-year nationwide panel data set of Kenyan rural households collected in 1997, 2000, 2002 and 2004. The 2002 survey does not contain information on the household outcomes that are of interest in this essay. However, it contains valuable information on mortality. Therefore, changes in household outcomes are described for the 1997, 2000 and 2004 surveys while mortality information is derived from all surveys.

As is typical of any longitudinal study, the data used in this study suffer from attrition, with 6.2 percent of the initial 1,500 households dropping out between 1997 and 2000 while 9.3 percent were not re-interviewed in the 2004 survey. Over the entire 7-year period the attrition rate is 11.7 percent. Tables 3-1, 3-2, 3-3 and 3-4 present additional information on attrition by survey wave and also show the relationship between attrition, dissolution[6], disease-related mortality and household size.

[6] Dissolution means that remaining members dispersed, or in the case of one-person households, the household no longer existed.

Table 3-1 Relationship between disease-related working-age adult mortality, household attrition dissolution, and initial household size for the 1997-2000 period

Household size in 1997	Households in 1997 survey	Households attriting in 2000	Households attriting due to apparent dissolution in 2000	Households incurring a working-age death
Number	Number	Number (%)[a]	Number (%)[a]	Number (%)
1	13	0 (0.00)	0 (0.00)	0 (0.00)
2	43	3 (6.97)	0 (0.00)	1 (2.33)
3	86	7 (8.14)	0 (0.00)	6 (6.98)
4	158	10 (6.33)	3 (1.90)	8 (5.06)
5	197	15 (7.61)	3 (1.52)	17 (8.63)
6	249	14 (5.62)	1 (0.40)	9 (3.61)
7	234	14 (5.98)	0 (0.00)	17 (7.27)
8	172	11 (6.40)	0 (0.00)	8 (4.65)
9	118	8 (6.78)	1 (0.80)	6 (5.08)
>=10	230	11 (4.78)	1 (0.40)	18 (7.83)
Total	1500	93 (6.2)	9 (0.60)	90 (6.00)

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

Note: [a] The percentages of the total number of households sampled in the initial period are in parentheses

Table 3-2 Relationship between disease-related working-age adult mortality, household attrition and initial household size for the 2000-2002 period

Household size in 2000	Households in 2000 survey	Households attriting in 2002[b] (%)	Households incurring a working-age death
Number	Number	Number (%)[a]	Number (%)
1	18	7 (38.89)	0 (0.00)
2	48	12 (25.00)	1 (2.08)
3	80	12 (15.00)	3 (3.75)
4	152	31 (20.39)	8 (5.26)
5	200	30 (15.00)	6 (3.00)
6	220	34 (15.45)	5 (2.27)
7	216	36 (16.67)	3 (1.39)
8	151	34 (22.52)	0 (0.00)
9	123	4 (3.25)	2 (1.63)
>=10	238	26 (10.92)	6 (2.52)
Total	1446	226 (15.63)	34 (2.35)

Source: Tegemeo Institute (Nairobi)/Michigan State University Agricultural Monitoring and Policy Analysis Household Surveys in 2000 and 2002.

Note: [a] The percentages of the total number of households sampled in the initial period are shown in parentheses
[b] The percentage of households attriting due to dissolution could not be computed because there was no information on the reasons for household attrition in the 2002 survey.

Table 3-3 Relationship between disease-related working-age adult mortality, household attrition, dissolution and initial household size for the 2002-2004 period

Household size in 2002	Households in 2002 survey	Households attriting in 2004	Households attriting due to apparent dissolution in 2004	Households incurring a working-age death
Number	Number	Number (%)[a]	Number (%)	Number (%)
1	19	3 (15.79)	1 (5.20)	0 (0.00)
2	46	7 (15.22)	1 (2.17)	1 (2.17)
3	97	27 (27.84)	1 (1.03)	0 (0.00)
4	145	15 (10.34)	0 (0.00)	9 (6.21)
5	208	35 (16.83)	3 (1.44)	5 (2.40)
6	210	35 (16.67)	1 (0.48)	6 (2.86)
7	193	30 (15.54)	0 (0.00)	8 (4.15)
8	161	21 (13.04)	0 (0.00)	5 (3.11)
9	122	11 (9.02)	0 (0.00)	3 (2.46)
>=10	219	20 (9.13)	1 (0.46)	12 (5.48)
Total	1420	204 (14.37)	8 (0.56)	49 (3.45)

Source: Tegemeo Institute (Nairobi)/Michigan State University Agricultural Monitoring and Policy Analysis Household Surveys in 2002 and 2004.

Note: [a] The percentages of the total number of households sampled in the initial period are shown in parentheses

Table 3-4 Relationship between disease-related working-age adult mortality, household attrition, dissolution and initial household size for the 1997-2004 period

Household size in 1997	Households in 1997 survey	Households attriting in 2004	Households attriting due to apparent dissolution in 2004	Households incurring a working-age death
Number	Number	Number (%)[a]	Number (%)	Number (%)
1	13	1 (7.69)	0 (0.00)	0(0.00)
2	43	7(16.28)	0 (0.00)	4(9.30)
3	86	9 (10.46)	3 (3.48)	7(8.14)
4	158	21(13.29)	3 (1.90)	20(12.66)
5	197	19(9.64)	3 (1.52)	25(12.69)
6	249	28(11.24)	5 (2.01)	22(8.84)
7	234	21(8.97)	4 (1.71)	34(14.53)
8	172	11(6.40)	0 (0.00)	16(9.30)
9	118	7(5.93)	0 (0.00)	12(10.17)
>=10	230	15(6.52)	1 (0.43)	31(13.48)
Total	1500	139(9.27)	19 (1.27)	171(11.40)

Source: Tegemeo Institute (Nairobi)/Michigan State University Agricultural Monitoring and Policy Analysis Household Surveys in 1997, 2000, 2002 and 2004

Note: [a] The percentages of the total number of households sampled in the initial period are shown in parentheses

Between 1997 and 2000, 20 percent of the households had 4 or fewer members (i.e., are small households) and these households accounted for 22% of attrited households, while between 2000 and 2002, such households accounted for 20% and 27% of total and attrited households, respectively. Similarly, in the 2002-2004 period, 22% of the households had 4 or fewer members and they accounted for 25% of attrited households.

The reasons for attrition include: the household moved away or dissolved, no one was at home to be interviewed, or household refused to participate in the survey. Household dissolution is likely to be associated with mortality. For example, Urassa et al (2001) found that in Kisesa, Tanzania, 42.5 percent of households had dissolved after the death of a male household head. With respect to mortality, our data show that these smaller households represent 17%, 35%, and 20% of households experiencing adult mortality in the periods 1997-2000, 2000-2002, and 2002-2004, respectively. Thus, larger households are more likely to experience working-age adult mortality. As regards, dissolution, the smaller households represent 33% of dissolved households between 1997 and 2000, and 38% between 2002 and 2004 surveys. Therefore, dissolution is a more important reason for attrition among smaller households than larger households. In general, household attrition may lead to attrition bias, an issue which is examined further in subsequent sections.

The surveys contain information on household demographics, socio-economic characteristics of household members, agricultural, livestock and off-farm activities, household assets as well as child and adult mortality. Possible disease-related mortality of working-age adults (15-59 age-ranges) is tracked between 1997 and 2004, and is related to various household outcomes to assess the impact of death on households. Table 3-5 shows number of households afflicted by working-age adult morbidity and mortality by survey period. Between 1997 and 2000 surveys, 93 working-age adults passed away due to disease-related causes, with 89 households having at least one death. In the 2000-2002 period, there were 37 cases of death and none of the afflicted households had multiple cases of death. Between 2002 and 2004, there were 65 cases of working-age adult deaths in 59 households, 6 of which had 2 cases of working-age adult mortality. Additional information on the number of individuals dying from disease and the adult mortality rates is presented in Table 2-1 (Chapter 1).

Table 3-5 Number of households incurring working-age adult morbidity and mortality by survey period[a]

Survey period	Disease-related working-age adult mortality						
	Households incurring a male head death	Households incurring a female head/spouse death	Households incurring other male death	Households incurring other female death	Households with at least one adult death	Households with multiple deaths in a survey period	Households with a death in multiple years[b]
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
1997-2000	27	11	22	30	89	3	
2000-2002	4	7	12	14	37	0	
2002-2004	14	15	12	21	58	5	
1997-2004	45	32	46	62	171	17	9

Survey year	Working-age adult morbidity[c]			
	Households with male head illness		Households with non-male head illness	
	1 year before death	2 years before death	1 year before death	2 years before death
	(1)	(2)	(3)	(4)
1997	7	10	17	24
2000	4	6	7	20

Source: Tegemeo Institute (Nairobi)/Michigan State University Agricultural Monitoring and Policy Analysis Household Surveys in 1997, 2000, 2002 and 2004

Notes [a] The numbers in this table relate to individuals who were in the households at the beginning of each survey period i.e. they exclude individuals who joined the households when they were already ill and later died within the survey period.

[b] This means that a household incurred death in any two or more of the three survey periods.

[c] Households with morbidity are those for which Dpre=1 for each survey year; see section 3.6.1 (Econometric model) for definition and computation of this variable.

3.5 Disease progression and the economic impacts of AIDS-related mortality

There are multiple channels by which by disease-related adult mortality may affect household outcomes such as agricultural production, assets and income. Such channels have often been studied using the sustainable livelihoods framework (Gillespie, 2003) or its variants that view the household as a system of interactions between its supply of labor to farm production and off-farm activities and the return flow to the household of food and cash to sustain their livelihoods (FAO, 1995; Chapoto, 2006). As mentioned earlier, disease-related adult mortality in Africa has increased significantly with the advent of HIV/AIDS. In addition, it has been recognized that HIV/AIDS is a long-wave crisis (Barnett and Whiteside, 2002), suggesting that it has long-term effects. As a result, attempts to measure the economic impacts of disease-related mortality may benefit from the recognition that these impacts are expected to be different over time since there is a progression of stages at which afflicted households are likely to suffer.

First, the onset of AIDS symptoms leads to chronic illness which is characterized by increasingly frequent bouts of sickness as the disease progresses. This long-term illness is associated with diminished labor capacity and lost earnings of the sick member while the families hit by AIDS have to draw down savings and sell assets to meet treatment expenses. In addition, other household members may have to take time off work or withdraw from school to provide care. Often, the immediate spending on treatment can be large and the economic costs of illness may increase over time as the disease becomes more severe. Overall, this reduces the financial resources of the household and may impair a household's future economic prospects. In response to these effects, households adopt ex-post illness (or ex-ante death) strategies that influence the behavior of their members concerning many decisions such as farm production and schooling. For example, Evans and Miguel (2007) show that there is a decrease in child school participation before the death of a parent, presumably due to pre-death morbidity.

Second, following this period of illness is the death event, which is associated with large funeral expenses which are often a heavy burden on the family budget. Funeral costs appear to be even higher than medical expenses in some settings (FAO, 1995). The death of an individual constitutes a permanent loss of labor (for agricultural, off-farm and home-related activities) and related income, but at the same time frees time and cash that were previously devoted to care giving (White and Robinson, 2000). In addition, there is a loss of acquired human capital investments, management and caring skills, as well as farming experience, knowledge and skills. The loss of labor, human and financial capital implies a loss in productive resources. Assets and savings may be depleted as households use them to meet their increased needs.

Third, a household enters the post-death period in which it may either recover from the impacts of death, remain at a lower constant level of welfare, or decline further into poverty. Death effects might either compound over time if a households financial situation does not recover quickly after the death of the sick member or perhaps diminish if effective coping mechanisms emerge. In other words, time matters when measuring the impacts of AIDS-related illness and death.

Therefore, in order to capture the mortality dynamics (ex-ante and ex-post effects), we need to consider the period ranging from before death to several years after death. However, most studies that attempt to measure the impacts of death tend to capture the one-time, average and permanent effects rather than the dynamic effects. An exception is Evans and Miguel (2007) who consider both parental pre-death and post-death effects on child school participation.

This temporal pattern of the impacts of death is analogous to that observed in empirical studies on the effects of job displacement on wages and earnings (Jacobson et al, 1993). Evidence from these studies shows that workers' earnings begin to decline significantly in years prior to job loss, drop discontinuously when they actually leave their jobs, and then recover to varying degrees in the years following job displacement. In this literature, the time pattern of earnings losses is therefore seen to occur mainly along three dimensions namely, the rate at which earnings "dip" in the period before job loss, the size of the "drop" that occurs at the time of the job loss, and the rate of "recovery" in the period following job displacement (Jacobson et al, 1993). The dip is usually referred to as Ashenfelter's dip[7]. A similar pattern may characterize how smallholder farm households' welfare responds to death shocks. To capture the death dynamics over time, this essay follows the dip-drop-recovery approach in specifying a statistical model. This type of model, combined with relatively long panel data, provides a more comprehensive assessment of the temporal pattern of adult death dynamics than has previously been possible.

Using a nationally representative panel dataset from Kenya, this study examines the dynamic effects of adult mortality on household composition, cultivated land (total

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[7] In the context of evaluating training programs, Ashenfelter (1978) observed that the mean earnings of participants in government training programs decline in the period prior to program entry or participation. This drop in earnings of trainees relative to the comparison group has become known in the economics literature as the ''Ashenfelter's dip'' or the "pre-program dip" and it has subsequently been found to be a feature of virtually all training and adult education programs. Ashenfelter identified the bias for inferring long-term impacts of training that can arise when there is a pre-program earnings dip.

and by crop types), value of crop output, household asset base (total assets, cattle, small animals, farm equipment and other assets) and income (i.e.; total, off-farm, crop and livestock). This is perhaps the first study to have measured the longer-run impacts of working-age adult mortality using panel data based on national household surveys, which cover areas of diverse HIV/AIDS prevalence rates.

The preceding discussion provides some insight into the potential pathways by which adult morbidity and mortality may affect household outcomes over time. Based on this, I consider four hypotheses. The first hypothesis is that there are significant morbidity impacts on household outcomes because negative effects, particularly financial stress, are usually observed in the period of illness preceding death. The second hypothesis is that there are large, negative and significant mortality impacts during the year of death as households' financial resources decline further. Third, *a priori*, the direction of the post-death impacts cannot be determined because they depend on how mortality affects the resources of the household and how effective the coping mechanisms are. The fourth hypothesis is that working-age adult death may have differential effects on the dip-drop-recovery pattern depending on the deceased's gender and position in the household. For instance, to the extent that the contribution of a male head to household resources is more important than that of all other working-age adults, we may expect male head mortality to have large effects on household outcomes.

3.6 Empirical analysis of the dynamics of mortality impacts

3.6.1 Econometric model

To measure the impacts of adult mortality, I use an econometric approach similar to that used by Jacobson et al (1993) to examine the earnings losses of displaced workers. The statistical model used by these authors is borrowed from the program evaluation literature, such as that used in studies which evaluate the earnings impact of public-sector training programs. I use panel data on households that are afflicted by death within the survey period and a comparison group of households that are not afflicted at any time during this period, thus exploiting a counterfactual strategy that takes into account the impacts of death across both time and households.

The effects of adult mortality on household outcomes over time can be depicted as in Figure 3-1, which shows a very simple representation of the dynamics of adult mortality over time. This representation can be modeled as in equation (3.1).

$$Y_{it} = \alpha + \beta EA_i + \delta WD_{it} + X_{it}\lambda + YR_t\gamma + \varepsilon_{it} \qquad (3.1)$$

where Y_{it} denotes an outcome, such as value of farm output or off-farm income for household *i* at year of survey *t*; *EA* stands for ever afflicted and is a dummy variable equal to 1 if a household experienced a prime-age death at any time between 1997 and 2004 (i.e. the "treatment group"), and 0 otherwise; *WD* is a single binary variable equal to 1 if household *i* experienced a working-age adult death between the previous survey and the survey year *t*, and 0 otherwise; X_{it} is a vector of time-invariant and time-varying household and community characteristics that influence household outcomes but are not

Figure 3-1 Modeling the impact of working-age adult mortality on household outcomes over time

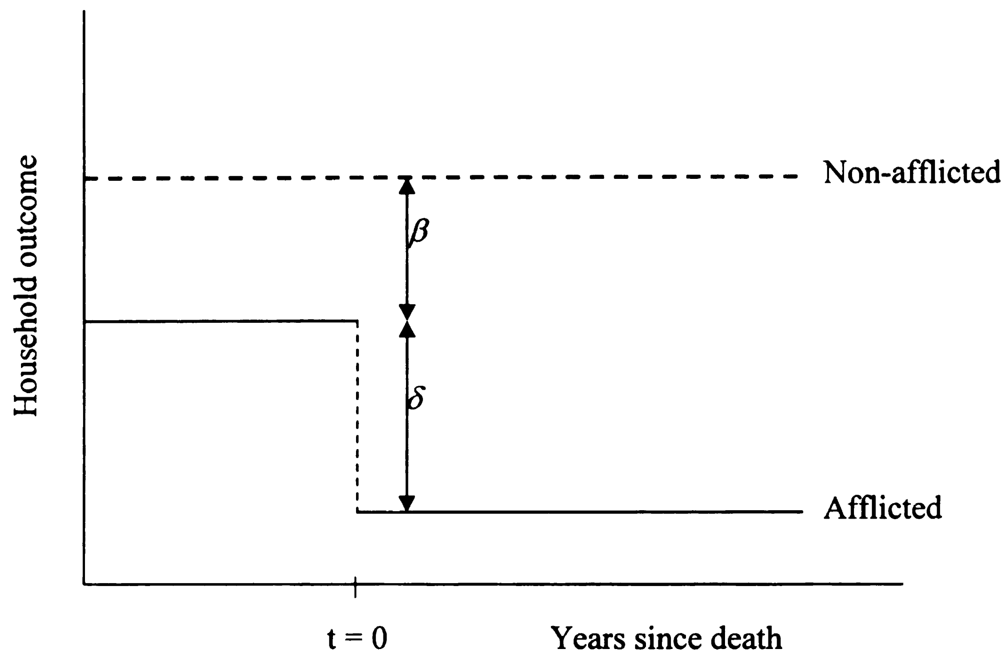
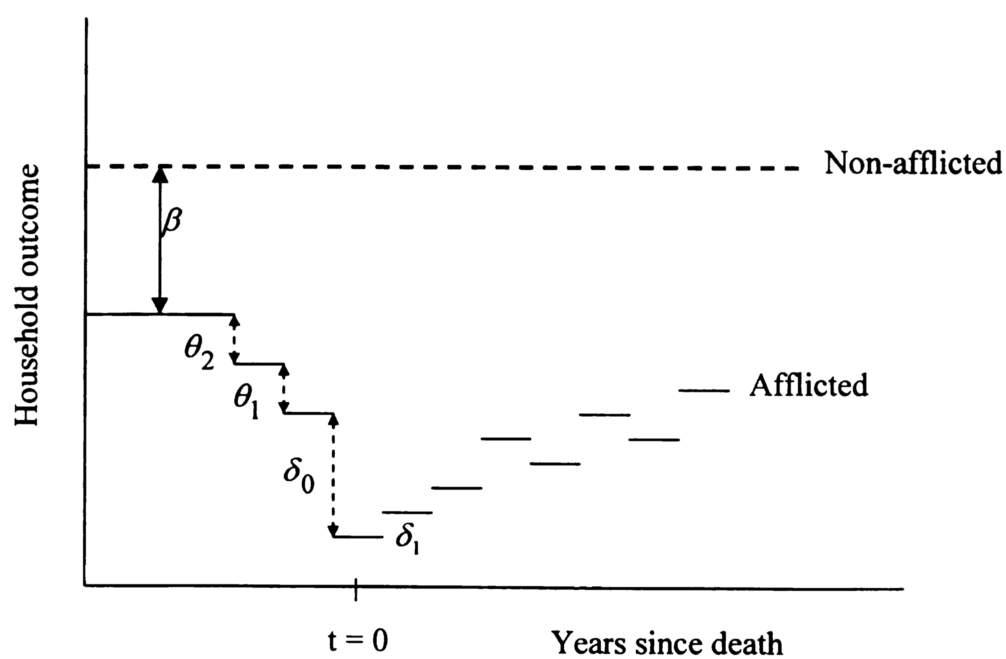


Figure 3-2 Modeling the impact of working-age adult mortality with binary variables for years before and after death



themselves affected by death[8]; YR_t is a vector of year dummy variables that take a value of one in year t for t=2000 or 2004. These variables control for secular economic conditions that may cause changes in Y_{it} regardless of whether households are afflicted or not; and ε_{it} is an error term.

The coefficient β in equation (3.1) is a measure of any pre-death persistent differences between afflicted and non-afflicted households. In Figures 3-1 and 3-2, β is shown as negative but it can also take on positive values. The parameter δ captures an average effect of adult mortality. The approach used in this study to estimate the impacts of death is cast in the spirit of the difference-in-difference estimator by using a counterfactual approach to capture impacts of death across both time and households. The difference-in-difference method first considers the pre-death and post-death dimension. Then, because not all households are afflicted by working-age mortality, it accounts for this by considering the "with death" (treatment group) and "without death" (control group) dimension. Therefore, it takes into account differences across households both before and after death. While the coefficient β accounts for any pre-death persistent differences between afflicted and non-afflicted households, δ captures the after death differences between these two categories of households. Therefore, with longitudinal data, the approach used here controls for time-invariant household characteristics just as in the difference-in-difference method.

The δ parameter imposes a constant effect of adult death for all households and regardless of when the adult died. However, an adult death is not necessarily associated

8 A priori, we cannot think of many household-level variables in X_i that are unlikely to change as a result of prime-age death. However, X_i may contain variables like age and education of the head, and community characteristics that are likely to remain unaffected by mortality in a particular household, such as distance to the market.

with just a one-time or permanent adjustment in household outcomes. This model can be extended to examine if the estimated mortality impacts are different over time and whether they tend to persist. This is done by including a series of binary variables that indicate the number of years between death and the date of survey. In addition, in the case of higher mortality due to AIDS-related illness, deaths are likely to be preceded by a potentially severe and lengthy episode of illness. Therefore, we include variables that account for the fact that household outcomes may begin to deteriorate prior to death as households deal with illness of their members. Therefore, the impacts of adult mortality can be modeled as in Figure 3-2 and equation (3.2):

$$Y_{it} = \alpha + \beta EA_i + X_{it}\lambda + \sum_{s=0}^{s=7} Dpost_{it}^{s}\,\delta_s + \sum_{k=1}^{k=2} Dpre_{it}^{k}\,\theta_k + YR_t\gamma + \varepsilon_{it} \qquad (3.2)$$

Figure 3-2 is also a simple representation of the dynamics of adult mortality over time but unlike Figure 3-1, it accounts for: (i) the 'dip' that may be expected before death as depicted for example, by θ_1 and θ_2 for one and two years before death, respectively; (ii) distinguishes between the 'drop' during the year of death (as measured by δ_0) and the 'recovery' that takes place in the post-death period (for example, as measured by δ_1 for one year after death). The post-death pattern shown here is for illustrative purposes. Although we don't expect the post-death effects to be constant, households may or may not recover from the death shock. Whether these post-death effects decay or persist is an empirical question.

The representation in Figure 3-2 can be modeled as in equation (3.2) where $DPost_{it}^{s}$ is equal to 1 if in the year of the survey (t), household i experienced a death s years earlier (i.e. s years have elapsed since a household experienced death) and so there are multiple *DPost* binary variables for various years after death. The coefficients on these variables will reflect the persistence of the effects of death over time, for up to seven years after death. These variables account for the fact that the impacts of death in the post-death period are not necessarily constant and may not decline or grow linearly over time during this post-death stage.

The variable $Dpre_{it}^{k}$ is equal to 1 if household *i* experienced death *k* years after the year of the survey for both 1997 and 2000 surveys. This vector consists of two binary variables since *k* takes the value of 1 or 2 for deaths occurring one and two years after the survey, respectively[9]. This means that $Dpre_{i}^{1}$ is equal to 1 if death occurred in 1998 for the 1997 observations and equal to 1 if death occurred in 2001 for the 2000 data, and zero otherwise. These variables capture the fact that household outcomes may begin to be affected during the period preceding death.

The specification in (3.2) investigates the dynamics of the effects before and after death. It allows us to fully capture the dip-drop-recovery temporal pattern of the dynamics of death through *Dpre* and *DPost* binary variables. Hence, we can estimate the pre- and post-death impacts, and the extent to which these impacts persist over time.

Previous studies on the impacts of adult mortality show that these impacts depend on the gender and position of the deceased member (Yamano and Jayne, 2004; Chapoto and Jayne, 2008). It has also been argued that the impact of death on a household may be greater if the deceased is a male head since he is an influential member of a household and is more likely to have access to greater financial resources and social capital. To

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[9] AIDS deaths are typically preceded by 4 to 17 months of illness and so negative effects might be expected up to two years before an adult death due to AIDS-related morbidity (Evans and Miguel, 2004).

examine any differential effects, I interact each of the *Dpre* and *DPost* variables with a binary variable (MH) equal to 1 if the deceased person is a male head and zero, otherwise. The analysis that looks at possible differential effects is represented as:

$$Y_{it} = \alpha + \beta EA_i + X_{it}\lambda + \sum_{s=0}^{s=7} Dpost_{it}^{s} + \sum_{s=0}^{s=7} Dpost_{it}^{s} * MH\ \delta_s + \sum_{k=1}^{k=2} Dpre_{it}^{k}\ \theta_k + \sum_{k=1}^{k=2} Dpre_{it}^{k}\ \theta_k * MH + YR_t\gamma + \varepsilon_{it} \tag{3.3}$$

3.6.2 Model variables

The vector of dependent variables consists of household outcomes namely: (i) household composition which consists of household size, number of adult men, adult women, boys (6-14 years) and girls (6-14 years); (ii) farm production variables, including total cultivated land, cultivated land by crop types (cereals, roots and tubers, high-value crops), gross value of crop production and gross value of crop production per acre; (iii) total asset values and also represented by various components: farm equipment, small animals, cattle, and other assets, and; (iv) income (total, crop, livestock and off-farm). Although household composition is not a welfare measure, results on the changes in the composition provide a useful understanding of how households respond to working-age mortality and may aid in the interpretation of the effects of mortality on farm production (Yamano and Jayne, 2004). In particular, there is a widely held view that the death of an adult adversely affects supply of labor in a household. However, as Yamano and Jayne (2004) and Chapoto (2006) find, the effect of an adult death on a household's labor supply is likely to depend on the ability of a household to attract new family members or even send away others.

As explained above, the variable *Post* consists of a vector of time-since-death binary variables which indicate the number of years that have elapsed since a household experienced an adult death. These variables are also interacted with a male head dummy variable in order to examine the effect of gender and position on the persistence of the impacts of death.

The vector X_{it} consists of locational and market access variables namely district dummy variables, agro-ecological zone (AEZ) dummy variables and the distances to the tarmac road and fertilizer store. The district dummy variables capture geographical or locational differences and even farm characteristics such as soil types and land quality. The distance variables are used here as measures of the effective price that farm households receive (Strauss and Thomas, 1998), the remoteness of an area, the quality of road infrastructure and thus the associated transport costs. Therefore, we expect that the longer the distance the more expensive inputs costs become and so the less the area cultivated. Also the longer the distance, the less likely that people will participate in off-farm activities because the associated high transportation costs reduce the net benefits from these activities.

Other variables include the gender, education, age and age squared of the household head, which account for a household's life cycle stages and age structure.

3.6.3 Econometric concern: household attrition

The analysis of mortality impacts on households may be confounded by attrition bias which may lead to biased estimates. Our panel data exhibits an attrition rate of 11.7 percent over the entire 7-year period. Attrition raises a problem of selection bias if it is not random. To examine potential bias, I compare the means of variables measured in

1997 for households that were re-interviewed vs. those that attrited. The results presented in Table 3-6 indicate that there are statistically significant differences in means of variables between households that attrited and those that were re-interviewed. Households that were re-interviewed in either 2000 or 2004 exhibit the following characteristics: they have older and more educated heads, larger household sizes with more working-age and senior adults but fewer children in the 6-14 age-ranges. The last four rows of Table 3-6 show that households incurring a death or morbidity in 1997-2000 or 2000-2002 were less likely to attrite out of the 2004 survey.

The systematic differences between households that were re-interviewed and those that were not may lead to biased results. The inverse probability weighting (IPW) method is used to correct for attrition bias. The IPW method assumes that the probability of being re-interviewed (non-attrition) as a function of observable information is the same as the probability of being re-interviewed as a function of observables, plus unobservables that are only observed for non-attrited observations (Wooldridge, 2002). Thus, the IPW method works well if observations on observed variables are strong predictors of non-attrition and if observations on unobserved variables are not strong predictors of non-attrition.

Following Yamano and Jayne (2005), the re-interview model can be written as:

$$P(R_{it} = 1) = f(HC_{1997}, ET_{it}, PD) \tag{3.4}$$

where R_{it} is equal to 1 if a household *i* was re-interviewed at time *t*, conditional on the household being interviewed in the previous period, and zero otherwise; HC_{1997} is a set of household characteristics in the 1997 survey; ET_{it} is a set of enumeration team dummies; and PD is a set of provincial dummies. All of the variables are observable even for households that were not re-interviewed after the 1997 survey. Three to six enumeration teams conducted the surveys, each headed by a supervisor who was authorized to decide.

Table 3-6 Mean levels of 1997 household characteristics by attrition status

	Household re-interviewed in 2000	Household not re-interviewed in 2000	Difference		Household re-interviewed in 2004	Household not re-interviewed in 2004	Difference	
	Mean	Mean	Mean	t-stat	Mean	Mean	Mean	t-stat
Age of household head (years)	48.29	38.04	-10.2*	-5.24	48.56	44.02	-4.53^	-2.26
Age of spouse (years)	34.57	33.95	-0.62	-0.29	35.00	27.76	-7.23*	-3.29
Education of head (years)	6.39	5.19	-1.10*	-2.61	6.37	6.80	0.43	0.89
Education of spouse (years)	4.87	4.10	-0.77⁺	-1.75	4.87	4.86	-0.02	-0.04
Household size (number)	6.56	6.23	-0.32⁺	-1.77	6.61	5.62	-0.99*	-3.38
Male adult age 15-59 (number)	1.93	1.67	-0.26⁺	-1.81	1.96	1.53	-0.43*	-2.75
Male seniors age >59 (number)	0.25	0.10	-0.16*	-3.38	0.26	0.18	-0.08	-1.57
Female adult age 15-59 (number)	1.93	1.73	-0.19⁺	1.48	1.95	1.59	-0.36^	-2.54
Female seniors age>59 (number)	0.17	0.11	-0.06⁺	1.51	0.17	0.18	0.012	0.28
Children age<6 (number)	0.85	0.84	-0.01	-0.08	0.85	0.77	-0.08	-0.69
Children age 6-14 (number)	1.88	2.20	0.32^	2.01	1.89	1.71	-0.18	-1.06
Dependency ratio (number)	1.08	1.34	0.26^	2.34	1.07	1.24	0.17	1.47
Male highest education (years)	8.79	8.89	0.10	0.31	8.82	8.23	-0.59⁺	-1.67
Female highest education (years)	7.92	8.42	0.50	1.55	7.92	7.83	-0.09	-0.26
Value of assets ('000 Ksh)	146.37	396.61	250*	3.21	148.32	115.39	-32.93	-0.60
Landholding size (acres)	5.97	7.30	1.33	1.27	6.07	4.35	-1.72	-1.59
Distance to motorable road (km)	1.10	1.62	0.52^	2.54	1.09	1.28	0.19	0.90
Distance to tarmac road (km)	8.47	8.12	-0.32	-0.32	8.37	10.03	1.66	1.51
Distance to fertilizer store (km)	8.78	9.88	1.10	0.79	8.73	9.69	0.97	0.66
% of households incurring a working-age death (1997-2000)					5.40	0.53		
% of households incurring working-age morbidity (1997-2000)					2.54	0.20		
% of households incurring a working-age death (2000-2002)					2.40	0.07		
% of households incurring working-age morbidity (2000-2002)					1.47	0.00		

Source: Tegemeo Institute (Nairobi)/Michigan State University Agricultural Monitoring and Policy Analysis Household Surveys in 1997, 2000, 2002, 2004, and 2007.

when enumerators stop visiting households to establish contact. Thus, team dummies are an indicator of the amount of effort teams put in locating households in follow-up interviews.

Probit regressions based on equation (3.4) provide predicted probabilities of re-interview. For attrition between the 1997 and 2000 surveys, the predicted probability, P_{2000} is obtained while P_{2004} is obtained as the predicted probability between 2000 and 2004. The inverse probability weight for observations in the 2000 survey is given by $R_{2000} = 1/P_{2000}$. For the observations in the 2004 survey, the inverse probability weight R_{2004} is a product of $1/P_{2000}$ and $1/P_{2004}$ because these observations survived attrition twice. All models on impacts of working-age adult mortality are estimated using these inverse probabilities as weights.

3.7 Results

In this section, I present results on two aspects of this essay: determinants of household re-interview and the time dynamics of the impacts of working-age adult mortality on various household aspects namely household composition, amount of land cultivated, value of crop output, value of assets and income.

3.7.1 Determinants of household re-interview

The results of the re-interview models are presented in Table 3-7 and they indicate that households that were re-interviewed differ from those that attrited in terms of their characteristics in 1997. Household characteristics are jointly significant as determinants of re-interview. In particular, households with older heads and those with more male and female adults and children less than 6 years old are more likely to be re-interviewed. This may be because larger households are less likely to move or dissolve and it is easier for enumerators to find large households as well as potential respondents in these households during follow-up. Household assets are also positively associated with re-interview.

The community characteristics are jointly significant as determinants of re-interview. Distance to the tarmac road reduces the probability of re-interview in 2004, an indication that enumerators may have found it more difficult to follow up households in remote areas. HIV prevalence rate is positively associated with re-interview. This may suggest that in this sample, AIDS does not necessarily exacerbate attrition. It is possible that households that have been afflicted by AIDS-related deaths are not more likely than other households to dissolve or move away. Rather, such households may be predominantly composed of the elderly and young children. Also, HIV prevalence rates

Table 3-7 Probit models for household re-interview for the period 1997-2004

	Dependent variable =1 if:		
	Re-interviewed in 2000, contained in 1997 sample	Re-interviewed in 2004, and is in 1997 and 2000 samples	Pooled Model
Female head (=1)	0.026	-0.032	-0.002
	(1.44)	(1.57)	(0.13)
Age of household head	0.002**	0.001	0.002**
	(2.24)	(0.71)	(2.21)
Age of household head squared	-0.000	-0.000	-0.000
	(1.45)	(0.18)	(1.17)
Years of education of head	0.001	-0.002	-0.000
	(0.77)	(1.38)	(0.25)
Number of male adults	0.005	0.007	0.006*
	(1.20)	(1.46)	(1.88)
Number of female adults	0.004	0.007	0.007*
	(0.83)	(1.50)	(1.82)
Number of children 6-14 years	-0.007*	0.004	-0.002
	(1.84)	(0.87)	(0.79)
Number of children (<6 years)	0.005	0.010*	0.007*
	(0.86)	(1.82)	(1.83)
Ln (landholding size)	-0.009	0.001	-0.005
	(1.22)	(0.10)	(1.03)
Ln (Asset value)	0.006**	0.005*	0.006***
	(2.21)	(1.92)	(2.83)
Distance to tarmac road	0.000	-0.001*	-0.000
	(0.33)	(1.70)	(0.80)
Distance to fertilizer store	0.000	-0.000	0.000
	(0.29)	(0.08)	(0.17)
HIV prevalence	0.006**	0.001	0.003*
	(2.39)	(0.40)	(1.83)
Population density	-0.0006**	-0.000	-0.0003*
	(2.31)	(0.40)	(1.86)
Precipitation/evapotranspiration ratio	0.058	0.094*	0.073**
	(1.25)	(1.89)	(2.09)
Team dummies included	Yes`	Yes	Yes
Year 2004 (=1)			-0.008
			(0.40)
Chi-square joint test for [a]			
Household characteristics	38.58 (0.00)	25.45 (0.00)	46.91 (0.00)
Community characteristics	10.47 (0.06)	8.86 (0.11)	11.37 (0.04)
Team effects	15.23 (0.00)	5.38 (0.15)	21.16 (0.00)
Observations	1500	1407	2907

Source: Tegemeo Institute (Nairobi)/Michigan State University Agricultural Monitoring and Policy Analysis Household Surveys in 1997, 2000 and 2004

Notes: Estimated coefficients are marginal changes in probability; z statistics in parentheses, calculated using heteroskedasticity robust standard errors, clustered for households; *** indicates 1%; ** indicates 5% and;* indicates 10% significance level; [a] *p*-values in parentheses may be picking up other regional factors that may be negatively correlated with mobility and migration.

Households in highly populated districts are less likely to be re-interviewed while those from villages with a high precipitation/evapotranspiration rate are more likely to re-interviewed. Potential evapotranspiration is a representation of the environmental demand for evapotranspiration and the precipitation/evapotranspiration ratio is an aridity index; a numerical indicator of the degree of dryness (harshness) of the climate at a given location. The influence of these two variables on the probability of re-interview is as expected since in Kenya, migration and particularly urban-rural migration occurs typically in areas with harsh climatical conditions or high population density.

The enumeration team dummies are jointly significant at 1% for the 2000 survey and in the pooled model, signifying that team effort in contacting households during follow up greatly influences the probability of re-interview. The implication of these results from the re-interview probit models is that there is need to control for attrition and this is done in the regressions on the impacts of adult mortality on household outcomes by using the inverse probabilities as weights.

3.7.2 Impacts of working-age adult mortality on household composition

Changes in household structure have been shown to be part of households' coping strategies. This section examines how households adjust their composition as a means to cope with working-age adult death.

Table 3-8 presents ordinary least squares (OLS) results based on the specification in equation (3.1). They show that compared to households that have not experienced adult death, afflicted households tend to be larger and with more male adults. The death of a working-age adult reduces the household size by 0.684 person and the number of adult females by 0.326 person. This less than one-person decline suggests that partial replenishment is taking place, indicating that households are unable to fully replenish their numbers after incurring the death of a working-age adult member. The death of an elderly female reduces the household size by more than one-person and 0.557 person for female adults.

Male headed households have larger families and statistically significant larger numbers of all categories of household members except female adults. Results with regard to age of the head suggest a household composition that is consistent with a household's life cycle stages. As households mature, they have more adults and elder children but fewer young children and elderly adults. However, later in their lifecycle, the opposite scenario takes place, except in the case of younger children. This may be because older sons and daughters may themselves start families. Households with more educated heads tend to have fewer younger children which is consistent with the theory that education and fertility are negatively related.

The results in Table 3-9 are based on the specification (3.2) which includes dummy variables for years before and after death. The objective is to examine in a more comprehensive manner the likely dip-drop-recovery temporal pattern of the dynamic effects of death on household composition.

Table 3-8 The impact of working-age adult mortality on household composition, 1997-2004 (OLS with district dummies)

Explanatory variables	Household size	Number of: Female adults	Male adults	Girls 6-14 yrs	Boys 6-14 yrs	Children 0-5 yrs	Seniors
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Ever afflicted	0.365**	0.125	0.292***	0.022	-0.038	-0.026	-0.010
	(0.175)	(0.081)	(0.087)	(0.066)	(0.060)	(0.062)	(0.031)
Working-age adult death	-0.684**	-0.326**	-0.101	-0.060	-0.117	-0.091	0.011
	(0.308)	(0.142)	(0.143)	(0.108)	(0.098)	(0.098)	(0.056)
Elderly male death	-0.071	-0.071	-0.560	-0.059	0.291	-0.107	0.435***
	(1.078)	(0.596)	(0.530)	(0.302)	(0.312)	(0.297)	(0.128)
Elderly female death	-1.225**	-0.557***	-0.278	-0.346	0.020	-0.390	0.326
	(0.501)	(0.213)	(0.650)	(0.331)	(0.281)	(0.258)	(0.272)
Gender of head (male=1)	1.434***	0.108	0.484***	0.263***	0.270***	0.218***	0.091***
	(0.147)	(0.066)	(0.070)	(0.046)	(0.045)	(0.048)	(0.022)
Age of the head	0.268***	0.165***	0.173***	0.015**	0.022***	-0.065***	-0.042***
	(0.023)	(0.014)	(0.012)	(0.007)	(0.007)	(0.007)	(0.006)
Age of the head squared	-0.002***	-0.001***	-0.001***	-0.0002***	-0.0003***	0.0004***	0.001***
	(0.000)	(0.000)	(0.000)	(0.0001)	(0.0001)	(0.0001)	(0.000)
Education of the head	0.032**	0.022***	0.032***	-0.000	0.001	-0.020***	-0.003
	(0.012)	(0.006)	(0.007)	(0.004)	(0.004)	(0.004)	(0.002)
Year dummy for 2000	1.279***	0.492***	0.517***	0.057	0.107***	0.037	0.068***
	(0.104)	(0.050)	(0.054)	(0.039)	(0.039)	(0.037)	(0.019)
Year dummy for 2004	0.844***	0.263***	0.343***	0.037	0.045	0.095**	0.060***
	(0.110)	(0.052)	(0.056)	(0.040)	(0.040)	(0.038)	(0.019)
District dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	1.577**	-1.966***	-2.609***	0.959***	0.845***	3.745***	0.607***
	(0.796)	(0.407)	(0.367)	(0.257)	(0.249)	(0.256)	(0.171)
Observations	4157	4157	4157	4157	4157	4157	4157
R-squared	0.20	0.12	0.13	0.08	0.09	0.14	0.52

Source: Tegemeo Institute (Nairobi)/Michigan State University Agricultural Monitoring and Policy Analysis Household Surveys in 1997, 2000, 2002 and 2004

Notes: Robust standard errors in parentheses * significant at 10%; ** significant at 5%; *** significant at 1%

Table 3-9 Impact of working-age adult mortality on household composition by years before and after death, 1997-2004 (OLS with district dummies)

Explanatory variables	Household size	Number of: Female adults	Male adults	Girls 6-14	Boys 6-14	Children 0-5 yrs	Seniors
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Ever afflicted	0.357**	0.127	0.298***	0.018	-0.045	-0.028	-0.011
	(0.175)	(0.083)	(0.089)	(0.062)	(0.062)	(0.060)	(0.031)
Two years before death	-0.399	-0.554*	0.119	0.077	0.003	-0.124	0.096
	(0.698)	(0.330)	(0.357)	(0.246)	(0.248)	(0.240)	(0.165)
One year before death	-0.642	-0.600	0.399	0.054	-0.400	-0.287	0.212
	(0.876)	(0.414)	(0.448)	(0.308)	(0.311)	(0.301)	(0.140)
Year of death	2.378***	0.948***	0.435	0.571**	0.162	0.379*	-0.129
	(0.642)	(0.304)	(0.328)	(0.226)	(0.228)	(0.221)	(0.109)
One year since death	0.295	0.381	-0.043	-0.118	-0.025	0.052	0.030
	(0.541)	(0.256)	(0.277)	(0.191)	(0.193)	(0.186)	(0.155)
Two years since death	0.091	0.468	-0.278	-0.217	0.089	0.116	-0.106
	(0.806)	(0.381)	(0.412)	(0.284)	(0.287)	(0.277)	(0.148)
Three years since death	-1.082*	-0.407	-0.809**	-0.113	0.118	0.226	-0.100
	(0.626)	(0.296)	(0.320)	(0.220)	(0.223)	(0.215)	(0.074)
Four years since death	-1.232*	-0.363	0.222	-0.435*	-0.132	-0.416*	-0.094
	(0.655)	(0.310)	(0.335)	(0.231)	(0.233)	(0.225)	(0.106)
Five-seven years since death	0.410	0.463*	0.255	-0.168	-0.043	0.147	-0.244**
	(0.550)	(0.260)	(0.281)	(0.194)	(0.196)	(0.189)	(0.101)
Elderly male death	-0.388	-0.221	-0.658	-0.086	0.265	-0.099	0.417***
	(1.001)	(0.473)	(0.512)	(0.353)	(0.356)	(0.344)	(0.129)
Elderly female death	-1.207	-0.536	-0.311	-0.334	0.073	-0.372	0.278
	(1.213)	(0.573)	(0.620)	(0.427)	(0.431)	(0.417)	(0.317)
Gender of head (male=1)	1.362***	0.109*	0.453***	0.262***	0.247***	0.195***	0.093***
	(0.136)	(0.064)	(0.070)	(0.048)	(0.048)	(0.047)	(0.022)
Age of the head	0.2734***	0.1670***	0.1754***	0.0152**	0.0211***	-0.0645***	-0.0416***
	(0.0205)	(0.0097)	(0.0105)	(0.0072)	(0.0073)	(0.0070)	(0.0062)
Age of the head squared	-0.002***	-0.001***	-0.002***	-0.000***	-0.000***	0.000***	0.001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)

Table 3-9 continued

Explanatory variables	Household size	Number of: Female adults	Male adults	Girls 6-14	Boys 6-14	Children 0-5 yrs	Seniors
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Education of the head	0.033***	0.022***	0.032***	-0.000	0.001	-0.020***	-0.003
	(0.013)	(0.006)	(0.006)	(0.004)	(0.004)	(0.004)	(0.002)
Year dummy for 2000	1.272***	0.490***	0.511***	0.065*	0.105***	0.029	0.073***
	(0.111)	(0.053)	(0.057)	(0.039)	(0.040)	(0.038)	(0.019)
Year dummy for 2004	0.825***	0.261***	0.337***	0.038	0.044	0.089**	0.055***
	(0.114)	(0.054)	(0.058)	(0.040)	(0.041)	(0.039)	(0.019)
District dummies	Yes	Yes	Yes	Yes	Yes	Yes	yes
Constant	1.396*	-2.224***	-2.774***	1.059***	0.949***	3.712***	0.701***
	(0.772)	(0.365)	(0.395)	(0.272)	(0.275)	(0.265)	(0.181)
Observations	4157	4157	4157	4157	4157	4157	4157
R-squared	0.20	0.13	0.14	0.08	0.09	0.14	0.52

Source: Tegemeo Institute (Nairobi)/Michigan State University Agricultural Monitoring and Policy Analysis Household Surveys in 1997, 2000, 2002 and 2004

Notes: Robust standard errors in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%

These results show that there are no significant changes in household size and composition in the periods preceding death, except for the case of female adults. Two years before death, there is a significant decrease in the number of adult females as households begin to experience the effects of illness. This result is somewhat surprising and inconsistent with the expectation that additional female adults will both provide care to the sick and assist in other tasks related to home and farm production or income generation, which were previously undertaken by the sick household members or the care givers. However, the finding suggests that households afflicted by working-age adult mortality are not just making *ex post* responses to cope with death. Rather, they are also making pre-death illness adjustments in household composition.

In the year of death, we find an increase in household size and the number of female adults, girls and young children. A household's flexibility is a critical component in successfully responding to economic hardship. For instance, the presence of additional members can promote flexibility of households by facilitating alternative work arrangements among the core household members. New members can take on most of the domestic work, allowing core members to reallocate more time to income-generating activities. For afflicted households, inclusion of members may be motivated by economic considerations, owing to their greater economic hardships as a result of sickness and death.

There are few significant impacts of mortality in the years following death. Households experience a more-than-one person decline in household size in the third and fourth years after death. This is due to the death of the adult male member (column 3) and a reduction in the number of girls (column 4) and young children (column 6). A decline in the number of girls may indicate two things. First, the support of young girls in providing help with household chores and care giving is no longer needed four years after the adult's death. Second, households may send young girls to live with other extended family members or to seek for employment opportunities upon the death of a working-age adult. The out-migration of young children suggests that fostering is one of the coping strategies employed by afflicted households. Fostering helps by spreading the impact of death over several households. In the period five to seven years after death, there is an increase in the number of adult females but a decrease in the number of seniors. It is worthwhile to note that adult mortality does not appear to affect the number of boys in a household.

Overall, these findings show that changes in household composition take place over time, implying that such changes are part of households' coping strategies. Therefore, a household's flexibility is a critical component in successfully responding to extreme crises such as illness and death of an adult. Additionally, households afflicted by working-age mortality are not just making *ex post* responses to cope with death. Rather, they are also making pre-death illness adjustments as a coping strategy. It is also evident that the impacts of mortality on household composition are not just a one-time permanent adjustment.

Impacts of working-age adult mortality on household composition by the deceased's gender and position in household

The foregoing analysis indicates that on average, afflicted households experience changes in household composition and size. To determine how the pattern of these changes varies by gender and position of the deceased in the periods before and after death, I estimate model (3.3).

The results of this analysis are presented in Table 3-10. In the period 1-2 years before death, the impact of death does not vary by gender and position of the deceased. In the year of death, we find that compared to other deaths, a male head death leads to a decrease in the number of boys and young children. This means that when a male head dies, boys and young children are more likely to be fostered out since the household loses the main bread-winner. Also, four years after death, in comparison to other deaths, a male head death is associated with a more-than-one person decrease in the number of adult males. Overall, we find that changes in household composition depend to a limited extent on the gender and position of the deceased member.

Table 3-10 Impact of working-age adult mortality on household composition by gender and position of the deceased and by years before and after death, 1997-2004 (OLS with district dummies)

Explanatory variables	Household size	Number of: Female adults	Male adults	Girls 6-14	Boys 6-14	Children 0-5 yrs	Seniors
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Ever afflicted	0.352**	0.128	0.299***	0.017	-0.048	-0.031	-0.012
	(0.175)	(0.083)	(0.089)	(0.062)	(0.062)	(0.060)	(0.031)
Two years before death	-1.141	-0.628	0.045	-0.107	-0.367	-0.098	0.014
	(0.812)	(0.384)	(0.415)	(0.286)	(0.289)	(0.279)	(0.145)
One year before death	-1.597	-0.946*	0.374	-0.143	-0.681*	-0.267	0.067
	(1.083)	(0.512)	(0.554)	(0.382)	(0.385)	(0.372)	(0.194)
Two years before death*male head dummy	1.926	-0.042	0.299	0.588	1.049	-0.366	0.398
	(1.845)	(0.873)	(0.944)	(0.650)	(0.656)	(0.634)	(0.330)
One year before death*male head dummy	1.122	0.546	-0.323	0.420	0.135	-0.380	0.722
	(2.471)	(1.169)	(1.264)	(0.871)	(0.878)	(0.849)	(0.442)
Year of death	3.531***	0.853*	0.467	0.697**	0.732**	0.810**	-0.028
	(0.973)	(0.460)	(0.498)	(0.343)	(0.346)	(0.335)	(0.174)
One year since death	1.183	0.401	0.100	0.094	0.255	0.198	0.135
	(0.996)	(0.471)	(0.509)	(0.351)	(0.354)	(0.342)	(0.178)
Two years since death	1.398	0.499	-0.309	0.163	0.666	0.337	0.043
	(1.173)	(0.555)	(0.600)	(0.414)	(0.417)	(0.403)	(0.210)
Three years since death	0.657	-0.112	-0.731	0.250	0.789**	0.460	0.002
	(1.066)	(0.504)	(0.545)	(0.376)	(0.379)	(0.367)	(0.191)
Four years since death	-0.667	-0.445	0.656	-0.260	-0.106	-0.422	-0.091
	(0.815)	(0.386)	(0.417)	(0.287)	(0.290)	(0.280)	(0.146)
Five-seven years since death	0.996	0.733**	0.296	-0.076	0.054	0.166	-0.178
	(0.663)	(0.314)	(0.339)	(0.234)	(0.236)	(0.228)	(0.119)
Year of death*male head dummy	-1.559	0.111	0.128	-0.016	-0.901**	-0.745*	-0.136
	(1.222)	(0.578)	(0.625)	(0.431)	(0.434)	(0.420)	(0.219)
One year since death*male head dummy	-1.354	-0.431	-0.733	-0.307	0.098	0.267	-0.248
	(1.505)	(0.712)	(0.769)	(0.530)	(0.535)	(0.517)	(0.269)
Two years since death*male head dummy	-1.598	-0.028	0.389	-0.825	-0.543	-0.060	-0.531
	(2.054)	(0.972)	(1.050)	(0.724)	(0.730)	(0.706)	(0.368)

Table 3-10 continued

Explanatory variables	Household size	Number of: Female adults	Male adults	Girls 6-14	Boys 6-14	Children 0-5 yrs	Seniors
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Three years since death*male head dummy	-2.220	-0.624	-0.318	-0.415	-0.780	-0.178	0.094
	(1.753)	(0.829)	(0.896)	(0.618)	(0.623)	(0.603)	(0.314)
Four years since death*male head dummy	-1.281	0.257	-1.730**	-0.345	0.305	0.233	-0.003
	(1.426)	(0.674)	(0.729)	(0.503)	(0.507)	(0.490)	(0.255)
Five-seven years since death*male head dummy	-1.044	-0.529	0.124	-0.154	-0.153	-0.002	-0.329
	(1.470)	(0.696)	(0.752)	(0.518)	(0.523)	(0.506)	(0.263)
Elderly male death	-0.820	-0.283	-0.799	-0.153	0.237	-0.184	0.362**
	(1.020)	(0.483)	(0.522)	(0.360)	(0.363)	(0.351)	(0.183)
Elderly female death	-1.635	-0.584	-0.444	-0.402	0.008	-0.455	0.241
	(1.228)	(0.581)	(0.628)	(0.433)	(0.436)	(0.422)	(0.220)
Gender of head (male=1)	1.3629***	0.1114*	0.4542***	0.2595***	0.2476***	0.1947***	0.0953***
	(0.1370)	(0.0648)	(0.0701)	(0.0483)	(0.0487)	(0.0471)	(0.0245)
Age of the head	0.273***	0.167***	0.176***	0.015**	0.021***	-0.065***	-0.041***
	(0.020)	(0.010)	(0.010)	(0.007)	(0.007)	(0.007)	(0.004)
Age of the head squared	-0.002***	-0.001***	-0.002***	-0.000***	-0.000***	0.000***	0.001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Education of the head	0.033***	0.022***	0.032***	-0.000	0.001	-0.020***	-0.003
	(0.013)	(0.006)	(0.006)	(0.004)	(0.004)	(0.004)	(0.002)
Year dummy for 2000	1.271***	0.490***	0.513***	0.065*	0.103***	0.028	0.073***
	(0.111)	(0.053)	(0.057)	(0.039)	(0.040)	(0.038)	(0.020)
Year dummy for 2004	0.831***	0.261***	0.337***	0.039	0.046	0.091**	0.057***
	(0.114)	(0.054)	(0.058)	(0.040)	(0.041)	(0.039)	(0.020)
District dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	0.873	-2.166***	-2.798***	0.921***	0.696**	3.578***	0.646***
	(0.957)	(0.453)	(0.489)	(0.337)	(0.340)	(0.329)	(0.171)
Observations	4157	4157	4157	4157	4157	4157	4157
R-squared	0.20	0.13	0.14	0.08	0.09	0.15	0.52

Source: Tegemeo Institute (Nairobi)/Michigan State University Agricultural Monitoring and Policy Analysis Household Surveys in 1997, 2000, 2002 and 2004

Notes: Robust standard errors in parentheses * significant at 10%; ** significant at 5%; *** significant at 1%

3.7.3 Impacts of working-age adult mortality on farm production

In this section, we examine the impacts of working-age adult mortality on farm production in terms of total cultivated area, area cultivated by crop types, and the value of crop production. Our findings show that adult mortality affects households' farm productions decisions. A reduction in household size due to adult death may lead to labor shortages and labor re-allocation. Also, an adult death may result in the loss or decline of farming knowledge and skills, and increased medical and funeral expenses which may impose considerable cash constraints. As a result, we see effects of mortality on farm production through changes in area cultivated, cropping patterns and farm output. In particular, cash constraints and loss of labor and farming knowledge may lead to a reduction in cultivated area and shifts in crop mix away from labor-, management- and capital or input-intensive crops. For example, maize and high-value crops (e.g. tea, some horticultural crops) are considered more labor- and capital- intensive than root crops like sweet potatoes, yams and cassava.

3.7.3.1 Impacts of working-age adult mortality on cultivated land

Table 3-11 presents the results of the impact of adult mortality on cultivated area, in total and by crop type. These results show that although working-age adult mortality is associated with a decline in total land cultivated and the area devoted to the different crop types, none of these impacts are statistically significant. However, results in subsequent sections, which examine the dynamic effects of death reveal that mortality has significant effects on cultivated land.

Table 3-11 The impact of working-age adult mortality on total cultivated land and area by crop types in for the period 1997-2004 (OLS with AEZ[10] dummies)

	Natural logarithm of acres of cultivated land:			
Explanatory variables	Total	Cereals	High value crops	Roots and tubers
	(1)	(2)	(3)	(4)
Ever afflicted	-0.020	-0.013	-0.033	0.004
	(0.036)	(0.036)	(0.036)	(0.026)
Working-age adult death	-0.065	-0.019	-0.033	-0.032
	(0.062)	(0.060)	(0.060)	(0.044)
Elderly male death	-0.244	-0.153	-0.286**	-0.042
	(0.151)	(0.178)	(0.134)	(0.123)
Elderly female death	0.067	0.034	0.028	-0.121
	(0.243)	(0.197)	(0.274)	(0.173)
Gender of head (male=1)	0.075***	0.017	0.085***	0.054***
	(0.028)	(0.028)	(0.028)	(0.020)
Age of the head	0.015***	0.007	0.020***	0.012***
	(0.005)	(0.005)	(0.004)	(0.003)
Age of the head squared	-0.0001*	-0.0000	-0.0001***	-0.0001***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Education of the head	0.025***	0.019***	0.017***	0.002
	(0.003)	(0.003)	(0.003)	(0.002)
Distance to tarmac road (km)	0.011***	0.012***	0.005***	-0.000
	(0.001)	(0.001)	(0.001)	(0.001)
Distance to fertilizer store (km)	0.003**	0.003***	-0.003***	-0.001***
	(0.001)	(0.001)	(0.001)	(0.001)
Year dummy for 2000	0.086***	0.081***	0.417***	0.124***
	(0.023)	(0.024)	(0.023)	(0.017)
Year dummy for 2004	0.072***	0.049**	0.365***	0.105***
	(0.024)	(0.024)	(0.023)	(0.017)
AEZ dummies	Yes	Yes	Yes	Yes
Constant	0.554***	0.647***	0.031	0.219**
	(0.136)	(0.141)	(0.123)	(0.088)
Observations	4157	4157	4157	4157
R-squared	0.11	0.13	0.16	0.08

Source: Tegemeo Institute (Nairobi)/Michigan State University Agricultural Monitoring and Policy Analysis Household Surveys in 1997, 2000, 2002 and 2004

Notes: Robust standard errors in parentheses; * significant at 10%; ** significant at 5%; *** significant at 1%

[10] AEZ refers to agro-ecological zone

Other factors significantly affect the area of land that is cultivated. For instance, male-headed households have more acres of cultivated land in total and also under high-value crops and roots and tubers. The age of the household has a significant non-linear effect on total cultivated land and area devoted to high-value crops and roots and tubers. Observed differences in land area cultivated are consistent with both a resource-endowment and a demographic (based on a household's life cycle) explanation. When the head is young, the household age structure is young (due to the presence of infants and young children) and the household commands fewer resources. The high dependency ratio and fewer resources imply that relatively little land is farmed due to limited labor and capital available for agriculture. As time passes, the household accumulates more resources and the average age among the children increases. As children grow up and become more economically active, the dependency ratio decreases. This, coupled with more resources allows for the expansion of the land area cultivated.

Households with more educated heads have more cultivated land in total and under cereals and high-value crops. Also, the distance variables are positively related to land cultivated. The distance variables indicate the remoteness of an area, the quality of road infrastructure and thus the associated transport costs. Livelihoods of households residing in remote rural areas depend to a larger extent on farming. Therefore, they have more land under cultivation and particularly for cereals in order to ensure food security. However, as expected, the longer the distance to fertilizer store, the more expensive inputs costs become and so the less the area cultivated. This is true for the high-value crops which are intensive in the use of purchased inputs but is surprising in the case of roots and tubers.

The results in Table 3-12 show the temporal pattern of the dynamics of death effects on land cultivated. The coefficients on two years before death indicate that households have more cultivated total land and area under high-value crops and roots and tubers. One year before death, only the area under high-value crops appears to be significantly larger. In the year of death, there is no statistically significant effect on area cultivated both in total and by crop types. However, one year after death, area under roots and tubers declines while two years after death, total cultivated land and area under high-value crops, roots and tubers declines. Also, five to seven years after death, there is a significant decline in the area devoted to high-value crops. This pattern of effects reflects the progression of the severity of disease. Two years before death, illness is relatively mild and so households have enough labor and capital to farm their land. As the disease progresses and is followed by death, households may begin to face labor shortages and cash constraints causing them to cut back the area under cultivation. The decline in area under high-value crops even five to seven years after death may signify tighter cash constraints, causing households to shift away from high-value crops which require larger capital investment and possibly more labor than other crops.

To summarize, these results show that afflicted households experience different impacts of death on cultivated land as time passes since death. Except in the case of high-value crops, the impact of death does not persist beyond two years after death. This finding indicates some recovery in cultivated area. There is no statistically significant impact of morbidity and mortality on the area under cereals, indicating that households appear to be successful at safeguarding their food security position. However, they are less able to maintain the area under the capital- and labor-intensive high-value crops.

Table 3-12 The impact of working-age adult mortality on total cultivated land and area by crop types for years before and after death in the period 1997- 2004 (OLS with AEZ dummies)

	Natural logarithm of acres of cultivated land:			
Explanatory variables	Total	Cereals	High-value crops	Root and tubers
	(1)	(2)	(3)	(4)
Ever afflicted	-0.020	-0.011	-0.037	-0.001
	(0.036)	(0.037)	(0.035)	(0.027)
Two years before death	0.261*	0.151	0.323**	0.298***
	(0.145)	(0.150)	(0.143)	(0.107)
One year before death	0.229	0.173	0.373**	0.090
	(0.181)	(0.188)	(0.179)	(0.134)
Year of death	0.083	0.137	-0.040	0.080
	(0.133)	(0.138)	(0.131)	(0.098)
One year since death	-0.096	-0.059	-0.160	-0.143*
	(0.112)	(0.116)	(0.111)	(0.083)
Two years since death	-0.286*	-0.214	-0.389**	-0.253**
	(0.167)	(0.173)	(0.165)	(0.123)
Three years since death	-0.072	-0.083	-0.097	-0.002
	(0.130)	(0.134)	(0.128)	(0.096)
Four years since death	-0.034	-0.048	-0.073	-0.085
	(0.136)	(0.141)	(0.134)	(0.100)
Five-seven years since death	-0.029	0.036	-0.199*	-0.109
	(0.114)	(0.118)	(0.112)	(0.084)
Elderly male death	-0.235	-0.148	-0.262	-0.033
	(0.207)	(0.215)	(0.204)	(0.153)
Elderly female death	0.073	0.028	0.008	-0.088
	(0.251)	(0.260)	(0.248)	(0.186)
Gender of head (male=1)	0.067**	0.007	0.080***	0.052**
	(0.028)	(0.029)	(0.028)	(0.021)
Age of the head	0.015***	0.007	0.020***	0.012***
	(0.004)	(0.004)	(0.004)	(0.003)
Age of the head squared	-0.0001**	-0.0000	-0.0001***	-0.0001***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Education of the head	0.026***	0.019***	0.018***	0.003
	(0.003)	(0.003)	(0.003)	(0.002)
Distance to tarmac road (km)	0.011***	0.012***	0.005***	-0.000
	(0.001)	(0.001)	(0.001)	(0.001)
Distance to fertilizer store (km)	0.003***	0.004***	-0.003***	-0.001***
	(0.001)	(0.001)	(0.001)	(0.000)
Year dummy for 2000	0.086***	0.079***	0.417***	0.124***
	(0.023)	(0.024)	(0.023)	(0.017)
Year dummy for 2004	0.074***	0.050**	0.362***	0.104***
	(0.024)	(0.025)	(0.023)	(0.018)
AEZ dummies	Yes	Yes	Yes	Yes
Constant	0.468***	0.595***	0.088	0.228**
	(0.156)	(0.162)	(0.154)	(0.115)
Observations	4157	4157	4157	4157
R-squared	0.11	0.13	0.16	0.08

Source: Tegemeo Institute (Nairobi)/Michigan State University Agricultural Monitoring and Policy Analysis Household Surveys in 1997, 2000, 2002 and 2004

Notes: Robust standard errors in parentheses; *significant at 10%; **significant at 5%;***significant at 1%

Impacts of working-age adult mortality on cultivated land by the deceased's gender and position in household

In the results shown in Table 3-13, I examine if the effects of adult mortality in the periods before and after death vary depending on the gender and position of the deceased. In the period preceding death and up to two years after death, the effect of morbidity and mortality of male household heads on land cultivated does not differ from that of all other adult household members. By the third year after death, households afflicted by male head deaths as opposed to other adult deaths, face a large reduction in total cultivated land and area devoted to cereals and high-value crops. This suggests that the loss of a household head imposes greater hardship for households for various reasons. First, the household loses the main bread winner who has great influence and control of financial resources and social capital. In addition, the death of male heads may be associated with land sales and subdivision or widows may face great difficulties in retaining access to land after the death of their husbands.

Table 3-13 The impact of working-age adult mortality on total cultivated land and area by crop types, by gender and position of the deceased for years before and after death in the period 1997-2004 (OLS with AEZ dummies)

	Natural logarithm of acres of cultivated land:			
Explanatory variables	Total	Cereals	High-value crops	Root and tubers
	(1)	(2)	(3)	(4)
Ever afflicted	-0.029	-0.022	-0.042	-0.002
	(0.036)	(0.037)	(0.035)	(0.026)
Two years before death	0.102	0.018	0.223	0.279**
	(0.169)	(0.175)	(0.166)	(0.125)
One year before death	0.099	0.063	0.213	0.086
	(0.224)	(0.232)	(0.221)	(0.166)
Two years before death*male head dummy	0.199	0.131	-0.062	-0.078
	(0.386)	(0.400)	(0.381)	(0.286)
One year before death*male head dummy	-0.495	-0.521	-0.275	-0.310
	(0.513)	(0.532)	(0.507)	(0.380)
Year of death	0.189	0.279	0.080	0.181
	(0.172)	(0.179)	(0.170)	(0.128)
One year since death	-0.119	-0.025	-0.055	-0.130
	(0.138)	(0.143)	(0.136)	(0.102)
Two years since death	-0.248	-0.151	-0.206	-0.260*
	(0.190)	(0.197)	(0.187)	(0.141)
Three years since death	0.174	0.193	0.278	0.079
	(0.198)	(0.206)	(0.196)	(0.147)
Four years since death	-0.041	-0.072	0.075	-0.010
	(0.164)	(0.171)	(0.162)	(0.122)
Five-seven years since death	-0.027	0.023	-0.173	-0.123
	(0.137)	(0.142)	(0.135)	(0.102)
Year of death*male head dummy	-0.307	-0.353	-0.108	-0.165
	(0.267)	(0.277)	(0.264)	(0.198)
One year since death*male head dummy	-0.129	-0.252	-0.085	0.070
	(0.328)	(0.340)	(0.323)	(0.243)
Two years since death*male head dummy	0.239	0.227	0.077	0.363
	(0.431)	(0.446)	(0.425)	(0.319)
Three years since death*male head dummy	-0.937**	-0.959**	-0.923**	-0.245
	(0.365)	(0.378)	(0.360)	(0.270)
Four years since death*male head dummy	-0.185	-0.039	-0.441	-0.318
	(0.308)	(0.319)	(0.304)	(0.228)
Five-seven years since death*male head dummy	0.333	0.382	0.303	0.150
	(0.310)	(0.322)	(0.306)	(0.230)
Elderly male death	-0.259	-0.191	-0.309	-0.048
	(0.211)	(0.219)	(0.208)	(0.156)
Elderly female death	0.014	-0.049	-0.053	-0.111
	(0.254)	(0.263)	(0.251)	(0.188)
Gender of head (male=1)	0.067**	0.007	0.079***	0.053**
	(0.028)	(0.029)	(0.028)	(0.021)
Age of the head	0.015***	0.007	0.020***	0.012***
	(0.004)	(0.004)	(0.004)	(0.003)
Age of the head squared	-0.0001**	-0.0000	-0.0001***	-0.0001***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Education of the head	0.026***	0.019***	0.018***	0.003
	(0.003)	(0.003)	(0.003)	(0.002)

Table 3-13 continued

Explanatory variables	Natural logarithm of acres of cultivated land: Total	Cereals	High-value crops	Root and tubers
Distance to tarmac road (km)	0.011***	0.012***	0.005***	-0.000
	(0.001)	(0.001)	(0.001)	(0.001)
Distance to fertilizer store (km)	0.003***	0.004***	-0.003***	-0.001***
	(0.001)	(0.001)	(0.001)	(0.000)
Year dummy for 2000	0.085***	0.078***	0.417***	0.124***
	(0.023)	(0.024)	(0.023)	(0.017)
Year dummy for 2004	0.072***	0.048**	0.361***	0.104***
	(0.024)	(0.025)	(0.023)	(0.018)
AEZ dummies	Yes	Yes	Yes	Yes
Constant	0.549***	0.651***	0.030	0.212**
	(0.127)	(0.131)	(0.125)	(0.094)
Observations	4157	4157	4157	4157
R-squared	0.11	0.13	0.16	0.08

Source: Tegemeo Institute (Nairobi)/Michigan State University Agricultural Monitoring and Policy Analysis Household Surveys in 1997, 2000, 2002 and 2004

Notes: Robust standard errors in parentheses; *significant at 10%; **significant at 5%;***significant at 1%

3.7.3.2 Impacts of working-age adult mortality on the value of crop output

The impact of working-age adult mortality on value of crop output is shown in Table 3-14. Results indicate that mortality has no statistically significant impact on either the total or per acre gross value of crop output. However, the death of elderly male adults leads to a decline in the total gross value of crop output. This is probably due to two reasons. First, older men (60 years and above) are likely to be the ones who have title to land and may control a reasonable amount of productive resources. Second, they are also likely to be strong and productive even at this age, and compared to the working-age adults, they may allocate most of their time to crop production.

There are other factors that influence the value of crop output. Male-headed households have more crop output in total and on per acre basis. Age of the head has a non-linear effect on total but not per acre gross value of crop output. Also, households with more educated heads tend to have greater crop output and higher land productivity. The distance variables are positively related to total gross value of crop output but negatively related to gross value of crop output per acre. This may be because households residing in remote rural areas derive their livelihood mainly from crop cultivation. However, their location implies that inputs costs are likely to be high, leading to poor land productivity.

Table 3-15 shows that the impact of adult mortality on value of crop output does not vary over time, both for the periods before and after death. This result may reflect the fact that there are very few significant changes in area cultivated both in total and by crop types over time (Table 3-12). This may suggest that afflicted households may be well-cushioned from the potential effects of illness and death arising from loss of income, labor, farming knowledge and skills. It is possible that informal social safety nets provide support to afflicted households, particularly in the form of labor and seeds.

Table 3-14 The impact of working-age adult mortality on gross value of crop output in the period 1997-2004 (OLS with AEZ dummies)

	Natural logarithm of value of:	
Explanatory variables	Gross value of crop output	Gross value of crop output/acre
	(1)	(2)
Ever afflicted	0.022	0.033
	(0.069)	(0.056)
Working-age adult death	-0.092	0.025
	(0.120)	(0.097)
Elderly male death	-0.493*	-0.132
	(0.288)	(0.321)
Elderly female death	0.128	0.033
	(0.460)	(0.435)
Gender of head (male=1)	0.338***	0.209***
	(0.065)	(0.051)
Age of the head	0.026***	0.006
	(0.010)	(0.008)
Age of the head squared	-0.0002*	-0.0001
	(0.0001)	(0.0001)
Education of the head	0.053***	0.018***
	(0.006)	(0.005)
Distance to tarmac road (km)	0.010***	-0.004*
	(0.003)	(0.002)
Distance to fertilizer store (km)	0.003**	-0.000
	(0.001)	(0.001)
Year dummy for 2000	0.381***	0.263***
	(0.056)	(0.048)
Year dummy for 2004	-0.055	-0.162***
	(0.049)	(0.040)
AEZ dummies	Yes	Yes
Constant	7.995***	8.172***
	(0.309)	(0.264)
Observations	4157	4157
R-squared	0.24	0.27

Source: Tegemeo Institute (Nairobi)/Michigan State University Agricultural Monitoring and Policy Analysis Household Surveys in 1997, 2000, 2002 and 2004

Notes: Robust standard errors in parentheses; *significant at 10%; **significant at 5%;***significant at 1%

Table 3-15 The impact of working-age adult mortality on value of crop output for the years before and after death in the period 1997-2004 (OLS with AEZ dummies)

	Natural logarithm of value of:	
Explanatory variables	Gross value of crop output	Gross value of crop output/acre
	(1)	(2)
Ever afflicted	0.011	0.032
	(0.069)	(0.056)
Two years before death	-0.068	-0.346
	(0.291)	(0.265)
One year before death	-0.008	-0.289
	(0.341)	(0.341)
Year of death	0.154	0.172
	(0.283)	(0.179)
One year since death	-0.013	0.185
	(0.267)	(0.247)
Two years since death	-0.008	0.432
	(0.356)	(0.295)
Three years since death	-0.050	0.161
	(0.267)	(0.247)
Four years since death	-0.229	-0.203
	(0.254)	(0.185)
Five-seven years since death	-0.029	-0.004
	(0.234)	(0.211)
Elderly male death	-0.513*	-0.145
	(0.301)	(0.318)
Elderly female death	0.101	0.027
	(0.470)	(0.473)
Gender of head (male=1)	0.339***	0.210***
	(0.065)	(0.051)
Age of the head	0.027***	0.006
	(0.010)	(0.008)
Age of the head squared	-0.0002*	-0.0001
	(0.0001)	(0.0001)
Education of the head	0.053***	0.018***
	(0.006)	(0.005)
Distance to tarmac road (km)	0.010***	-0.004
	(0.003)	(0.002)
Distance to fertilizer store (km)	0.003**	-0.000
	(0.001)	(0.001)
Year dummy for 2000	0.380***	0.265***
	(0.057)	(0.048)
Year dummy for 2004	-0.059	-0.165***
	(0.049)	(0.040)
AEZ dummies	Yes	Yes
Constant	7.985***	8.166***
	(0.310)	(0.265)
Observations	4157	4157
R-squared	0.24	0.27

Source: Tegemeo Institute (Nairobi)/Michigan State University Agricultural Monitoring and Policy Analysis Household Surveys in 1997, 2000, 2002 and 2004

Notes: Robust standard errors in parentheses; *significant at 10%; **significant at 5%;***significant at 1%

Impacts of working-age adult mortality on value of crop output by the deceased's gender and position in household

In this section, I examine whether the impact of adult mortality on the value of crop output depends on the gender and position of the deceased adult. The results in Table 3-16 show that to a great extent, this impact does not vary by gender and position of the deceased. Three years after death, households afflicted by the death of male heads have greater value of crop output per acre, compared to households that experienced other adult deaths. However, in the period five-seven years since death, the opposite effect is observed. This may be attributed to combined effects of the loss of farming skills, human capital, and financial resources. In the longer term, these effects may be expected to be larger upon the death of the male heads due to their greater influence and control of these resources and social capital. In addition, the death of male heads may be associated with land sales and subdivision or widows may face great difficulties in retaining access to land after the death of their husbands. All these factors diminish the ability of afflicted households to maintain or improve land productivity over time.

Table 3-16 The impact of working-age adult mortality on gross value of crop output by gender and position of the deceased, for years before and after death in the period 1997-2004 (OLS with AEZ dummies)

	Natural logarithm of value of:	
Explanatory variables	Gross value of crop output	Gross value of crop output/acre
	(1)	(2)
Ever afflicted	0.011	0.032
	(0.069)	(0.056)
Two years before death	-0.196	-0.247
	(0.306)	(0.291)
One year before death	0.010	-0.105
	(0.377)	(0.388)
Two years before death*male head dummy	0.187	0.014
	(0.739)	(0.566)
One year before death*male head dummy	-0.825	0.190
	(0.619)	(0.523)
Year of death	0.248	0.080
	(0.368)	(0.265)
One year since death	-0.105	0.071
	(0.282)	(0.273)
Two years since death	-0.040	0.301
	(0.382)	(0.327)
Three years since death	0.015	-0.190
	(0.297)	(0.302)
Four years since death	-0.121	-0.126
	(0.278)	(0.221)
Five-seven years since death	0.071	0.045
	(0.251)	(0.236)
Year of death*male head dummy	-0.163	0.231
	(0.580)	(0.341)
One year since death*male head dummy	0.590	0.704
	(0.743)	(0.549)
Two years since death*male head dummy	0.759	0.168
	(0.831)	(0.604)
Three years since death*male head dummy	0.045	0.265***
	(0.571)	(0.048)
Four years since death*male head dummy	-0.485	-0.247
	(0.593)	(0.404)
Five-seven years since death*male head dummy	-0.344	-0.852**
	(0.524)	(0.399)
Elderly male death	-0.491*	-0.121
	(0.290)	(0.319)
Elderly female death	0.092	0.072
	(0.435)	(0.459)
Gender of head (male=1)	0.347***	0.217***
	(0.065)	(0.051)
Age of the head	0.027***	0.007
	(0.010)	(0.008)
Age of the head squared	-0.0002*	-0.0001
	(0.0001)	(0.0001)
Education of the head	0.053***	0.018***
	(0.006)	(0.005)

Table 3-16 continued

Explanatory variables	Natural logarithm of value of: Gross value of crop output	Gross value of crop output/acre
Distance to tarmac road (km)	0.010***	-0.004*
	(0.003)	(0.002)
Distance to fertilizer store (km)	0.003**	-0.000
	(0.001)	(0.001)
Year dummy for 2000	0.380***	0.265***
	(0.057)	(0.048)
Year dummy for 2004	-0.059	-0.166***
	(0.049)	(0.040)
AEZ dummies	Yes	Yes
Constant	7.969***	8.154***
	(0.310)	(0.266)
Observations	4157	4157
R-squared	0.24	0.27

Source: Tegemeo Institute (Nairobi)/Michigan State University Agricultural Monitoring and Policy Analysis Household Surveys in 1997, 2000, 2002 and 2004

Notes: Robust standard errors in parentheses; *significant at 10%; **significant at 5%;***significant at 1%

3.7.4 Impacts of working-age adult mortality on assets

Households may sell assets in order to deal with many shocks including additional financial constraints imposed on them by adult illness and mortality (Barnett and Blaike, 1992). In this section, we examine the impacts of adult mortality on the value of households' cattle, small animals, farm equipment and other assets.

Results in Table 3-17 indicate that adult mortality has adverse and significant effects on total assets, small animals and farm equipment but not on cattle and other assets. Consistent with findings by Yamano and Jayne (2004) and Chapoto and Jayne (2008), households experiencing adult death appear to rely heavily on the sale of small animals rather than cattle and farm equipment.

While male elderly death has no significant effect on household assets, surprisingly the death of an elderly female leads to a significant increase in total assets. Compared to female-headed households, male-headed households have more assets. The age of a household head has a non-linear effect on asset levels. This reflects the fact that the ability of a household to accumulate more assets over its lifecycle is greater at the earlier stages but diminishes later. Also, households with more educated heads tend to have more assets. Distance variables are positively related to the amount of assets, particularly small animals and farm equipment. This is because households that live in relatively more remote rural areas are mainly engaged in crop and livestock production.

The complete temporal pattern of the impact of working-age adult mortality on assets is shown in Table 3-18. The results show that the value of small animals, farm equipment and other assets varies over the period of illness and after death.

Table 3-17 The impact of working-age adult mortality on value of assets for the period 1997-2004 (OLS with AEZ dummies)

	Natural logarithm of value of:				
Explanatory variables	Total assets	Cattle	Small animals	Farm equipment	Other assets
	(1)	(2)	(3)	(4)	(5)
Ever afflicted	0.052	0.053	-0.075	-0.041	-0.187
	(0.150)	(0.278)	(0.182)	(0.253)	(0.229)
Working-age adult death	-0.129***	-0.637	-0.387***	-0.083***	0.306
	(0.022)	(0.471)	(0.127)	(0.030)	(0.313)
Elderly male death	-0.615	-0.306	0.309	-0.179	0.646
	(1.176)	(0.246)	(0.912)	(0.990)	(0.974)
Elderly female death	0.122***	0.290	-0.166	0.151	0.034
	(0.427)	(0.233)	(1.225)	(0.234)	(1.018)
Gender of head (male=1)	0.468***	0.336	0.662***	0.632***	0.692***
	(0.143)	(0.227)	(0.148)	(0.203)	(0.170)
Age of the head	0.047***	0.093***	0.038*	0.059**	0.107***
	(0.017)	(0.030)	(0.020)	(0.029)	(0.025)
Age of the head squared	-0.0003*	-0.0005*	-0.0002	-0.0001	-0.0006***
	(0.0001)	(0.0003)	(0.0002)	(0.0003)	(0.0002)
Education of the head	0.086***	0.131***	0.030**	0.257***	0.201***
	(0.011)	(0.019)	(0.012)	(0.018)	(0.015)
Distance to tarmac road (km)	0.002	-0.003	-0.001	0.026***	0.004
	(0.006)	(0.011)	(0.006)	(0.008)	(0.007)
Distance to fertilizer store (km)	0.010***	0.001	0.014***	0.004	0.004
	(0.002)	(0.005)	(0.003)	(0.004)	(0.004)
Year dummy for 2000	-0.583***	-0.830***	-0.617***	0.830***	3.763***
	(0.107)	(0.174)	(0.117)	(0.167)	(0.145)
Year dummy for 2004	-0.296***	-0.534***	-0.372***	0.418**	3.329***
	(0.085)	(0.168)	(0.110)	(0.166)	(0.142)
AEZ dummies	Yes	Yes	Yes	Yes	Yes
Constant	6.805***	-0.907	5.641***	-2.400***	-2.313***
	(0.540)	(0.936)	(0.618)	(0.883)	(0.763)
Observations	4157	4157	4157	4157	4157
R-squared	0.13	0.17	0.06	0.11	0.30

Source: Tegemeo Institute (Nairobi)/Michigan State University Agricultural Monitoring and Policy Analysis Household Surveys in 1997, 2000, 2002 and 2004

Notes: Robust standard errors in parentheses; * significant at 10%; ** significant at 5%; *** significant at 1%

Table 3-18 The impact of working-age adult mortality on value of assets for years before and after death in the period 1997-2004

	Natural logarithm of value of:				
Explanatory variables	Total assets	Cattle	Small animals	Farm equipment	Other assets
	(1)	(2)	(3)	(4)	(5)
Ever afflicted	0.053	0.044	-0.077	-0.033	-0.180
	(0.150)	(0.278)	(0.181)	(0.253)	(0.229)
Two years before death	-0.875	-0.300	-0.020**	-0.019	0.210
	(0.692)	(0.233)	(0.010)	(0.934)	(0.652)
One year before death	0.820	-0.672	-0.274**	-0.350	0.185
	(0.926)	(1.338)	(0.110)	(0.261)	(0.739)
Year of death	0.719	0.545	-0.465	-0.006*	0.017
	(0.455)	(1.031)	(0.659)	(0.003)	(0.012)
One year since death	0.025	0.855	-0.293	-0.321	0.095
	(0.018)	(0.821)	(0.246)	(0.722)	(0.420)
Two years since death	-0.046	-0.230	0.052**	-0.078*	-0.093*
	(0.731)	(1.204)	(0.025)	(0.045)	(0.050)
Three years since death	-0.612	0.859	0.016	-0.012	-0.088*
	(0.886)	(1.078)	(0.015)	(0.865)	(0.049)
Four years since death	-0.425	0.411	-0.008	0.356	-0.465
	(0.525)	(0.977)	(0.700)	(0.762)	(0.641)
Five-seven years since death	-0.503	-0.450	-0.293	-0.493	-0.360
	(0.563)	(0.878)	(0.670)	(0.693)	(0.551)
Elderly male death	-0.826	-2.189	-0.133	-0.123	0.435
	(1.199)	(1.471)	(0.888)	(0.923)	(0.944)
Elderly female death	0.734	0.166	-0.547	0.273	-0.269
	(0.463)	(0.234)	(1.301)	(0.266)	(1.018)
Gender of head (male=1)	0.484***	0.345	0.677***	0.641***	0.709***
	(0.143)	(0.227)	(0.148)	(0.203)	(0.170)
Age of the head	0.049***	0.095***	0.039**	0.059**	0.108***
	(0.017)	(0.030)	(0.020)	(0.029)	(0.025)
Age of the head squared	-0.0003*	-0.0005*	-0.0002	-0.0001	-0.0007***
	(0.0001)	(0.0003)	(0.0002)	(0.0003)	(0.0002)
Education of the head	0.085***	0.131***	0.028**	0.258***	0.200***
	(0.011)	(0.019)	(0.012)	(0.018)	(0.015)
Distance to tarmac road (km)	0.002	-0.004	-0.001	0.026***	0.005
	(0.006)	(0.011)	(0.006)	(0.008)	(0.007)
Distance to fertilizer store (km)	0.010***	0.001	0.014***	0.004	0.004
	(0.002)	(0.005)	(0.003)	(0.004)	(0.004)
Year dummy for 2000	-0.573***	-0.818***	-0.610***	0.837***	3.764***
	(0.108)	(0.175)	(0.118)	(0.169)	(0.146)
Year dummy for 2004	-0.306***	-0.551***	-0.381***	0.414**	3.329***
AEZ dummies	Yes	Yes	Yes	Yes	Yes
	(0.085)	(0.169)	(0.110)	(0.167)	(0.143)
Constant	6.448***	-1.262	4.983***	-2.239**	-1.843**
	(0.631)	(1.124)	(0.789)	(1.032)	(0.868)
Observations	4157	4157	4157	4157	4157
R-squared	0.13	0.17	0.06	0.12	0.30

Source: Tegemeo Institute (Nairobi)/Michigan State University Agricultural Monitoring and Policy Analysis Household Surveys in 1997, 2000, 2002 and 2004

Notes: Robust standard errors in parentheses;*significant at 10%;**significant at 5%;***significant at 1%

Significant declines in the value of small animals begin in the two years before death, but there are no significant effects on the value of cattle, farm equipment and other assets. This suggests that households may sell assets because of increased expenditures (medical and otherwise) and the financial loss they experience as a result of labor diverted from economically productive activities to care giving. The decline during one year before death is greater than that in the period of two years before death. This is consistent with the increased financial burden as the disease becomes more debilitating. The value of small animals increases in the second year after death but beyond this time, there is no clear pattern on the value as time passes by. The rebound in the value of small animals is a sign of recovery.

Significant reductions in the value of farm equipment emerge during the year of death and are also observed two years since death. However, in successive years, there is no clear pattern on how the value of farm equipment changes. It is likely that farm households rely heavily on remittances and non-farm income to capitalize their farm operations (Reardon et al, 1995) and maintain farm equipment. Consequently, mortality of working-age adults who may be the major sources of remittances and non-farm income diminishes the households' ability to maintain the number and quality of existing farm equipment as well as purchase new farm equipment.

The value of other assets (mainly durable assets like radios and TVs) declines in the second and third years after death. This suggests that households are coping with the financial capital effects of adult death through the sale of stores of value such as household goods.

There are no significant effects of death on value of cattle during the period running from two years before death and up to seven years after death. Therefore, findings from this study suggest that one coping strategy adopted by households facing illness and subsequent death is the sale of small animals and stores of value. This is consistent with findings from other studies. For instance, Topouzis and du Guerny (1999), show that most of the households are responding to illness and death in the short-term by disposing assets that can be easily replaced. In addition, households seem to be holding on to their cattle and rely on the sale of small animals (Yamano and Jayne, 2004) in the face of illness and mortality.

Impacts of working-age adult mortality on assets by the deceased's gender and position in household

In the preceding section, we find that working-age adult mortality has significant effects on household assets even in the years following death. In this section, I examine whether these effects depend on the gender and position of the deceased household member. The results are presented in Table 3-19 and they show that the impacts of adult mortality on total assets, cattle, farm equipment and other assets does not vary by gender and position of the deceased person. However, households experiencing a male head death compared to any other death, face a reduction in the value of small animals, one year before death. In terms of recovery, a male head death is associated with a smaller recovery in small animals compared to other deaths in the second year after death.

Table 3-19 The impact of working-age adult mortality on assets by gender and position of the deceased, for years before and after death in the period 1997-2004 (OLS with AEZ dummies)

	Natural logarithm of value of:				
Explanatory variables	Total assets	Cattle	Small animals	Farm equipment	Other assets
	(1)	(2)	(3)	(4)	(5)
Ever afflicted	0.050	0.075	-0.068	-0.070	-0.194
	(0.149)	(0.277)	(0.180)	(0.252)	(0.227)
Two years before death	-0.320	-0.269	-0.953	-0.083	-0.108
	(0.233)	(0.247)	(0.922)	(1.069)	(0.748)
One year before death	0.835	-0.057	0.182	0.212	0.428
	(1.131)	(1.728)	(0.233)	(0.481)	(1.089)
Two years before death*male head dummy	0.291	-0.006	-2.032	0.094	0.390
	(1.600)	(0.787)	(1.572)	(0.358)	(1.459)
One year before death*male head dummy	-0.154	-0.197	-0.115*	0.140	0.095
	(0.723)	(0.503)	(0.065)	(0.486)	(0.213)
Year of death	-0.410	-0.025	0.388	0.094	0.267
	(0.635)	(1.504)	(0.706)	(0.988)	(0.599)
One year since death	0.411	0.013	0.747	0.543	0.800
	(0.386)	(1.122)	(0.553)	(0.965)	(0.493)
Two years since death	-0.361	-0.102	0.102*	-0.847	-0.119
	(0.902)	(0.419)	(0.058)	(1.201)	(0.853)
Three years since death	-0.747	0.273	0.093*	0.322	0.209
	(1.119)	(1.649)	(0.050)	(1.304)	(1.031)
Four years since death	-0.945	-0.143	0.061	1.071	-0.159
	(0.743)	(1.168)	(0.093)	(0.860)	(0.779)
Five-seven years since death	-0.016	-0.245	-0.651	-0.776	-0.131
	(0.655)	(1.085)	(0.804)	(0.848)	(0.632)
Year of death*male head dummy	0.117	0.524	-1.127	0.561	-0.625
	(0.781)	(2.114)	(1.243)	(1.632)	(1.322)
One year since death*male head dummy	0.182	0.140	0.439	-0.128	-0.471
	(0.810)	(0.236)	(1.084)	(1.255)	(1.102)
Two years since death*male head dummy	0.983	0.159	-0.067*	-0.187	-0.241
	(1.679)	(0.469)	(0.039)	(0.453)	(0.270)
Three years since death*male head dummy	0.324	-0.237	-0.047	-0.184	-0.120
	(1.855)	(2.381)	(0.090)	(2.028)	(0.083)
Four years since death*male head dummy	0.011	1.270	-0.117	-0.048	0.052
	(0.028)	(2.010)	(0.427)	(0.062)	(1.493)
Five-seven years since death*male head	-0.024	0.304	-0.031	0.477	-0.107
	(0.016)	(1.750)	(0.051)	(1.561)	(1.141)
Elderly male death	-0.800	-0.032	0.101	-0.572	0.233
	(1.140)	(0.059)	(0.861)	(0.951)	(0.939)
Elderly female death	0.664	0.359	-0.516	0.272	-0.386
	(0.551)	(0.435)	(1.362)	(0.228)	(1.049)

Table 3-19 continued

	Natural logarithm of value of:				
Explanatory variables	Total assets	Cattle	Small animals	Farm equipment	Other assets
Gender of head (male=1)	0.502***	0.364	0.689***	0.619***	0.694***
	(0.144)	(0.229)	(0.149)	(0.204)	(0.171)
Age of the head	0.049***	0.096***	0.040**	0.059**	0.107***
	(0.017)	(0.030)	(0.020)	(0.029)	(0.025)
Age of the head squared	-0.0003**	-0.0005*	-0.0002	-0.0001	-.0006***
	(0.0001)	(0.0003)	(0.0002)	(0.0003)	(0.0002)
Education of the head	0.085***	0.130***	0.028**	0.259***	0.200***
	(0.011)	(0.019)	(0.012)	(0.018)	(0.015)
Distance to tarmac road (km)	0.002	-0.003	-0.000	0.026***	0.004
	(0.006)	(0.011)	(0.006)	(0.008)	(0.007)
Distance to fertilizer store (km)	0.010***	0.001	0.014***	0.004	0.004
	(0.002)	(0.005)	(0.003)	(0.004)	(0.004)
Year dummy for 2000	-0.573***	-0.815***	-0.610***	0.836***	3.762***
	(0.108)	(0.175)	(0.118)	(0.169)	(0.146)
Year dummy for 2004	-0.307***	-0.545***	-0.380***	0.405**	3.330***
	(0.085)	(0.169)	(0.110)	(0.167)	(0.143)
AEZ dummies	Yes	Yes	Yes	Yes	Yes
Constant	6.714***	-1.012	5.537***	-2.369***	-2.310***
	(0.540)	(0.936)	(0.618)	(0.887)	(0.763)
Observations	4157	4157	4157	4157	4157
R-squared	0.13	0.17	0.06	0.12	0.30

Source: Tegemeo Institute (Nairobi)/Michigan State University Agricultural Monitoring and Policy Analysis Household Surveys in 1997, 2000, 2002 and 2004

Notes: Robust standard errors in parentheses;*significant at 10%;**significant at 5%;***significant at 1%

3.7.5 Impacts of working-age adult mortality on household income

Table 3-20 presents the results on the impacts of working-age adult mortality on total, crop, livestock and off-farm income. Adult deaths lead to a decrease in livestock and off-farm income.

Other factors influence the level of household income. Male-headed households and those with more educated heads have higher incomes. The age of the head has a non-linear effect on total and livestock income only. Also, the distance to fertilizer store is negatively related to off-farm income, suggesting that it is harder to find off-farm income opportunities farther away from towns and trading centers.

The results in Table 3-21 show how death effects on income vary from two years before death up to seven years after death. Significant reductions in livestock and off-farm income begin in one year before death. This may be due to the loss of productive labor time for the sick, potential reduction in hours worked off-farm by the care givers, and sale of livestock assets.

There is a significant drop in livestock and off-farm income in the year of death, reflecting the additional burden of lost income experienced by households as the sick adult dies. In the period one to three years after death, there is no significant change in income. However, four years after death, we find a significant increase in livestock and off-farm income. Also, five to seven years after death, off-farm income increases. This recovery in livestock income may be due the ability of households to restock their small animals after death (Table 3-18). The post-death increase in off-farm income may be consistent with a situation where afflicted households experience a large financial loss as

Table 3-20 The impact of working-age adult mortality on income for the period 1997-2004 (OLS with AEZ dummies)

	Natural logarithm of income:			
Explanatory variables	Total	Crop	Livestock	Off-farm
	(1)	(2)	(3)	(4)
Ever afflicted	-0.061	-0.047	0.131	-0.237
	(0.084)	(0.137)	(0.208)	(0.260)
Working-age adult death	-0.011	-0.034	-0.657*	-0.274**
	(0.116)	(0.204)	(0.394)	(0.110)
Elderly male death	-0.455	-0.330	0.534	0.613
	(0.305)	(0.327)	(1.344)	(0.670)
Elderly female death	0.191	0.432	-0.716	-2.926
	(0.348)	(0.488)	(1.898)	(2.495)
Gender of head (male=1)	0.387***	0.415***	0.569***	0.508**
	(0.067)	(0.105)	(0.183)	(0.197)
Age of the head	0.030***	0.021	0.097***	0.045
	(0.008)	(0.016)	(0.026)	(0.030)
Age of the head squared	-0.0002***	-0.0001	-0.0007***	-0.0004
	(0.0001)	(0.0002)	(0.0002)	(0.0003)
Education of the head	0.077***	0.058***	0.064***	0.222***
	(0.005)	(0.009)	(0.016)	(0.017)
Distance to tarmac road (km)	0.003	0.006	-0.000	0.002
	(0.003)	(0.005)	(0.007)	(0.007)
Distance to fertilizer store (km)	-0.003	0.002	-0.006	-0.012***
	(0.002)	(0.002)	(0.005)	(0.004)
Year dummy for 2000	0.227***	0.900***	-0.573***	0.992***
	(0.051)	(0.088)	(0.139)	(0.166)
Year dummy for 2004	-0.236***	0.498***	-0.891***	0.554***
	(0.050)	(0.083)	(0.141)	(0.169)
AEZ dummies	Yes	Yes	Yes	Yes
Constant	10.300***	7.098***	2.967***	8.383***
	(0.246)	(0.484)	(0.777)	(0.871)
Observations	4157	4157	4157	4157
R-squared	0.17	0.21	0.09	0.10

Source: Tegemeo Institute (Nairobi)/Michigan State University Agricultural Monitoring and Policy Analysis Household Surveys in 1997, 2000, 2002 and 2004

Notes: Robust standard errors in parentheses; * significant at 10%; ** significant at 5%; *** significant at 1%

Table 3-21 The impact of working-age adult mortality on income for years before and after death in the period 1997-2004 (OLS with AEZ dummies)

	Natural logarithm of income:			
Explanatory variables	Total	Crop	Livestock	Off-farm
	(1)	(2)	(3)	(4)
Ever afflicted	-0.060	-0.047	0.126	-0.240
	(0.084)	(0.137)	(0.208)	(0.260)
Two years before death	-0.165	-0.413	-0.179	-0.105
	(0.217)	(0.447)	(0.132)	(0.135)
One year before death	0.248	-0.472	-0.007*	-0.033**
	(0.265)	(0.570)	(0.004)	(0.016)
Year of death	-0.175	-0.155	-0.088*	-0.213*
	(0.224)	(0.347)	(0.049)	(0.118)
One year since death	-0.138	0.228	-0.026	-0.573
	(0.173)	(0.352)	(0.765)	(0.699)
Two years since death	-0.268	0.581	-0.332	-0.372
	(0.250)	(0.595)	(1.120)	(0.326)
Three years since death	-0.272	0.225	-0.763	0.121
	(0.198)	(0.272)	(0.799)	(0.235)
Four years since death	-0.006	-0.230	0.109**	0.005*
	(0.224)	(0.344)	(0.044)	(0.003)
Five-seven years since death	-0.214	0.034	-0.883	0.095**
	(0.177)	(0.346)	(0.768)	(0.038)
Elderly male death	-0.476*	-0.346	0.404	0.521
	(0.271)	(0.362)	(1.159)	(0.661)
Elderly female death	0.180	0.450	-0.858	-3.053
	(0.325)	(0.509)	(1.462)	(2.417)
Gender of head (male=1)	0.390***	0.415***	0.576***	0.523***
	(0.067)	(0.105)	(0.183)	(0.197)
Age of the head	0.030***	0.022	0.101***	0.047
	(0.008)	(0.017)	(0.026)	(0.030)
Age of the head squared	-0.0002***	-0.0001	-0.0007***	-0.0004
	(0.0001)	(0.0002)	(0.0002)	(0.0003)
Education of the head	0.077***	0.057***	0.065***	0.222***
	(0.005)	(0.009)	(0.016)	(0.017)
Distance to tarmac road (km)	0.003	0.006	0.000	0.003
	(0.003)	(0.005)	(0.007)	(0.007)
Distance to fertilizer store (km)	-0.003	0.002	-0.006	-0.012***
	(0.002)	(0.002)	(0.005)	(0.004)
Year dummy for 2000	0.231***	0.902***	-0.548***	1.003***
	(0.052)	(0.088)	(0.140)	(0.167)
Year dummy for 2004	-0.240***	0.495***	-0.921***	0.543***
	(0.050)	(0.083)	(0.142)	(0.170)
AEZ dummies	Yes	Yes	Yes	Yes
Constant	10.372***	7.018***	2.856***	8.726***
	(0.301)	(0.587)	(0.956)	(1.031)
Observations	4157	4157	4157	4157
R-squared	0.17	0.21	0.10	0.11

Source: Tegemeo Institute (Nairobi)/Michigan State University Agricultural Monitoring and Policy Analysis Household Surveys in 1997, 2000, 2002 and 2004

Notes: Robust standard errors in parentheses; * significant at 10%; ** significant at 5%; *** significant at 1%

a result of medical and funeral expenses, lost income of the deceased member and labor diverted from economically productive activities to care giving. Consequently, some surviving members may participate in off-farm activities in order to restore the lost income streams. Participation in such activities seems a reasonable strategy for afflicted households since it provides an avenue to generate faster returns and income that is required to meet the large and urgent financial needs.

Impacts of working-age adult mortality on income by the deceased's gender and position in household

Results in Table 3-22 show that over time, the impacts of adult mortality don't generally vary by gender and position of the deceased individual. However, compared to other deaths, households that experience a male head death show smaller recovery in livestock income four years after death. In the year of death, the decline in off-farm income is smaller for households with a male head death, suggesting that non-head adult members may be the major sources of off-farm income. Also, five-seven years after death, households that experience death other than that of the male head have better recovery in off-farm income. Therefore, surviving members of afflicted households turn to off-farm activities as a means to replace lost income streams due to morbidity and mortality of working-age adults. As time passes, more non-head members of the family become economically active and engage in off-farm activities.

Table 3-22 The impact of working-age adult mortality on income by gender and position of the deceased for years before and after death in the period 1997-2004 (OLS with AEZ dummies)

	Natural logarithm of income:			
Explanatory variables	Total	Crop	Livestock	Off-farm
	(1)	(2)	(3)	(4)
Ever afflicted	-0.062	-0.071	0.177	-0.201
	(0.071)	(0.122)	(0.216)	(0.249)
Two years before death	0.099	-0.423	-0.057	-0.107
	(0.334)	(0.574)	(0.039)	(0.297)
One year before death	0.377	-0.430	-0.010	-0.085
	(0.444)	(0.763)	(0.007)	(0.927)
Two years before death*male head dummy	-0.178	0.041	-0.246	-0.379
	(0.765)	(1.313)	(2.333)	(2.688)
One year before death*male head dummy	-1.197	-0.311	-0.071	-0.060
	(1.018)	(1.748)	(0.596)	(0.108)
Year of death	0.424	0.126	-0.125	-0.165*
	(0.342)	(0.587)	(0.081)	(0.086)
One year since death	-0.062	0.007	-0.097	0.032
	(0.274)	(0.471)	(0.836)	(0.963)
Two years since death	-0.246	0.295	-0.166	-0.123
	(0.377)	(0.646)	(1.148)	(0.203)
Three years since death	-0.097	0.040	0.135	-0.188
	(0.394)	(0.676)	(0.169)	(0.237)
Four years since death	0.104	-0.287	0.105**	-0.340
	(0.326)	(0.560)	(0.046)	(1.147)
Five-seven years since death	-0.196	0.343	0.061	0.097*
	(0.272)	(0.467)	(0.093)	(0.055)
Year of death*male head dummy	-0.401	0.011	-0.187	0.015*
	(0.530)	(0.911)	(0.117)	(0.009)
One year since death*male head dummy	0.273	0.593	-0.036	-1.612
	(0.650)	(1.115)	(1.982)	(2.283)
Two years since death*male head dummy	0.809	0.962	0.958	0.381
	(0.854)	(1.466)	(2.605)	(0.767)
Three years since death*male head dummy	-0.443	0.577	-3.520	0.134
	(0.723)	(1.242)	(2.206)	(2.542)
Four years since death*male head dummy	-0.325	-0.082	-0.007*	-0.507
	(0.611)	(1.049)	(0.004)	(2.147)
Five-seven years since death*male head dummy	0.163	-1.013	0.103	-0.043*
	(0.616)	(1.057)	(0.093)	(0.024)
Elderly male death	-0.517	-0.314	0.753	0.318
	(0.418)	(0.718)	(1.275)	(1.469)
Elderly female death	0.100	0.457	-0.645	-0.023
	(0.504)	(0.865)	(1.538)	(0.061)
Gender of head (male=1)	0.382***	0.406***	0.539***	0.489**
	(0.056)	(0.096)	(0.171)	(0.197)
Age of the head	0.031***	0.021	0.099***	0.045
	(0.008)	(0.014)	(0.025)	(0.029)
Age of the head squared	-0.0002***	-0.0001	-0.0007***	-0.0004
	(0.0001)	(0.0001)	(0.0002)	(0.0003)
Education of the head	0.077***	0.058***	0.062***	0.224***
	(0.005)	(0.009)	(0.016)	(0.018)

Table 3-22 continued

Explanatory variables	Natural logarithm of income: Total	Crop	Livestock	Off-farm
	(1)	(2)	(3)	(4)
Distance to tarmac road (km)	0.004*	0.006	0.000	0.005
	(0.002)	(0.004)	(0.007)	(0.008)
Distance to fertilizer store (km)	-0.003***	0.002	-0.006	-0.013***
	(0.001)	(0.002)	(0.004)	(0.005)
Year dummy for 2000	0.225***	0.914***	-0.561***	0.978***
	(0.046)	(0.079)	(0.139)	(0.161)
Year dummy for 2004	-0.257***	0.497***	-0.945***	0.498***
	(0.047)	(0.080)	(0.143)	(0.165)
AEZ dummies	Yes	Yes	Yes	Yes
Constant	10.258***	7.105***	2.946***	8.354***
	(0.251)	(0.431)	(0.766)	(0.883)
Observations	4157	4157	4157	4157
R-squared	0.18	0.21	0.10	0.11

Source: Tegemeo Institute (Nairobi)/Michigan State University Agricultural Monitoring and Policy Analysis Household Surveys in 1997, 2000, 2002 and 2004

Notes: Robust standard errors in parentheses; * significant at 10%; ** significant at 5%; *** significant at 1%

3.8 Conclusion and policy recommendations

3.8.1 Summary of main findings

This study has examined the dynamics of the impacts of working-age adult morbidity and mortality on household composition, total cultivated area, area cultivated by crop types, value of crop production, assets and income for a period of time extending from two years before death and up to seven years after death. In addition, it has examined whether the temporal pattern of the mortality effects differs by the gender and position of the deceased individual. The main contribution of this work is that it reveals more information about the dynamics of household responses and the longer-run impacts of mortality on household outcomes than any prior quantitative study based on household survey data. Moreover, it provides much greater detail than past studies about how impacts of mortality depend on the gender and position of the deceased over time. Lastly, the study is based on a nationally representative panel dataset and hence provides an understanding of the dynamic effects of adult mortality from an area of diverse rates of HIV/AIDS. Therefore, it complements earlier instructive studies from particular areas known to suffer from high rates of HIV/AIDS.

The essay highlights six key findings that will better inform intervention policies and strategies. First, working-age adult death affects various household outcomes. For instance, it is associated with changes in household structure, reduction in value of small animals and farm equipment, as well as a decline in livestock and off-farm income.

When we take into account the dynamics of prime-age death, the second finding is that small negative impacts of working-age adult mortality begin to emerge in the period preceding death, presumably due to pre-death morbidity. Third, significant negative impacts are observed in the year of death. Fourth, mortality impacts are not just a one-time post-death adjustment but rather they persist over time. The fifth conclusion is that in most cases, negative effects are larger in the period closest to the death event, suggesting that households are somewhat able to recover over time. However, we note that afflicted households are less able to recover from the impacts of death on area under high-value crops.

Sixth, impacts of adult mortality differ by the gender and position of the deceased adult. Overall, changes in household composition depend to a limited extent on the gender and position of the deceased member. When a male head dies, boys and young children are more likely to be fostered out owing to the loss of the main bread winner.

Households afflicted by male head deaths as opposed to other adult deaths, face a large reduction in total cultivated land and area devoted to cereals and high-value crops. Three years after death, households afflicted by the death of male heads have greater value of crop output per acre, compared to households that experienced other adult deaths. However, in the period five-seven years since death, the opposite effect is observed.

One coping strategy adopted by households facing illness and subsequent death is the sale of small animals. Households with a male head death compared to any other death face a reduction in the value of small animals one year before death, and have a smaller recovery in small animals two years after death.

In terms of income, households that experience a male head death show smaller recovery in livestock income four years after death, smaller decline in off-farm income in the year of death, and smaller recovery in off-farm income five-seven years after death. It appears that surviving members of afflicted households turn to off-farm activities as a means to replace lost income streams due to morbidity and mortality of working-age adults.

3.8.2 Implications for mitigation and poverty reduction programs

Findings from this study have a number of implications for the appropriateness of existing programs and interventions meant to mitigate the effects of adult mortality as well as the design of future interventions. First, for the mitigation efforts to succeed there is need to recognize that illness preceding death and timing of death matter. In particular, since mortality impacts are not just a one-time post-death adjustment, blanket recommendations for interventions should not be made for all afflicted households. Instead, interventions should be made while taking into account the time that has elapsed since death. In most cases, the impact of death is largest in the period closest to death, which suggests that policy interventions should be made in the short-term when the impact is greatest. Although most households will generally recover after some years, early interventions as well as interventions on a descending scale in the short to medium-term will help afflicted households recover faster and with more ease.

Secondly, given that illness before death has negative impacts on household outcomes, there may be gains from policies that reduce the burden of taking care of the sick at home and the cost of treatment. The provision of universal health care and life insurance, free medical care for AIDS-patients and improved community health care systems, may help afflicted households deal with the burden of illness without selling their small animals or compromising their agricultural incomes.

Third, the finding that the decline in cultivated area in total and by crop types is greater for households that experience a male head death compared to all other deaths raises concern for the welfare of widows, particularly with respect to their food security position. Therefore, policy makers need to take into account that gender and position of the deceased matters, a recognition that may lead to the provision of targeted interventions for the more vulnerable widow-headed households. For example, direct food aid as well as targeted inputs can be given to widow-headed households to minimize effects on food security. Also, fostering women farmers' participation in programs such as extension activities and farmer field schools could reduce the impact of death on agricultural output and income for the widows' households. In addition, this finding raises the issue of potential gender inequalities that exist in terms of access to and control over land and other productive resources. Although it is generally observed that women devote more labor time to agriculture than men, households experiencing the death of a male household head face a large reduction in total cultivated land and area devoted to cereals and high-value crops. Therefore, efforts to mitigate the impacts of adult mortality and improve household livelihoods should take into account such gender inequalities. Also, there is need to encourage cultural changes that empower widows to retain access to land and assets after the death of their husbands. Introduction of such changes may be an important component of poverty alleviation strategies. However, because this may upset the traditional norms of property inheritance, it will arguably require careful and sustained campaigns to garner support from the local communities.

The fourth implication relates to the lack of evidence of a shift toward labor-saving crops but a modest tendency to shift away from capital-intensive high-value crops. This suggests that cash constraints may be more important than labor constraints for most afflicted households. Easy access to affordable credit will enable afflicted households to maintain cultivated area under high-value crops. Therefore, rather than overly prioritizing labor-saving crop and input technologies, there may be great gains arising from the removal of policies and distortions that bring about great disparity in access to farm credit. For instance, support by government, donor agencies and the private sector for input provision schemes and inter-linked credit arrangements may be more effective in helping afflicted households cope with death faster and in more robust ways that do not threaten their future livelihood. Providing afflicted households with short-term subsidized input credit for fertilizers, seed, and cash for hiring labor will enable them to maintain cultivated area under high-value crops in the short-term. Further research that addresses this issue will provide useful information on how access to credit under appropriate institutional structures and arrangements can be helpful in the recovery process by creating opportunities for financing farm operations.

Fifth, the finding that in- and out-migration of individuals is a potential coping strategy suggests that more community resources can be mobilized to care for afflicted households and help them develop other effective coping mechanisms. For instance, more linkages across households can be developed in terms of labor-support groups, cash or in-kind remittances as coping mechanisms. However, it has been argued that increasing deaths and illness due to HIV/AIDS may lead to a breakdown of social capital and local institutions, particularly in hard-hit communities. Therefore, there is need for government and donor agencies support to make such community initiatives sustainable.

Sixth, a decline in area cultivated and off-farm income may imply a reduction in household food supply and the share of food expenditures. If higher food shares translate into better nutrition and health status, the lack of adequate nutrition will comprise members' immunity and labor quantity and/or quality. This may increase the chances of more disease-related mortality and reduce agricultural productivity. Therefore, HIV/AIDS mitigation programs must include improvements in food security. Food aid and community based mutual help groups can provide income and boost nutrition. While this may provide relief temporarily, there is need to integrate HIV/AIDS prevention and mitigation into agricultural extension systems, development projects/programs and microfinance. For instance, increased agricultural productivity will lower the cost of food and contribute to improved food security and better health.

Seventh, we find that afflicted households suffer a loss of off-farm income one year before death and during the year of death. This is probably due to the loss of

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