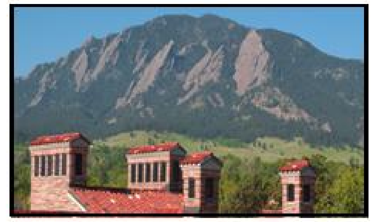
IBS

POPULATION PROGRAM
INSTITUTE OF BEHAVIORAL SCIENCE
UNIVERSITY OF COLORADO AT BOULDER



*WORKING PAPER*

# Adult mortality, food security and the use of wild natural resources in a rural district of South Africa: Is AIDS a unique shock?

Wayne Twine
Lori M. Hunter

December 2009

Population Program POP2009-16

Adult mortality, food security and the use of wild natural resources in a rural district of South Africa: Is AIDS a unique shock?

Wayne Twine

School of Animal, Plant and Environmental Sciences, University of the Witwatersrand, c/o Wits Rural Facility, Private bag X420, Acornhoek, 1360, South Africa,

rcrd@global.co.za

Lori M. Hunter

Institute of Behavioral Science, CU Population Center, University of Colorado at Boulder, USA

[a]Introduction

The environmental dimensions of the HIV pandemic remain little explored, despite the centrality of the natural environment in the livelihoods of the rural poor across Africa (Hunter et al. 2008). Nowhere is the empirical investigation of these linkages more important than in southern Africa, which has the highest rates of HIV infection in the world (UNAIDS 2008). In South Africa (the setting of this chapter) one in six prime-age adults (15-49 years) is HIV positive (Shisana et al. 2009). The region is also plagued by chronic food insecurity in which the livelihood impacts of HIV may be an exacerbating factor (de Waal & Whiteside 2003; Misselhorn 2005). At the same time, natural resource harvesting makes an important contribution to rural livelihoods in the region (Shackleton et al. 2001). In this context, the extent to which natural resource harvesting might mitigate the impacts of HIV on household food security is a topic worthy of serious scholarly attention, and is the focus of this chapter.

Rural communities across southern Africa make extensive use of wild natural resources such as fuelwood, edible wild vegetables, wild fruit, edible insects, bushmeat, and medicinal plants (Clarke et al. 1996; Shackleton et al. 2002; Letsela et al. 2002; Twine et al. 2003). The levels of use are often substantial; rural South African households consume a mean of 5.3 tonnes of fuelwood, 104 kg of edible wild fruit and 58 kg of wild vegetables per year (Shackleton & Shackleton 2004). In the face of difficult economic conditions, these natural resources offer inexpensive alternatives to otherwise purchased goods. The combined direct-use value of these resources averages roughly US$520 per household per year in South Africa (Shackleton & Shackleton 2004) and is comparable to that of crop and livestock production

(Dovie et al. 2002). This constitutes a savings if these resources are harvested without financial cost.

Households also sell a range of raw and processed natural products to earn income (Brigham et al. 1996). Although variable, these incomes are generally modest (Shackleton et al. 2008). Dovie et al. (2002) calculated that households in a rural village in South Africa earned a mean total of US$127 per year from natural resources trade.

Taken together, these varied uses of natural resources constitute a 'rural safety net', buffering households against hardship and crisis (Shackleton & Shackleton 2001; Shackleton & Shackleton 2004; Paumgarten 2006). This is especially important in the current era of rising mortality rates among prime-age adults in South Africa due to AIDS (Kahn et al. 2007) . A nascent body of research in South Africa is beginning to shed light on how resource use might buffer HIV-impacted households against food insecurity. Kaschula (2008) showed that the use of wild foods may render households more economically resilient, but that households associated with HIV proxies often make less use of such resources, possibly due to labor shortages or stigma. Focusing on children, McGarry & Shackleton (2009) found the highest use of wild foods among children from households characterized as HIV-afflicted, especially among those not attending school. Selling wild foods was also a more common activity among such children. The use of these wild foods improved the children's dietary diversity and protein intake. It is unknown what influence cash savings from resource use might have in shaping food security after an AIDS death, but early evidence from our own ongoing work suggests that households impacted by a prime-age adult death may collect natural resources to supplement previously purchased goods, including food (Hunter et al. 2007).

While these studies suggest important linkages between HIV, natural resource use and food security, they relied on proxy measures, such as presence of orphans or chronic illness or death of a prime age adult, rather than data on cause of death to identify HIV-mortality impacted households. The study presented in this chapter thus makes an important contribution to advancing knowledge on this topic, since it used mortality data from a rural South African health and demographic surveillance system to identify households which had experienced the recent death of a prime-age adult due to HIV-related causes. This study examined food security among HIV-impacted households, compared to non-HIV-impacted households, with a particular focus on the role of natural wild resources (e.g. wild foods) in shaping household resilience following the death of a prime-age adult.

[a] Study Setting, Data and Research Methods

[b]Study site

The study was conducted in the Agincourt Health and Demographic Surveillance Site in Bushbuckridge rural municipality, Mpumalanga Province, South Africa. Named after one of the local villages, the Agincourt site consists of 24 villages, comprising over 14 000 households and 84 000 people. Village size ranges from 480 to 6 834 in population. Approximately a quarter of the residents are former Mozambican refugees, most of whom fled to South Africa during the civil war in Mozambique in the 1980's.

The area is typical of rural communities across South Africa, being characterized by poverty and high human densities. Few households are able to support themselves on agriculture alone, primarily due to the shortage of land and declining interest in agriculture as a result of the previous government's forced relocation and separate development policies for black South Africans (Hargreaves & Pronyk 2003). Due to poor local employment opportunities, a large proportion of adults are migrant labourers, working on commercial farms and in towns and cities across the country.

HIV prevalence in the region, estimated from antenatal surveillance data, was 19% in 1998 (DOH 1998), while AIDS and TB (often associated with HIV) are the leading causes of death for adults between the ages 15-49 in the study site (Kahn et al. 1999). Furthermore, mortality among young adults increased fivefold in the study site over the decade between 1992-1993 and 2002-2003, attributed largely to the emerging HIV pandemic (Kahn et al. 2007).

In terms of environmental conditions, the area is characterized by poor soils and highly variable rainfall. The underlying geology is primarily coarse granite and gneiss, giving rise to leached, sandy soils. The region is semi-arid, with a mean annual rainfall of 650 mm. The natural vegetation is predominantly broad-leaf savanna woodland.

[b]Data sources

Three data sources were used for this study:

1) *Agincourt Health and Demographic Surveillance System (AHDSS)*: Data on the demographic characteristics of Agincourt households and individuals was provided through the longitudinal health and demographic surveillance system of the University of the Witwatersrand/Medical Research Council's Rural Public Health and Health Transitions

Research Unit (abbreviated hereafter as the Agincourt Unit). Since 1992, the Agincourt Unit has collected census data at 12-18 month intervals from all households in the AHDSS site. The resulting data are incredibly rich in socio-demographic detail, allowing identification of key household characteristics (e.g. size, male/female headship, age composition, socio-economic status). The AHDSS also provided data on individual mortality, which was crucial for our study design which required the differentiation between households with different types of adult mortality experience.

2) *Quantitative Survey*: We surveyed 290 households with differing experience of an adult mortality, collecting data on food security and use of wild natural resources (refer to household survey and sampling design below).

3) *Remote Sensing:* The state of the local natural environment, in terms of woodland cover, was assessed for the study villages using satellite imagery. Additional detail is provided below.

[c]Household mortality experience

Mortality experience is the primary analytical variable in the study, and the Agincourt Unit's demographic surveillance data were used to identify households that had experienced the death of an adult member during the past two years. Cause of death was obtained from the AHDSS. This is ascertained by the Agincourt Unit through 'verbal autopsies' undertaken for each mortality experience within the study site after each annual census (Kahn et al. 2000; Kahn et al. 2007). Within a verbal autopsy, a trained lay fieldworker interviews the closest available caregiver of the deceased in the vernacular, using a structured questionnaire. The interview transcript is then assessed independently by two medical doctors to assign a probable cause of death. If these doctors' perceptions correspond, the diagnosis is accepted.

If they differ, the two doctors discuss the case to try to reach consensus. If no agreement is reached, the interview transcript is sent to a third doctor who has not seen the prior diagnoses. If there is agreement between the third assessment and one of the other two, this is accepted as the most probable cause of death. If consensus can still not be reached between at least two doctors, cause of death is logged as “ill-defined”. This approach to verbal autopsy was validated locally using hospital records in the 1990’s (Kahn et al. 2000), and has recently been re-validated specifically for HIV/AIDS assessment (Kahn et al. 2007). The data from the verbal autopsies thus allowed classification of HIV-related deaths (which are not reflected on death certificates) and other mortality experiences.

The study focused on mortality of prime-age adults (15-49), as this age range represents the period of largest economic contribution to the household, as well as being the ages of those most susceptible to HIV infection. Deaths occurring in this age group over the two years prior to the survey were classified as either HIV-related (abbreviated hereafter as ‘HIV death’) and non-HIV-related (abbreviated hereafter as ‘non-HIV death’). Non-HIV deaths were further classified as ‘sudden’ (e.g. heart attack, motor vehicle accident) or ‘slow’ (e.g. cancer). We used these mortality classifications to sample households from three mortality strata: 1) HIV mortality: experienced a prime-age adult death due to HIV-related causes in the two years prior to the survey, 2) non-HIV mortality: experienced a sudden prime-age adult death, where cause of death was not related to HIV, in the two years prior to the survey, and 3) no mortality: experienced no death of a prime-age adult in the two years prior to the survey. Non-HIV mortality households were included in the survey since we were unable to directly address the question of HIV morbidity, due to the cross-sectional nature of the study. More specifically, by comparing households with HIV and sudden non-HIV deaths, we aimed to indirectly capture some of the unique impacts of HIV mortality, which often includes a preceding long period of illness.

[c]Household survey

The survey instrument was developed based upon central literature in the relevant fields, as well as the investigators' previous experience in the Agincourt field site. The instrument focused on 1) food security, 2) livelihood strategies, and 3) use of natural resources, especially in relation to meeting household food requirements.

The survey's three topical sections were:

1) <u>Household food security</u> was assessed using accepted proxy indicators and methodologies appropriate for the local context (see Hoddinott (1999) and Hendriks (2005)). Our choice of methods, based on trade-offs between time, cost, accuracy and the expertise required, was as follows: i) *Dietary Diversity Index* for 99 food items, including commonly used species of wild foods, recording whether the item was eaten by household members at least once in the last week, month, year, or not at all (see Hoddinott & Yohannes (2002); Swindale & Bilinsky (2005)), ii) *Household Experience of Hunger and Access to Food*, such as number of times in the last 30 days in which the household worried about, or ran out of, food (see Household Food Insecurity Scale (FANTA 2004) or the Food Access Survey Tool (Coates et al. 2003)), and iii) *Coping Strategies* based on frequency of short-term responses to food shortage, such as skipping meals or asking neighbors for food (see Maxwell (1996) and Maxwell et al. (1999)). All of the above methods were adapted for local conditions through insight gained from three focus groups with local women. The focus group participants assisted in the development of lists of foods eaten locally, as well as coping strategies used when facing food

shortages.

2) Adaptive livelihood strategies, which are longer term livelihood strategies in contrast to short-term 'coping' strategies, were assessed in the context of food security for all households. This survey section dealt with household livelihood strategies which relate directly to household food provisioning, including agricultural production, purchasing food, and gathering wild foods. Indirect provisioning, such as when resources are used as sources of household income, were also quantified. The role of social capital in livelihoods and coping strategies was assessed in terms of reliance on social networks, such as borrowing food from neighbours, friends or family. Participation in social groups such as women's groups, churches or burial societies was also recorded in the survey's livelihoods section.

3) Household use of wild natural resources for a) direct provisioning of food, b) selling to earn money, and c) saving money through not having to buy commercial alternatives, was recorded. There was a certain degree of overlap between the food security, adaptive livelihood strategies and woodland resource use sections, and this was purposeful to ensure thorough coverage and allow triangulation of the collected data.

The cross-sectional nature of the survey posed a major analytical challenge. For this reason, we asked all households about recent changes in their food security, livelihoods and resource use. For those sampled households which had experienced an adult mortality in the last two years, we also asked carefully phrased questions about changes in food security, livelihood strategies, and use of woodland resources specifically as a result of the passing of the household member.

The survey was conducted by experienced local fieldworkers from the Agincourt Unit. The respondents were typically the female household member primarily responsible for food acquisition and preparation, as well as acquisition of woodland resources. The survey was conducted in May and June 2006, using the dominant local language of the field site (Shangaan).

[c]Woodland cover

The Normalised Difference Vegetation Index (NDVI) was used as an index of woodland cover around villages. Data from Landsat 5 TM images (May 2004) allowed calculation of NDVI in ERDAS Imagine. Such indices are commonly used as indicators of environmental change's impact on vegetation greenness (Wang et al. 2003; Zhou et al. 2003). Chlorophyll absorbs red light and the mesophyll tissues in plants scatter near infrared light -- the NDVI is the difference between the values in the red and near-infrared bands divided by the sum of these same values (Tucker 1979). This ratio varies from -1 to 1, and negative values indicate senescent or dead vegetation. Positive values reflect actively growing green vegetation. NDVI values saturate at high biomass (Huete et al 2002), but preliminary field work shows that Agincourt, which falls in a semi-arid savanna region, does not contain areas with high enough biomass to approach this saturation point. This provides evidence that the NDVI can effectively proxy for vegetation cover in the region. Tree biomass (e.g. fuel wood) and productivity (e.g. seed production, stem growth) are also positively correlated with NDVI (Foody et al. 2001; Mutanga and Skidmore 2004). As such, the availability of natural resources used directly by Agincourt residents (i.e. wild foods, fuel wood) can be effectively mapped with this greenness proxy. For this study, the NDVI was averaged across all 30m x 30m pixels in 1 km buffers around each village, giving a mean village NDVI value per village.

[c]Sampling design

The household survey included 290 households. A stratified random sample of households was drawn from the AHDSS database across the three mortality strata as follows: 1) HIV mortality: n=109, 2) non-HIV mortality: n=71 and 3) no mortality: n=110. The third category constituted a control stratum. This sampling frame enabled quantification and comparison of food security and resource use across the three strata. The original intent of interviewing 100 households per category, determined by available project resources, was adjusted since insufficient households met the criteria for the 'non-HIV mortality'. Still, the constraints within this category allowed for increased sampling of the other strata. Selected households were located in the field using their unique identifier number on digital aerial photographs used by the Agincourt Unit in their annual census. This is one example of the benefit of linking with a surveillance site. Indeed, within this project, embedding the work within the AHDSS enabled us to a) draw a random stratified sample from a known population, b) incorporate actual cause of death, rather than HIV proxies, and c) include other household data, such as size and socio-economic status, within the analyses.

As noted, the Agincourt Unit's database provided background on each sampled household's socio-economic status (SES). SES was reflected through a wealth ranking based on household ownership of assets (e.g. appliances) and access to services and amenities (e.g. a water tap in the yard). Household SES score was derived from principal component analysis of the wealth ranking and is a relative value. These scores were then used to classify households into SES quintiles.

[c]Data analysis

Dietary diversity, experience of hunger, coping strategies and resource use variables were expressed as both ordinal and binary outcomes. As an example, inclusion of a food item (e.g. beef) in the household diet was expressed as 1) an ordinal scale of frequency (at least once in the last week, month, year, or not at all) and 2) as a binary yes/no response for each of these frequency categories individually.

Several steps were taken to calculate a dietary diversity score, reflecting both diversity and frequency of particular foods. First, frequency per food item was converted to a weekly fraction as follows:

1) At least once in the last 7 days (1 week ): 1/1 = 1

2) At least once in the last 30 days (30 days/7 days = 4.29 weeks): 1/4.29 = 0.23

3) At least once in the last 12 months (365 days/7 days = 52.14 weeks): 1/52.14 = 0.02

4) More than 12 months ago/never: = 0

These values were then summed for all 99 food items to give an absolute dietary diversity score out of 99, which then incorporated both the range of food items eaten and the frequency of consumption. This additive value was then converted to a proportional dietary diversity score by dividing the absolute value by the maximum possible (99).

Bivariate associations were explored between household food security, adult mortality experience, proximate woodland cover, household use of woodland resources for consumption or sale, and socio-economic status, as well as other relevant household characteristics (e.g., household size). Statistical tests included Chi-squared test, logistic regression and one-way analysis of variance (ANOVA) with Tukey post hoc test. Multivariate models, such as multifactorial ANOVA, analysis of co-variance (ANCOVA) with Tukey post hoc test, multiple regression analysis and multivariate logistic regression analysis, were then estimated to predict food security as a function of adult mortality experience, household characteristics, resources use, and environmental context simultaneously. In these models, only the more commonly used wild foods were considered.

[a]Results

Presentation of results is structured as follows: First, descriptive characteristics of the study households within the three mortality strata are provided. We then examine associations between household mortality experience and use of natural resources. Then, focusing specifically on HIV-impacted households, the simultaneous influences of household characteristics, use of key natural resources, and woodland cover, on food security are analyzed. Finally, we investigate how adult mortality, household characteristics, use of natural resources and woodland cover intersect to shape food security. Explanations and implications of observed relationships are explored in the final discussion.

[b]Household characteristics

Mean household size did not differ significantly between the three mortality strata, averaging roughly five permanent members. Households with a non-HIV adult death were significantly wealthier, on average, than either HIV-impacted households or ‘no death’ households. This was true both before the focal adult death (2003) and after (2005). SES score remained static for HIV-impacted households over this period . Most households impacted by a non-HIV death were in the two highest SES quintiles. HIV-impacted households were more evenly distributed across wealth classes, with the poorest class over-represented relative to the 'no death' group (Figure 1). By contrast, the majority of households with no mortality had low or intermediate SES, although few were in the poorest category. The odds of a household experiencing an HIV adult death decreased among those with greater SES (Odds ratio (OR) = 0.81, $p<0.05$), while the converse was true for households with a non-HIV adult death (OR=1.43, $p<0.01$). Household members participated in, or were members of, an average total of roughly three social groups, clubs or organizations, and there was no significant difference in this organizational dimension across the three strata. Membership in social groups was greater among larger households ($r=0.20$, $R^2=0.04$, $p<0.001$) and those with higher SES ($r=0.33$, $R^2=0.11$, $p<0.001$).

Neither time since the death, nor the total number of deaths over the last two years differed between the two mortality strata. However, the role that the deceased had played in providing food for the household differed slightly between the two categories of households. While the deceased had commonly contributed income, tended fields and/or collected wild natural resources in both categories, fewer had contributed income or tended fields among HIV-impacted households, while fewer had collected wild foods among households where the cause of death had not been HIV-related (Table 1)

**Figure 1**. *Frequency profile of household socio-economic status classes (1 = poorest, 5 = wealthiest) in 2005, differentiated by mortality experience.*

Table 1. The role that the deceased had played in the household economy, with relevance to food security, expressed as percent (%) of households in which the deceased had played the

given role.

| Role of deceased | HIV Death | Non-HIV Death |
|---|---|---|
| Contributed income | 59.6 | 70.8 |
| Tended food gardens and/or fields | 59.6 | 64.6 |
| Collected natural resources | 51.9 | 46.2 |

[b]Associations between adult mortality and household use of woodland resources

[c]Use of wild natural resources as a source of food, cooking energy and medicine

Indigenous wild vegetables, fruit and insects were part of the diet of the vast majority of households, with no statistically significant differences in prevalence of use between mortality strata (Figure 2). Wild birds, fish and mammals were much less commonly used across all three strata. Although fuelwood was the dominant energy source for cooking across all three mortality strata, a higher percentage of HIV-impacted households (93%) used fuelwood than households having experienced a non-HIV mortality (85%) or no mortality (83%). Interestingly, there was no significant difference in relative frequency of households using traditional medicine across the three strata.

Most households used wild vegetables and wild fruit more than once a week (when in season), but relatively fewer HIV-impacted households (74%) made frequent use of wild vegetables than households with a non-HIV death (85%) or no death (89%) (Figure 3). A 'no death' household was thus significantly more likely to make frequent use of wild vegetables than an HIV-impacted household (OR=2.82, $p<0.05$). This remained true even when controlling for SES (which decreased the odds of a household using wild vegetables often) and household size (which increased the odds). Neither the time since adult death nor the total number of household deaths experienced was associated with the likelihood of a mortality-impacted household using wild foods.

Despite being less likely to make frequent use of wild vegetables, both types of mortality-impacted households were more likely than 'no death' households to have increased their use of wild vegetables in the last twelve months (HIV death to no death: OR = 0.11, $p<0.005$; non-HIV death to no death: OR = 0.13, $p<0.005$). These patterns persisted when controlling for SES and household size. Approximately 30% of households in both mortality strata indicated they relied more on wild vegetables after the passing of their adult member than before. Of the eleven households which indicated they had started eating foods in the last twelve months which they had not eaten previously, all were households which had experienced a recent adult death (HIV=6, non-HIV=5), and all had started eating wild vegetables. Woodland cover, indexed by mean normalised difference vegetation index (NDVI) in a 1 km buffer around each village, exhibited no association with whether households used any given natural resource.

**Figure 2.** *Prevalence of the use of wild foods, fuelwood and traditional medicine across mortality strata.*

**Figure 3.** *Prevalence across mortality strata of the use of wild foods more than once a week.*

[c]Use of wild natural resources to earn and save money

Few households (14) sold natural resources, but of those that did, 86% (12) were mortality-impacted households, most of which (7) had experienced a non-HIV death. Natural resource-based products sold included reed mats, marula beer, and fuelwood. Because of the low incidence, none of the logistic regression models were significant, but the pattern is certainly of interest and worth additional exploration.

For a total of 13 wild natural resources, significantly more mortality-impacted households indicated they used the resource specifically to save money as compared to those with no adult death (Figure 4). At least one of the resources was used to save money by 32% and 38% of HIV and non-HIV-impacted households respectively, compared to only 6% of 'no death' households. The resources most widely used for cost savings were grass hand brooms, fuelwood and wild vegetables. For all resources except traditional medicine and marula beer, slightly more 'non-HIV death' households than HIV-impacted households used the resource for cash savings. These associations still held when controlling for woodland cover (mean NDVI), and the likelihood of any household using at least one of these resources to save money was greater among those with more woodland cover.

Households were more likely to use at least one type of resource to save money if they had a higher SES (OR=1.28, $p<0.05$) or had more permanent members (OR=1.10, $p<0.05$). When controlling for these two factors, mortality-impacted households were still more likely than 'no death' households to use at least one type of resource to save money (HIV death to no death: OR=0.12, $p<0.001$; non-HIV to no death: OR=0.11, $p<0.05$). Households in which more time had passed since the adult mortality were more likely to use wild fruit, insects, carvings and reed mats to save money.

**Figure 4.** *Prevalence of the use of wild natural resources specifically to save money (only those resources for which there was significant variation between mortality strata).*

[b]The environmental contribution to food security among HIV-impacted households

In order to assess if otherwise-similar HIV-impacted households were more food secure if they made use of natural resources and live in villages with better woodland cover, we analyzed food security among HIV-impacted households in relation to use of wild vegetables, wild fruit, and insects, use of natural resources to save money, sale of natural resources, and mean village NDVI, controlling for SES and household size. With regard to dietary diversity, higher weekly, monthly and proportional dietary diversity scores were associated with higher SES, while dietary diversity over 12 months was positively associated with household size (Table 2). All four dietary diversity measures were positively associated with household use of wild fruit and insects, and households using wild vegetables also generally had higher dietary diversity scores for the year. Households using resources to save money had generally eaten a greater number of food items in the last month. Neither woodland cover (mean NDVI) nor using resources to earn money were associated with dietary diversity. None of the models for experience of hunger or coping strategy for HIV-impacted households were significant, except that households with higher SES were less likely to have skipped meals for an entire day in the last week ($OR=0.79$, $p<0.005$).

Table 2. Multivariate regression estimates for the four dietary diversity indices among HIV-impacted households (n=109). Values for independent variables are beta coefficients ($p<0.05$

in bold italics).

| Variable | Foods items eaten in the last week | Foods items eaten in the last month | Foods items eaten in the last year | Proportional dietary diversity score |
|---|---|---|---|---|
| Model | $R^2$=0.24 p<0.001 | $R^2$=0.27 p<0.001 | $R^2$=0.33 p<0.001 | $R^2$=0.26 p<0.001 |
| *Beta coefficients* | | | | |
| SES | ***0.20*** | ***0.21*** | 0.09 | ***0.21*** |
| Household size | 0.17 | 0.14 | ***0.17*** | 0.16 |
| Use wild vegetables | 0.12 | 0.13 | ***0.29*** | 0.13 |
| Use wild fruit | ***0.24*** | ***0.27*** | ***0.31*** | ***0.26*** |
| Use insects | ***0.30*** | ***0.25*** | ***0.36*** | ***0.30*** |
| Use to save money | 0.02 | ***0.24*** | 0.09 | 0.09 |
| Use to earn money | 0.11 | 0.03 | -0.01 | 0.09 |
| Mean NDVI | -0.04 | -0.07 | -0.04 | -0.05 |

[b]The intersection between HIV mortality, poverty, resource use, woodland cover and food security

The final set of analyses reflect the simultaneous associations between food insecurity, death of a prime-age adult due to HIV, poverty, resource use and environmental context, while controlling for household size.  HIV-impacted households had significantly lower mean dietary diversity than 'no death' households, net of the other variables (Table 3).  HIV-impacted household only had lower dietary diversity than non-HIV death households when considering food items eaten over the last year. Poorer households (low SES) had significantly lower dietary diversity than wealthier households for all measures of dietary diversity, and the use of wild fruit and insects was associated with higher dietary diversity. In addition, the number of food items eaten in the last month and year was higher in households which used wild vegetables. Dietary diversity over the last month was also higher in households which used natural resources to save money. Neither woodland cover (mean NDVI) nor using resources for income generation was associated with the household dietary diversity.

Households with no mortality were less likely than HIV-impacted households to have had multiple experiences of hunger (Table 4). Wealthier households were less likely to have worried about food or gone hungry in the last 30 days. Households which used wild vegetables and insects were less likely to run out of food, but slightly more likely to run out if there was good woodland cover around their village. Households which used insects were also less likely to have had all three experiences of hunger. Experience of an adult mortality had no significant effect on household coping strategies in the multivariate models. The only model with any significant independent variables predicted a significant decrease in the likelihood of a household skipping meals for a day with increasing SES (OR=0.63, $p<0.001$).

Table 3. Results of the analysis of covariance (ANCOVA) models for dietary diversity indices across mortality strata. Adjusted means for mortality strata with common superscripts

are not significantly different from each other ($p<0.05$). Values for independent variables are beta coefficients ($p<0.05$ in bold italics).

| Variable | Foods items eaten in the last week | Foods items eaten in the last month | Foods items eaten in the last year | Proportional dietary diversity score |
|---|---|---|---|---|
| *Model* | $R^2=0.25$<br>$p<0.001$ | $R^2=0.26$<br>$p<0.001$ | $R^2=0.24$<br>$p<0.001$ | $R^2=0.26$<br>$p<0.001$ |
| *Adjusted means* | | | | |
| HIV mortality | 22.6[a] | 33.6[a] | 58.6[a] | 0.259[a] |
| Non-HIV mortality | 23.0[ab] | 33.8[a] | 60.2[ab] | 0.262[ab] |
| No mortality | 25.1[b] | 36.9[b] | 61.8[b] | 0.287[b] |
| *Beta coefficients* | | | | |
| SES | ***0.27*** | ***0.27*** | ***0.18*** | ***0.28*** |
| Household size | 0.04 | 0.061 | 0.11 | 0.05 |
| Use wild vegetables | 0.08 | ***0.11*** | ***0.19*** | 0.10 |
| Use wild fruit | ***0.12*** | ***0.17*** | ***0.21*** | ***0.14*** |
| Use insects | ***0.31*** | ***0.26*** | ***0.24*** | ***0.30*** |
| Use to save money | 0.02 | ***0.14*** | 0.01 | 0.05 |
| Use to earn money | 0.02 | 0.02 | -0.01 | 0.02 |
| Mean NDVI | 0.04 | -0.04 | 0.04 | 0.02 |

Table 4. Results of statistically significant multivariate logistic regression models comparing experience of hunger for HIV-impacted households to households with a non-HIV death or no

death. Values are odds ratios: >1 indicates an increase in likelihood, <1 indicates a decrease in likelihood ($p<0.05$ in bold italics).

| Variable | Worried about food | Ran out of food | Went hungry | All three |
|---|---|---|---|---|
| Model | LR chi$^2$=29.09 $p<0.005$ | LR chi$^2$=36.64 $p<0.001$ | LR chi$^2$=19.60 $p<0.05$ | LR chi$^2$=19.60 $p<0.05$ |
| *Odds ratios (HIV=ref)* | | | | |
| Non-HIV death | 1.83 | 2.29 | 1.48 | 1.62 |
| No death | 0.78 | 0.87 | 0.58 | ***0.46*** |
| SES | ***0.80*** | 0.77 | ***0.75*** | 0.80 |
| Household size | 1.02 | 1.00 | 1.01 | 1.02 |
| Use wild vegetables | Dropped | ***0.26*** | 0.92 | 0.78 |
| Use wild fruit | 2.03 | 2.55 | 1.31 | 0.87 |
| Use insects | 0.53 | ***0.33*** | 0.61 | ***0.43*** |
| Use to save money | 1.71 | 1.05 | 1.15 | 0.92 |
| Use to earn money | 3.43 | 2.99 | 1.51 | 1.40 |
| Mean NDVI | 1.04 | ***1.05*** | 1.02 | 1.02 |

[a]Discussion

This project was designed to elucidate the role of the use of wild natural resources, especially wild foods, in food security among HIV-impacted households. By taking poverty, indexed by SES, into consideration, and comparing HIV-impacted households with those impacted by a sudden non-HIV adult death or no death, we aimed to unravel the nuances between adult mortality, poverty, resource-use and food security.

On the whole, the study suggests that mortality-impacted households are generally less food secure than households not directly impacted by an adult death. However, HIV-related mortality does not appear to necessarily represent a unique form of mortality impact. Within our examination, HIV-impacted households and households experience other forms of adult mortality were similarly impacted by food insecurity. Even so, although not unique regarding general food security, adult HIV-related mortality was associated with lower dietary diversity and food sufficiency, even when controlling for socio-economic status (SES). This is in contrast with Kaschula (2008) who also found lower food quantity security scores in AIDS-afflicted households, but no significant impact on short-term dietary diversity. However, Kaschula only considered dietary diversity within the last 48 hours, whereas this study considered longer periods of time (the last week, month and year), which have been more sensitive to differences in dietary diversity.

Our findings point to the general importance of wild foods, especially wild vegetables, fruit and insects, in the local diet . This concurs with findings of other studies such as Twine et al. (2003) and Kaschula (2008) and accounts for the lack of any discernible difference in the prevalence in use of these resources between mortality strata. One exception is the use of wild vegetables, where households which <u>had</u> experienced an HIV death tended to use these foods less frequently. The lessened consumption of wild vegetables is likely due to the deceased's prior role as resource collector. Indeed, reduced resource collection due to a reduction in human capital in households characterized by AIDS proxies was also observed by Kaschula in her South African research (2008). Nevertheless, in the study presented here some mortality-impacted households (regardless of cause of death) became <u>more</u> reliant on wild vegetables after an adult mortality, and in some cases, added wild vegetables as a new item to the household diet. Human resources were less limited in such households and, therefore, collection constraints less likely to be felt.

Central to this study was the question of whether the use of natural resources translated into improved food security for vulnerable households. The consumption of wild foods did, indeed, contribute to dietary diversity. In addition, results suggest that the consumption of wild vegetables and insects mitigated against actually running out of food. As related to mortality, wild foods, especially wild vegetables, played a more important role in the diet of mortality-impacted households than those without such experience. Even so, mortality-impacted households still tended to have less diverse diets than households with no mortality. In this way, the use of these resources did not fully mitigate mortality impacts on food sufficiency. Based on these findings, we conclude that the use of natural resources may be seen as an important component of dietary coping strategies of mortality-impacted households, but not as a fully supportive safety net.

The strong association identified between mortality experience and use of natural resources specifically to save money is also noteworthy and important. Generally, this association points to the broader ‘safety net’ function (beyond food provision) that natural resources play in rural livelihoods particularly in times of crisis (Shackleton & Shackleton 2004). In fact, the use of resources for cost savings was far more prevalent than the use of natural resources for income generation. That said, given the cross-sectional nature of the study, it is not possible to discern the extent to which cost savings through natural resource use actually contributed to economic resilience and/or improved livelihoods more generally.

HIV-mortality impacted households did not appear unique in their use of natural resources for cost savings. However, such a strategy was more prevalent among non-HIV mortality households. In many cases, these households endured the sudden loss of income due to the death of a breadwinner, and the intensified use of natural resources appeared to be a response to worrying about having enough food. In this way, natural resources may provide a short term coping mechanism for sudden household shocks of this form. Even so, the likelihood of using woodland resources to save money was greater as time passed since mortality, thereby also suggesting a longer-term adaptive strategy for many households. The positive relationship between cost savings strategy and local woodland cover may indicate that greater resource abundance enhances the likelihood of levels of use which afford real cost savings.

Interestingly, greater levels of woodland cover was not associated with more use of wild foods or better food security among HIV-impacted households. As noted in the methods section, woodland cover is not a reliable proxy of particular forms of resource abundance, especially for resources such as wild herbs. It also cannot be used as a direct measure of resource availability around the village, as this is also influenced by factors such as institutional regulation of resource use. That being said, households living in local villages with poor vegetation cover have to invest more time in securing some resources, such as wild fruit or firewood (Kirkland et al. 2007; Giannecchini et al. 2007).

While mortality was, indeed, associated with household food insecurity, our work suggests that *poverty* is central in shaping food security. Poor households, regardless of recent adult mortality experience or woodland cover, were similarly vulnerable. This observation is very important, and echoes the findings of other studies such as Peters et al. (2008), that show that much of the observed hardship associated with HIV is essentially due to preexisting levels of poverty. Even so, mortality experience matters. After controlling for socio-economic status, HIV-impacted households tended to be less food secure than non-impacted households.

In contrast to the conventional view that HIV systematically erodes household capital and causes poverty (Masanjala 2007; Whiteside 2002), we found that household socio-economic status (as measured through possessions) had not changed among those impacted by an HIV-related mortality. That is not to say that such households were not worse off financially after the death, but household assets had not noticeably eroded. Of course, it is also possible that two years is not a sufficiently long period to observe mortality impacts on the household asset base.

Finally, this study was cross-sectional in design, which has certain limitations. For example, we were not able to shed much light on the impact of HIV-related illness on household food security prior to the death. Longitudinal studies are thus needed to gain greater understanding of the longer-term dynamics between adult mortality, livelihoods, environment and food security. Even so, embedding this work within a demographic surveillance site has allowed for the addition of substantial nuance to the examination related to cause of death – allowing disaggregation of mortality to better explore the unique nature of AIDS impacts.

The work presented here, combined with prior work on AIDS mortality and food security, begins to add nuance to our understanding of one among many myriad impacts on affected households. The story emerging is one in which adult mortality exacerbates existing vulnerabilities to food insecurity, primarily associated with poverty. The story, too, involves natural resources, and in this way, we aim to contribute to understanding of the environmental dimensions of the AIDS pandemic. Specifically, we find that proximate natural resources act as a 'safety net' allowing for cost savings and, in some cases, creation of resource-based products sold for generation of household income. With a focus on AIDS, however, the mortality shock to the household is not unique – we find that adult mortality negatively impacts household well-being, regardless of its underlying cause. In this way, programs and policies aiming to enhance food security and/or manage local natural resources, would do best to target vulnerable, mortality-impacted households more broadly, as opposed to a singular focus on those impacted by adult mortality resultant of AIDS.

[a]Acknowledgements

This project was funded by the International Food Policy Research Institute (IFPRI), via the Regional Network on HIV/AIDS, Rural Livelihoods, and Food Security (RENEWAL). We would like to thank Stuart Gillespie (IFPRI) and the IPFRI team, as well as Bruce Frayne and Scott Drimmie (RENEWAL) for their support and assistance. The other RENEWAL grantees are to be thanked for their comments and suggestions in the development stage of this project.

We are grateful to the University of the Witwatersrand/Medical Research Council Rural Public Health and Health Transitions Research Unit (Wits/MRC Agincourt Unit) for their support with logistics, data, administration and advice. We would like to especially mention Steve Tollman, Kathy Kahn, Mark Collinson, Paul Mee, Benjamin Clark, Rhian Twine, Geoffrey Tibane, Obed Mokoena, Mildred Shabangu, Zubeida Bagus and Doreen Nkuna, and our team of field assistants. In the Wits School of Animal, Plant and Environmental Sciences, we thank Norman Owen-Smith for moral support and encouragement, Barend Erasmus for processing and analyzing satellite imagery and Hazel Khanyi for assistance with administration. We are grateful to Paul Pronyk of the Rural AIDS Development and Action Research programme (RADAR) for comments and advice on the design of the household questionnaire and sampling. At the University of Colorado, we would like to thank Jane Menken for her role as mentor, Steve Graham for administrative support, and Laura Patterson for assistance with analysis of the NDVI data. In addition, this research has benefited from the NICHD-funded University of Colorado Population Center (grant R21 HD51146) through administrative and computing support. Even so, the content is solely the responsibility of the author and does not necessarily represent the official views of NIH or NICHD. Finally, this research would not have been possible without the cooperation of the households and community leadership in the villages of the Agincourt HDSS site, and we are very grateful to them for partnering with us in this project.

[a]References

Brigham, T., Chihongo, A. & Chidumayo, E., 1996. Trade in woodland products from the Miombo region. In *The Miombo in Transition: Woodlands and Welfare in Africa*.

CIFOR, Bogor, pp. 137-174.

Brigham, T., Chihongo, A. & Chidumayo, E., 1996. Trade in woodland products from the miombo region. In B. Campbell *The miombo in trnasiotion: Woodlands and Welfare in Africa*. Bogor: CIFOR, pp. 137-174.

Clarke, J., Cavendish, W. & Coote, C., 1996. Rural households and Miombo woodlands: Use, value and management. In B. Campbell *The Miombio in Transition: Woodlands and Welfare in Africa*. Bogor: CIFOR, pp. 101-135.

Coates, J., Webb, P. & Houser, R., 2003. *Measuring Food Insecurity: Going Beyond Indicators of Income and Anthropometry*, Washington DC: FANTA, Academy for Education Development.

de Waal, A. & Whiteside, A., 2003. New variant famine: AIDS and food crisis in southern Africa. *The Lancet*, 362, 1234-1237.

Dovie, D.B., Shackleton, C.M. & Witkowski, E.T., 2002. Direct-use values of woodland resources consumed and traded in a South African village. *International Journal of Sustainable Development and World Ecology*, 9, 269-283.

FANTA, 2004. *Measuring Household Food Insecurity* Workshop R., Washington DC: FANTA, Academy for Education Development

Foody, GM, Cutler, ME, Mcmorrow J, Pelz D, Tangki H, Boyd DS & Douglas I. 2001. “Mapping the biomass of Bornean tropical rain forest from remotely sensed data.” *Global Ecology and Biogeography.* 10:44, 379-387.

Giannecchini, M., Twine, W. & Vogel, C., 2007. Land-cover change and human–environment interactions in a rural cultural landscape in South Africa. *The Geographical Journal*, 173(1), 26-42.

Hargreaves, J. & Pronyk, P., 2003. HIV/AIDS and rural development: Realities, relationships and responses. *Development Update*, 4(1), 85-107.

Hendriks, S.L., 2005. The challenges facing empirical estimation of household food (in)security in South Africa. *Development Southern Africa*, 22(1),103-123.

Hoddinott, J. & Yohannes, Y., 2002. *Dietary Diversity as a Household Food Security Indicator*, Washington DC: FANTA, Academy for Education Development.

Hoddinott, J., 1999. *Choosing outcome indicators of food security* Technical ., Washington DC: IFPRI.

Huete A., Didan K., Miura T., Rodriguez E.P., Gao X., & Ferreira L.G., 2002. Overview of the radiometric and biophysical performance of the MODIS vegetation indices. *Remote Sensing of Environment.* 83:195-213.

Hunter, L.M., De Souza, R. & Twine, W., 2008. The environmental dimensions of the HIV/AIDS pandemic: a call for scholarship and evidence-based intervention. *Population and environment*, 29(3-5), 103-107.

Hunter, L.M., Twine, W. & Patterson, L., 2007. "Locusts are now our beef": adult mortality and household dietary use of local environmental resources in rural South Africa. *Scandinavian journal of public health. Supplement*, 35(Supplement 69), 165-74.

Kahn, K. et al., 2007. Mortality trends in a new South Africa: Hard to make a fresh start. *Scandinavian Journal of Public Health*, 35(Supplement 69), 26-34.

Kahn, K. et al., 2007. Research into health, population and social transitions in rural South Africa: Data and methods of the Agincourt Health and Demographic Surveillance System. *Scandinavian Journal of Public Health*, 35(Suplement 69), 8-20.

Kahn, K. et al., 2000. Validation and application of verbal autopsies in a rural area of South Africa. *Tropical Medicine and International Health*, 5(11), 824-831.

Kahn, K. et al., 1999. Who dies from what? Determining cause of death in Africa's rural north-east. *Tropical Medicine and International Health*, 4(6), 433-441.

Kaschula, S.A., 2008. Wild foods and household food security responses to AIDS: evidence from South Africa. *Population and Environment*, 162-185.

Kirkland, T., Hunter, L. & Twine, W., 2007. "The Bush is No More": Insights on Institutional Change and Natural Resource Availability in Rural South Africa. *Society & Natural Resources*, 20(4), 337-350.

Letsela, T., Witkowski, E. & Balkwill, K., 2002. Direct use values of communal resources in Bokong and Tsehlanyane in Lesotho: whither the commons. *International Journal of Sustainable Development*, 9, 1-18.

Masanjala, W., 2007. The poverty-HIV/AIDS nexus in Africa: A livelihood approach. *Social Science and Medicine*, 64(5), 1032-1041.

Maxwell, D. et al., 1999. Alternative food-security indicators: revisiting the frequency and severity of ‘coping strategies’. *Food Policy*, 24, 411-429.

Maxwell, D.G., 1996. Measuring food insecurity: the frequency and severity of "coping strategies." *Food Policy*, 21(3), 291-303.

Misselhorn, A., 2005. What drives food insecurity in southern Africa? a meta-analysis of household economy studies. *Global Environmental Change*, 15(1), 33-43.

Mutanga, O. &. Skidmore, A.K., 2004. Merging double sampling with remote sensing for a rapid estimation of fuelwood, *Geocarto International*, 19(4): 49 – 55.

Paumgarten, F., 2006. The Role of non-timber forest products as safety-nets: A review of evidence with a focus on South Africa. *GeoJournal*, (2005), 189-197.

Peters, P.E. et al., 2008. *The Effects of Increasing Rates of HIV/AIDS-related Illness and Death on Rural Families in Zomba District, Malawi: A Longitudinal Study*, Washington DC: IFPRI/RENEWAL.

Shackleton, C. & Shackleton, S., 2004. The importance of non-timber forest products in rural livelihood security and as safety nets: a review of evidence from South Africa. *South African Journal of Science*, 100, 658-664.

Shackleton, C.M., Cousins, B. & Shackleton, S.E., 2001. The role of land-based strategies in rural livelihoods: the contribution of arable production, animal husbandry and natural resource harvesting in communal areas in South Africa. *Development Southern Africa*, 18, 582-604.

Shackleton, S. et al., 2008. Links between the local trade in natural products, livelihoods and poverty alleviation in a semi-arid region of South Africa. *World Development*, 36(3), 505-526.

Shackleton, S.E. et al., 2002. Use patterns and values of savanna resources in three rural villages in South Africa. *Economic Botany*, 56(2), 130-146.

Shisana, O. et al., 2009. *South African National HIV Prevalence, Incidence, Behaviour and Communication Survey, 2008: A turning tide among teenagers?*, Cape Town: HSRC.

Swindale, A. & Bilinsky, P., 2005. *Household dietary diversity score (HDDS) for measurement of household food access: Indicator guide*, Washington DC: FANTA, Academy for Education Development.

Tucker C.J. 1979. Red and photographic infrared linear combinations for monitoring vegetation. *Remote Sensing of Environment*, 8: 127-150.

Twine, W. et al., 2003. Consumption and direct-use values of savanna bio-resources used by rural households in Mametja, a semi-arid area of Limpopo province, South Africa. *South African Journal of Science*, 99, 467-473.

UNAIDS, 2008. *2008 Report on the Global AIDS Epidemic*, Geneva, Switzerland: UNAIDS.

Wang, J., Rich, P.M. & Price, K.P., 2003. Temporal responses of NDVI to precipitation and temperature in the central Great Plains, USA. *International Journal of Remote Sensing.* 24(11): 2345–2364.

Whiteside, A., 2002. Poverty and HIV/AIDS in Africa. *Third World Quarterly*, 23(2), 313-332.

Zhou, L., Kaufmann, R.K. Tian, Y. Myneni, R.B. & Tucker, C.J. 2003. Relation between interannual variations in satellite measures of northern forest greenness and climate between 1982 and 1999. *Journal of Geophysical Research.* 108(D1): 3-2 – 3-11.

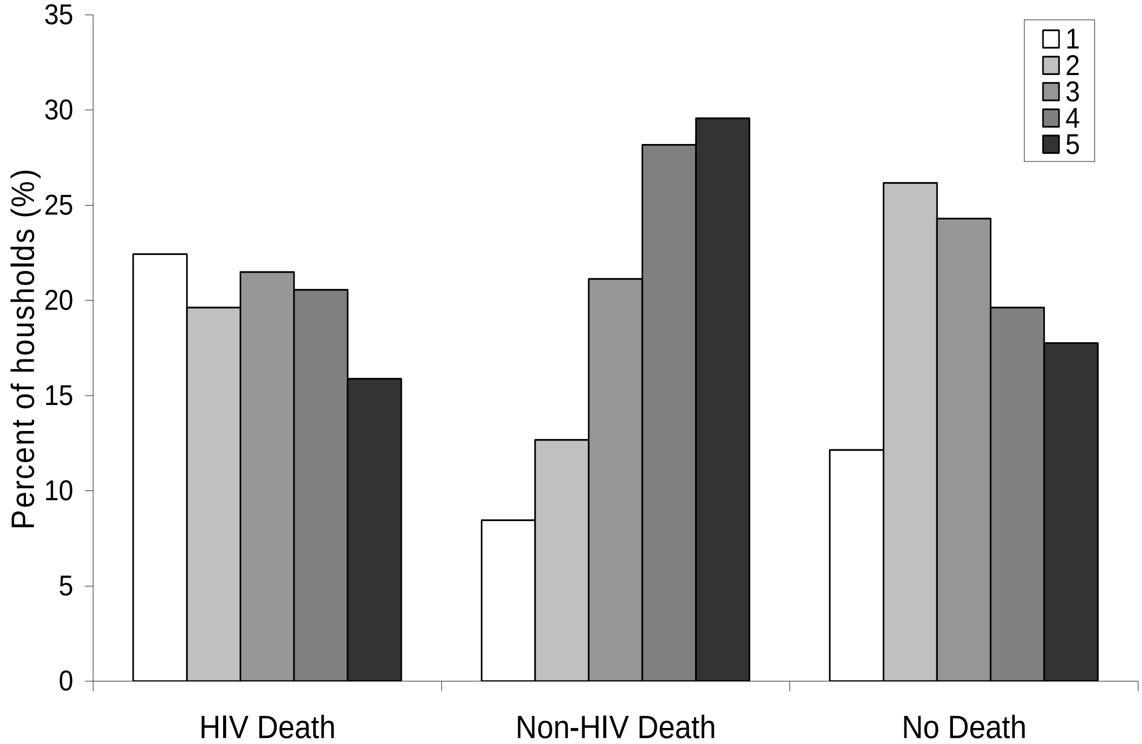



**Figure 1**. *Frequency profile of household socio-economic status classes (1 = poorest, 5 = wealthiest) in 2005, differentiated by mortality experience.*

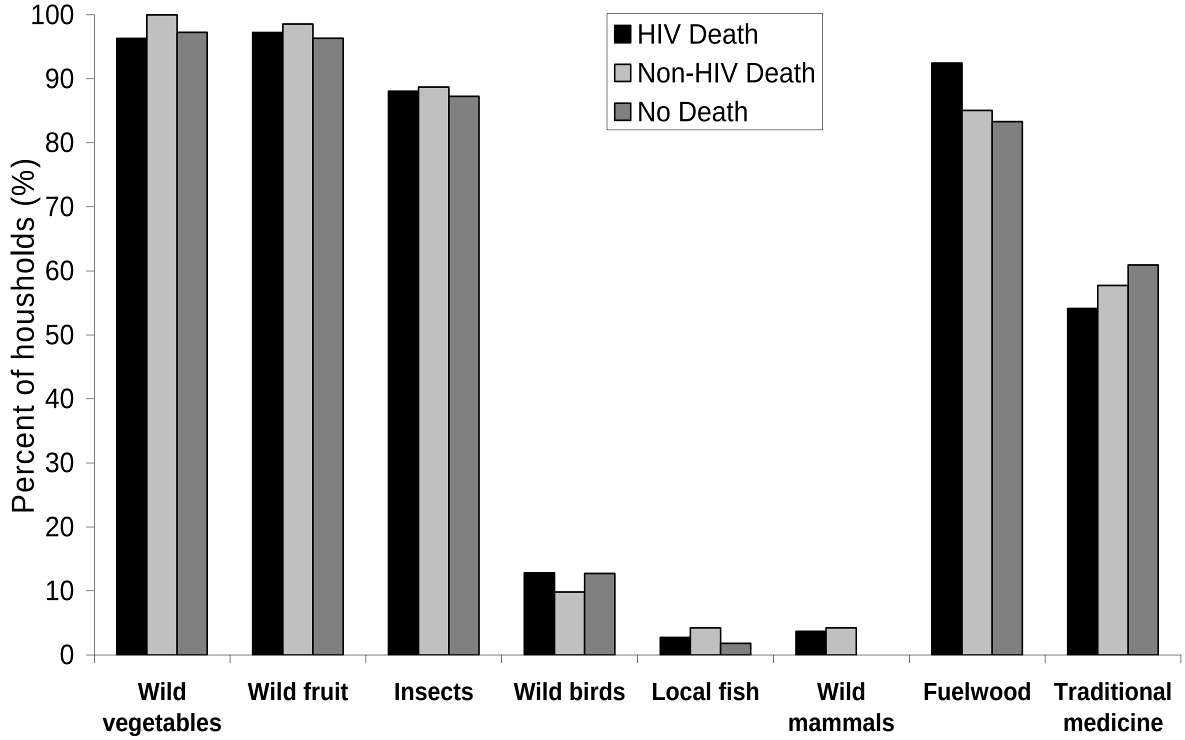



***Figure 2.*** *Prevalence of the use of wild foods, fuelwood and traditional medicine across mortality strata.*

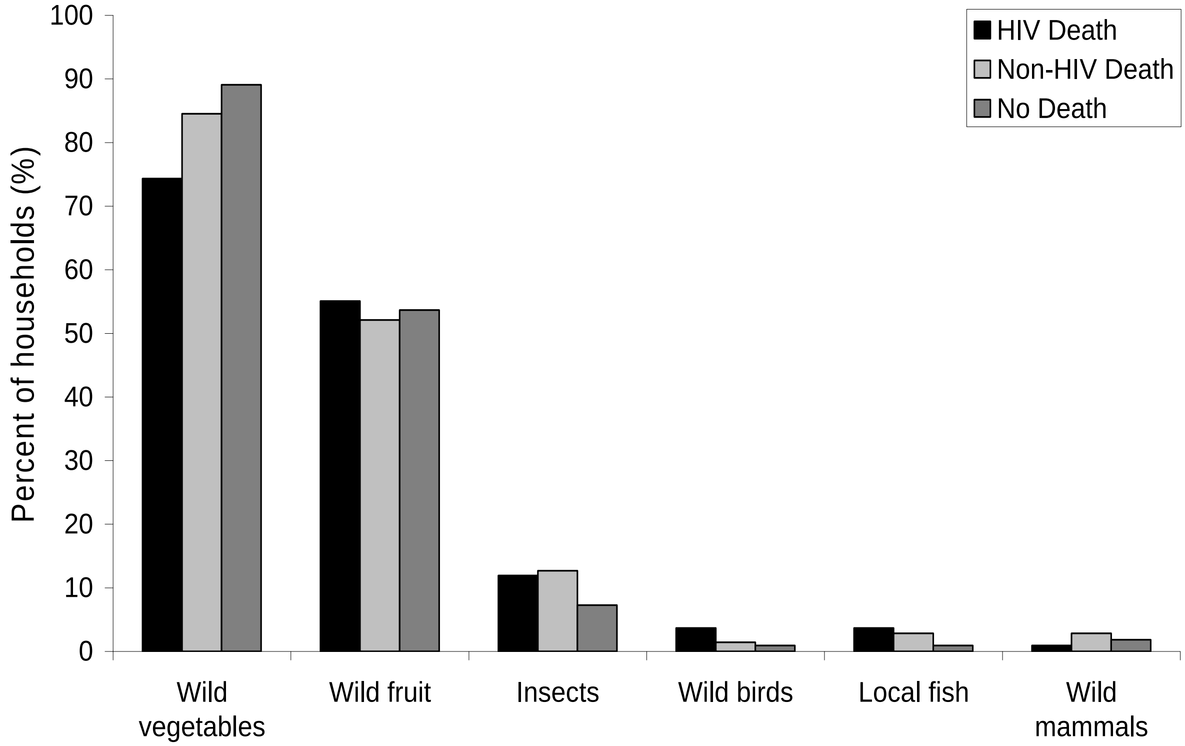



***Figure 3.*** *Prevalence across mortality strata of the use of wild foods more than once a week.*

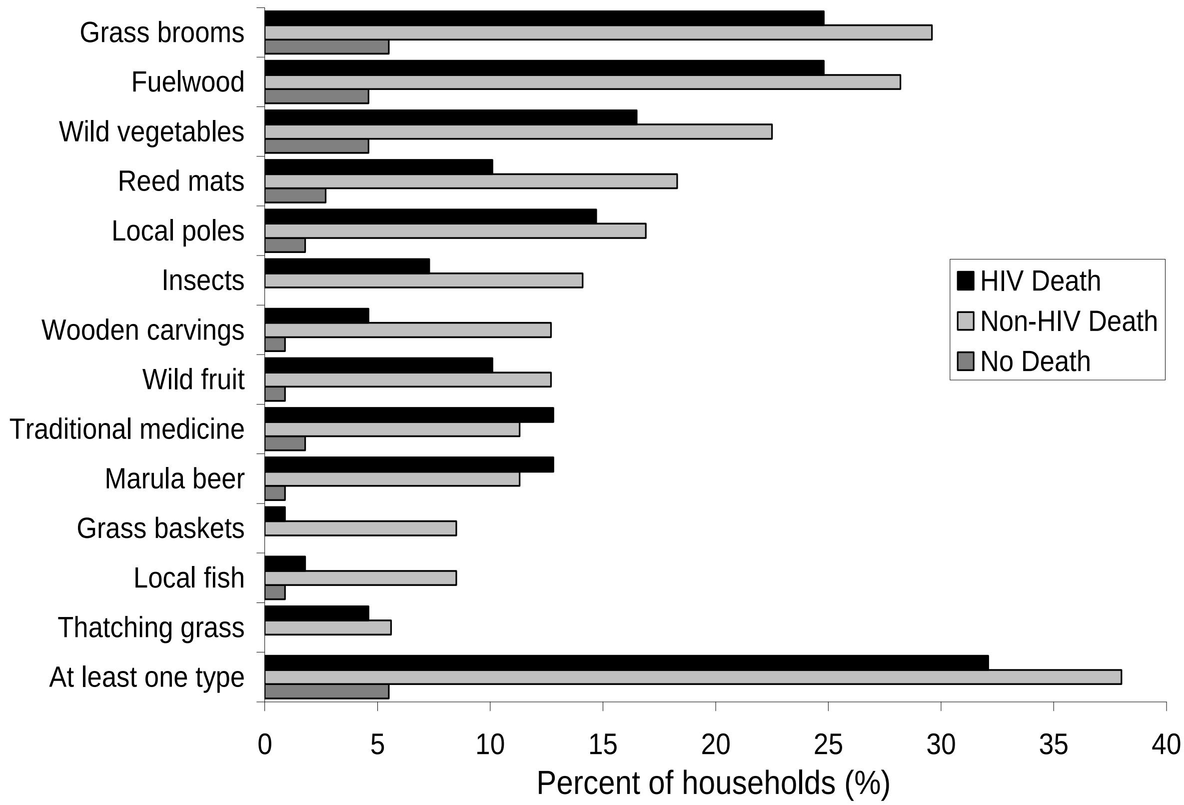



***Figure 4.*** *Prevalence of the use of wild natural resources specifically to save money (only those resources for which there was significant variation between mortality strata).*