

## **Understanding Rwandan Agricultural Households' Strategies to Deal with Prime-Age Illness and Death: A Propensity Score Matching Approach**

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### **Objectives**

The increasing prevalence of HIV in Rwanda, along with the likelihood of continued effects of the genocide of 1994, suggests that many rural households may be facing extreme stress, and their agricultural production may be changing. Policy-makers and development practitioners seek to understand how Rwandan households are affected and how they are reacting to the stress so that development policies can best support improvements in rural livelihoods under this changing environment. If production systems are shifting to less nutritious crop mixtures or ones that increase the potential for soil erosion on the hillsides, measures may be needed to counterbalance the negative effects.

This research seeks to evaluate the agricultural strategies used by households in dealing with morbidity and mortality and to determine differences in crop production between households that have experienced a recent adult illness or death from illness and those without adult morbidity or mortality. With 90 percent of the population living in rural and semirural settings and engaged in agriculture, the consequences of illness and death may be reflected in agricultural production, particularly because of a declining labor supply, as suggested by Gillespie (1989).

Several characteristics of rural Rwanda might tend to dampen the potential negative effect on agricultural production of labor lost through adult morbidity and mortality. Given high land scarcity in rural areas, high population densities,

population growth, and relatively few off-farm income opportunities, farmers may not be faced with the kind of labor difficulties predicted, even in the face of HIV/AIDS. In addition, Gillespie did not allow for potential household responses to loss of adult labor, such as obtaining additional labor through social networks, attracting new household members, and hiring labor, as found in other studies (Yamano and Jayne 2004; Mather et al. 2004a).

One of the key analytic challenges to understanding possible changes and differences is that of determining what the households affected by death and illness would have been doing if they had not had such traumatic events, to thereby understand the impact of the events. The chapter provides insight on both the research question and the use of a specific research methodology, propensity score matching (PSM), applied in the context of adult mortality and morbidity.

This chapter provides several contributions to the research. It takes earlier theoretical literature about potential effects and empirically tests some of the effects. It uses a nationally representative cross-sectional survey that also has a limited panel set to quantitatively assess impacts. This combination is a relatively low-cost method where annual agricultural surveys are already being conducted. Propensity score matching has been used in the program evaluation literature when experimental design was not possible, but there have been few applications in a development context. This combination of data allows application of PSM to difference in difference estimations in an effort to control for the unobserved differences between households.

This research is also one of the few that looks separately at the effects of HIV/AIDS during the period of adult illness and after an adult death has occurred. As will be noted, the relatively small death effects found in this work may be a reflection that predeath measurements occurred during the illness period, when the household was already adjusting to HIV/AIDS. If the “predeath” measurement of outcome is taken after adult illness has ensued, the households may have already adjusted household assets, crop production, and so on, in which case the “death effect” would underestimate the extent to which the household was initially affected and had to change because adjustments during illness may be later compensated through demographic or other changes in the households. The periods just before and after death may be when some households are feeling and trying to deal with the worst of the shocks and may undertake strategies that lead into a poverty trap. This research demonstrates that measuring the average effects of adult illness and death separately provides a test of how illness and death effects compare and provides insight into the possible need for interventions during illness to mitigate the most severe effects, which cause permanent livelihood declines.

## **Background**

In the early years of the HIV/AIDS epidemic, researchers relied on economic logic to understand the potential impacts of the disease on household structure, production, and livelihoods. In the agricultural sector, major labor scarcities were predicted, both because of the lack of labor contribution by those with AIDS and also because of the need to care for the ill and the pressure to sell production assets to cover medical and burial costs. The loss of skills of the person with AIDS and loss of time for skill transfer to children were all predicted to contribute to severe labor shortages and knowledge loss, which would result in cropping shifts and declines in agricultural production (Topouzis and du Guerny 1999).

Over time, the empirical base to evaluate the morbidity and mortality impacts and the strategies used to minimize them is improving. The early studies were generally of specific locations with high prevalence (e.g., Ainsworth, Ghosh, and Semali 1995), but broad studies over entire countries have also been conducted (Shisana and Simbayi 2002). Qualitative studies that focused on stated adjustment strategies of households are now being complemented by more quantitative studies that seek to measure impact. Longitudinal studies compare households in two or more periods of time (Beegle 2003; Yamano and Jayne 2004). One of the patterns emerging from the literature is the heterogeneity of household response strategies and the impacts of adult mortality, such that the impacts of adult mortality appear to be conditioned by household characteristics such as the gender and role of the deceased, predeath asset levels, and postdeath household composition and community characteristics such as population density and cropping systems (Mather et al. 2004b).

Research in Kenya indicates that the demographics of the household and the gender and role in the household of the person who is ill or had died strongly condition the outcome (Yamano and Jayne 2004). Tanzanian research demonstrates that households change their labor allocations to adapt to illness and death in different ways, and the overall effect on agricultural production will vary (Beegle 2003).<sup>1</sup> In Mozambique, households in the south are larger and less dedicated to agriculture, such that agricultural impacts are thought to be low, whereas in the north with more nuclear households and a focus on agriculture, the overall agricultural impact may be significant, if the epidemic continues to rise (Mather et al. 2004b).

## **Understanding Adjustment Strategies of Households**

Assessing how households deal with the stress related to HIV/AIDS in rural areas has required new research tools and a multidisciplinary approach. For example, because of the costs and technical demands of assessing HIV status of populations,

earlier research in Rwanda and elsewhere has used adults between the ages of 15 and 60 as “prime-age” (PA) adults because they are in sexually active years as well as in their most productive working years. It is this age group that tends to suffer from premature death and that is most likely to be associated with HIV/AIDS, particularly if murder and accidents can be removed as a cause of death.

Donovan et al. (2003) presented the preliminary results from the household survey of 1,520 rural Rwandan households that is analyzed here. During that survey, respondents were asked about what strategies they pursued to respond to the stress of a current PA adult with chronic illness or the death of a PA adult from January 1998 through early 2002. They were also asked about the major impacts the stress had on their agricultural activities. In cases of both illness and death, and regardless of the gender of the person involved, the majority of households cited a loss of farm labor. Among the agricultural strategies, it was logical to find that the strategies cited involved trying to replace lost labor, bringing in new family members or hiring in labor. The declared strategies varied depending on the gender and role of the person who was ill or died. However, there were very few households indicating a shift in cropping mix, although this is often cited in HIV/AIDS literature as a likely strategy (Topouzis and du Guerny 1999).<sup>2</sup>

Simple comparisons of crop production and area in different crops between affected and unaffected households suggested that there had been shifts in production or that there are characteristics of households with PA illness or death that make them more likely to cultivate more sweet potatoes or less coffee, for instance. There may be an underreporting of cropping shifts in the strategy responses, but the stated strategies indicate attempts to maintain agricultural labor supplies. The ex post comparisons of households also showed that the households affected by illness or death did tend to be ex post in the lower two expenditure quartiles (Donovan et al. 2003). One of the concerns raised by the previous work (Donovan et al. 2003) is that some of the shifts may entail more erosive cropping or cropping patterns that suggest substantially lower income generation by affected households. For intervention programs, it will be important to assess this more thoroughly.

## **Methodology**

There is a large body of literature that seeks to understand how programs or events affect people or households. Rosenbaum and Rubin (1983) proposed an evaluation technique called propensity score matching (PSM). The method has seen a recent surge in use, and we employ this method here. Propensity score matching provides an alternative to experimental methods to evaluate program or event effects.<sup>3</sup> To get the true effect of illness or death, we need two things: the outcome of a house-

hold with an illness or death (hereafter, an “affected” household) and the outcome of that same household under the same conditions but without illness or death. Because the latter is unobservable, we need to construct a proxy for the missing counterfactual data. Information on each affected household is matched to that of “similar” unaffected households for the same two periods. To determine which households to match, the PSM method evaluates the predicted probability of experiencing an illness or death on the basis of household and local area characteristics. PSM matches each affected household with “similar” unaffected households and uses the outcome of the unaffected households as a proxy for the outcome of the affected household if it had not had an illness or death.

The identification of “similar” is a key feature. There are two aspects to the similarity. First, there may be something about the affected households and why they have a member infected with the HIV virus that makes them different from the general set of households. For example, if a household with a head who has higher than average education is more likely to have a member with HIV, we would want to consider the education of the head (before the trauma) in matching the households. Secondly, if education of the head tends to be a factor determining the outcome, in this case crop production, clearly we would want to compare the outcomes of households with similarly educated heads. Thus, matching entails identifying a set of characteristics that are associated with an increased propensity to have a member with HIV and are likely to influence the outcome, crop production. The better the set of characteristics in accounting for outcome differences in the absence of treatment, the better the chance of eliminating confounding factors that affect the outcome (Becker and Ichino 2002).

Unlike regression approaches using instrumental variables (IV), PSM uses characteristics that have not been affected by the event under study but that are correlated with both the outcome and the event. With HIV/AIDS, it is often difficult to find an appropriate instrument that is unrelated to the outcome of interest. Another benefit of PSM over the IV approaches is that no functional form must be assumed for the relationship between the outcome and the characteristics.<sup>4</sup> However, it is assumed that those characteristics can be mapped into a single number, the propensity score. Rosenbaum and Rubin (1983) show that if the expected outcome in the counterfactual state for an affected household is equal to the expected outcome for an unaffected household, conditional on a set of characteristics, then the expected counterfactual outcome for the affected household is equal to expected outcome for the unaffected household, conditional on that single number, the propensity score.

We estimate the effect of the illness or death on household outcomes for the cases of affected households, not for all households in the general population. This

is known in the literature as the average treatment effect on the treated (ATT). For this, we will estimate the counterfactual of what crop production for affected households would have been if no prime-age adult had become ill or died in these households. The estimation of death effects and illness effects will be done separately, so hereafter the estimation strategy will be discussed in terms of the “affected households.” Death and illness refer only to those of prime-age adults. Also, the outcome variables to be evaluated are the crop production in 2001/02 (ex post) and the change in crop production from 1999/2000 to 2001/02 for specific crops.

We use a probit model to estimate the propensity score for each household. The dependent variable is an indicator of prime-age death or illness in a household, with separate probit regressions for each type of stress. Recognizing that our estimate of the propensity score is imperfect and that idiosyncratic factors will affect the individual unaffected household outcomes, we estimate the counterfactual outcomes by averaging outcomes across households that come within a set distance of the predicted propensity score for an ill household. This averaging over many similar unaffected households should provide a better estimate of the counterfactual by averaging out unobservable factors affecting both the probability of death and production outcomes (assuming the unobservable factors are not systematically related to the probability of death or illness). This method of estimating the counterfactual is known as radius matching. An additional effort to control for household unobservables is made by calculating the difference in crop production from 2000 to 2002 and then estimating the effects on those differences, as suggested in the work of Smith and Todd (2005) and Wooldridge (2002).<sup>5</sup>

## Data

The Department of Agricultural Statistics (DSA) at the Rwandan Ministry of Agriculture, beginning in 1999/2000 and through 2001/02, visited a set of 1,584 Rwandan agricultural households during each of the two main agricultural seasons to detail their crop production and land use during the season. In early 2001, a demographic survey was conducted with these households, including information on age, sex, education, and work activities. In early 2002, the households were again asked about their members, including new members, members who were no longer with the households, and currently ill members. There was no medical testing conducted to determine HIV status. Instead, the chronic illness or death from illness by adults in their prime ages (15–60 years of age) was used to proxy for probable HIV/AIDS presence among ill members (Donovan et al. 2003).

For this analysis, households with a current prime-age adult who was chronically ill (at the time of the FSRP interview in 2002) or those who experienced a

prime-age adult death in the previous four years will be compared to households without prime-age adult illness or death (“unaffected households”). Three years of production data are available for the households to capture the main period of effects of illness and at least part of the period of effects of a death. The 1999/2000 crop year had periods of drought and so was not a very good crop year for most households in Rwanda. We expect that production for most crops by households in 2001/02 would have increased because of better rainfall, even if land area dedicated to the crop remained constant. It is how affected households compare to unaffected that will be of interest.

For a variety of reasons, some households were no longer in the sample in 2002, so only 1,520 households were included. To understand the reasons for attrition of households, neighbors and relatives were asked to indicate why a household could no longer be interviewed. In most cases, the informants indicated that people had left to find new land or look for work, but there were a few households that had left because of a death.<sup>6</sup> Additionally, households with incomplete information had to be dropped from the sample. Thus, there remain 1,168 households in the analysis, of which 65 experienced a PA death. In estimating the PSM for illness, households with a death are dropped from the control, and vice versa, to avoid confounding cases.

### **Propensity Score Estimation Results**

The results of the propensity score estimation are presented in Table 6.1 both for the cases of households with a PA illness and for those with a PA death and are based on STATA (2004) programming by Becker and Ichino (2002). Characteristics in each of the probit regressions between death and illness vary (see Annex 6.2). A key reason for exclusion of some variables was the belief that they might not have been measured before the death. Because deaths go back four years and illness goes back only 12 months (with most cases less than that), there are aspects recorded in 2000 that should not be considered “pre-event.” Balancing property requirements, based on statistical tests of differences in means between matched and control households, ensure that when groups are matched based on the propensity score, the average characteristics within a group are not significantly different.

As can be seen in Table 6.1, almost the full set of available households was matched with death households. In the case of illness, the common support region (CSR) is narrower, and 30 percent of the unaffected households are excluded from the control group.<sup>7</sup> The characteristics used in the probits are expected to be useful in predicting probability of having a member with AIDS (i.e., being an affected household). As noted earlier, unlike instrumental variables estimations, those characteristics can also be associated with crop production outcomes. For example,

**Table 6.1 Coefficients from probit estimates of propensity scores: Propensity to have a PA illness in household or a PA death in household**

Characteristics	Prime-age illness in household				Prime-age death in household			
	Coefficient	SE	z	P >  z	Coefficient	SE	z	P >  z
Central agricultural zone	0.484	0.193	2.51	0.01	-0.298	0.142	-2.10	0.04
Eastern agricultural zone	0.904	0.221	4.10	0.00	-0.317	0.176	-1.80	0.07
Cellule population (log)	-0.169	0.148	-1.15	0.25	0.144	0.129	1.11	0.27
Cellule with departures greater than arrivals (1 = yes)	0.016	0.155	0.11	0.92	-0.044	0.136	-0.32	0.75
Regular market in cellule (1 = yes)	0.424	0.178	2.39	0.02	0.203	0.158	1.29	0.20
Newly forested areas in last 12 months (1 = yes)	0.203	0.141	1.43	0.15	-0.220	0.131	-1.67	0.10
Access to primary market good more than 4 km	0.561	0.227	2.47	0.01	0.148	0.200	0.74	0.46
Health center (1 = yes)	-0.030	0.170	-0.18	0.86	0.222	0.134	1.66	0.10
Churches (number)	-0.208	0.122	-1.70	0.09	-0.140	0.091	-1.54	0.12
Access to rural credit in cellule (1 = yes)	-0.172	0.170	-1.01	0.31	0.065	0.141	0.46	0.64
Access to farmer association in cellule (1 = yes)	0.196	0.215	0.91	0.36	0.049	0.181	0.27	0.79
Use of fertilizers and pesticides in cellule (1 = yes)	0.502	0.167	3.01	0.00	-0.149	0.137	-1.09	0.28
Sex of household imputed head in 1999 (1 = male; 2 = female)	0.284	0.167	1.70	0.09	0.200	0.137	1.46	0.14
Age of head in 1999	-0.003	0.005	-0.65	0.52	-0.001	0.004	-0.15	0.88
Head completed primary school in 1999 (1 = yes)	0.021	0.171	0.12	0.90	-0.144	0.164	-0.88	0.38
Head is either married or separated (1999)	0.454	0.156	2.91	0.00	-0.400	0.148	-2.69	0.01
Household uses manure/pesticides	-0.102	0.182	-0.56	0.58	na			
Number of rooms in house > 4 (1 = yes)	0.104	0.188	0.58	0.58	0.216	0.153	1.41	0.16
Total income in 2000 (log)	-0.105	0.058	-1.79	0.07	na			
Residence in cellule for more than 8 years (1 = yes)	-0.395	0.157	-2.52	0.01	0.147	0.132	1.12	0.26
Household member has received remittances (1 = yes)	-0.056	0.137	-0.41	0.68	na			
Household has paid for transport (1 = yes)	0.567	0.186	3.05	0.00	na			
Constant	-0.632	1.252	-0.50	0.61	-2.466	0.931	-2.65	0.01
Number of observations				1,129				1,168
Log likelihood				-210.98				-265.135
LR chi <sup>2</sup> (22)				75.33				42.59
Probability > chi <sup>2</sup>				0				0.0009
Pseudo R <sup>2</sup>				0.1515				0.0743

having a regular market in the community may be related to higher contacts outside the home and also might be associated with higher incentives for agricultural production for surplus sales. Those households that have lived in the area since before the genocide in 1994 may have greater stability in both land and household members. One of the puzzling results is that households in central and eastern zones tend to have higher illness prevalence but lower death prevalence than those households in western zones.

### **Estimated Effects of Illness for Households Experiencing Illness**

The PSM of affected households with unaffected control households within the common support region identified significant differences for the total crop production in 2001/02 of selected main crops and for the change in crop production of those crops from 1999/2000 to 2001/02. The ex post total production helps us to understand if the households are significantly different after the effects of illness or death are felt. We look at production changes over time to allow for the possibility that ill households had different starting points of production. As suggested earlier, if ill and nonill households differed in their initial production levels (on average), we would mistakenly attribute this difference to having an ill prime-age adult if we looked only at the ex post results.

#### **Ex Post Level of Crop Production**

Table 6.2 shows that for beans, peas, maize, cassava, Irish potatoes, cooking bananas, fruit bananas, and coffee, there were no significant estimated effects of illness on production in 2001/02. However, beer bananas (a cash crop) showed a significantly lower total production amount for households with illness compared to households without illness. Beer bananas require processing generally completed by women, so as the labor demands on women to care for the ill increase and labor declines because of illness among women, this would be expected.

Sweet potato production for households experiencing illness was significantly higher than production for households without illness. Sweet potatoes play a key role in consumption in Rwanda (Tardiff-Douglin 1991), and they have a labor advantage in production. The labor demands for sweet potatoes are not necessarily lower than those for other crops, but the timing of labor is more flexible, as harvesting can take place over time, and planting can be timed outside the main planting period for other crops. That flexibility makes it an important food security crop, and households with an illness are cropping up to an average of 531 kilograms more than comparable households.

**Table 6.2 Matching estimates of the effects on production in 2002 for selected crops: Average treatment effect (ATT) on households with a prime-age adult illness (in kilograms)**

Crop	Beans	Peas	Maize	Cassava	Irish potato	Sweet potato	Cooking banana	Beer banana	Fruit banana	Coffee
ATT	30.25	-0.05	-16.80	-2.61	26.73	531.18	-118.42	-64.64	71.59	-0.32
t-statistic	0.83	-0.02	-0.69	-0.02	0.11	2.54***	-1.43	-1.78*	1.63	-0.05
Households with illness	64	64	64	64	64	64	64	64	64	64
Control households	753	753	753	753	753	753	753	753	753	753
Average control production	161.26	8.19	81.50	507.39	251.81	905.53	520.50	281.57	118.01	17.88

Source: DSA data, 2002. Estimates based on propensity score specification found in Table 6.1.

Notes: Controls refers to the number of households without prime-age illness who form the basis for the counterfactuals. Radius of 0.01 was used for matching. Significance of t: \*, \*\*, \*\*\* indicate 0.10, 0.05, and 0.01 significance levels, respectively.

### **Changes in Crop Production**

The changes in crop production from one period to the next reflect a difference-in-differences approach, for the changes are contrasted between the affected and unaffected households (Table 6.3). As expected with the improved climatic condition in 2001/02, the control households increased their production of all the major commodities. The effect of illness on beer banana and sweet potato production remains strong. Households with an illness experienced higher growth in sweet potato production and much lower growth/recuperation in production of beer bananas. In general, illness households increased sweet potato production by more than 450 kilograms over the increase experienced by similar unaffected households. Beer bananas increased only 43 percent of the increase experienced by the control households. Because beer bananas have been a major source of income for women (Kangasniemi 1998), this result implies a relative decline in women's income-earning potential in the affected households compared to the control households. Additionally, coffee production declined significantly among households with illness over the period.

### **Estimated Effects of Death on Crop Production for Households Experiencing Death**

Households experiencing a death show few significant differences in crop production as compared to matched nonaffected households without a death or illness. This tends to follow the descriptive analysis in Donovan et al. (2003), indicating that households with a death appear to be quite similar to those without a death in the period after a death.

### **Ex Post Level of Crop Production**

Table 6.4 shows the results of evaluating the difference in levels of production in 2001/02 between those households with and without a death. All crops show lower production amounts for households with a death, but with variability between households, significant differences are found only for beans, beer bananas, and fruit bananas. The difference in bean production might be important for beans are a key food security crop for Rwandan households, and the average household production per control household for 2002 was 150 kilograms of beans (Table 6.4), so this reflects 18 percent lower production levels in affected households. The banana shifts indicate lower income potential with the lower production for beer bananas of 31 percent, and there is a strong 38 percent difference in fruit bananas, compared to control households. Again, if production shifts occur in years of illness, before death, our analysis does not capture that effect.

**Table 6.3 Matching estimates of the effects on change in production from 1999 to 2002 for selected crops: Average treatment effect (ATT) on households with a prime-age adult illness (in kilograms)**

Crop	Beans	Peas	Maize	Cassava	Irish potato	Sweet potato	Cooking banana	Beer banana	Fruit banana	Coffee
ATT	20.99	0.74	-21.19	101.12	-72.23	467.88	-102.65	-205.40	-35.81	-9.31
t-statistic	0.60	0.24	-0.79	0.73	-0.96	2.45***	-1.57	-1.82*	-0.87	-1.79*
Households with illness	64	64	64	64	64	64	64	64	64	64
Control households	753	753	753	753	753	753	753	753	753	753
Average control production change	41.93	2.33	43.38	10.20	84.46	243.14	307.00	361.17	58.85	9.25

Source: DSA data, 2002. Estimates based on propensity score specification found in Table 6.1.

Notes: Controls refers to the number of households without prime-age illness who form the basis for the counterfactuals. Radius of 0.01 was used for matching. Significance of t: \*, \*\*, \*\*\* indicate 0.10, 0.05, and 0.01 significance levels, respectively.

**Table 6.4 Matching estimates of the effects on production in 2002 for selected crops: Average treatment effect (ATT) on households with a death (in kilograms)**

Crop	Beans	Peas	Maize	Cassava	Irish potato	Sweet potato	Cooking banana	Beer banana	Fruit banana	Coffee
ATT	-27.62	-2.60	-10.79	-108.46	-46.71	-75.83	-112.53	-88.06	-40.204	-5.42
t-statistic	-1.87*	-1.29	-0.67	-1.43	-0.34	-0.55	-0.89	-3.10***	-2.648**	-0.83
Households with a death	77	77	77	77	77	77	77	77	77	77
Control households	1,046	1,046	1,046	1,046	1,046	1,046	1,046	1,046	1,046	1,046
Average control production	150.38	9.50	86.13	506.40	262.06	830.42	443.86	282.07	106.75	19.44

Source: DSA data, 2002. Estimates based on propensity score specification found in Table 6.1.

Notes: Controls refers to the number of households without prime-age death who form the basis for the counterfactuals. Radius of 0.01 was used for matching. Significance of t: \*, \*\*, \*\*\* indicate 0.10, 0.05, and 0.01 significance levels, respectively.

**Crop Production Changes**

Table 6.5 presents the results of analysis on the changes in production quantities from 1999/2000 to 2001/02. As expected because of the improved climatic conditions between the two years, the control households increased their production of both bananas along with sweet potatoes and the other crops. The affected households showed significant differences only in beer and fruit bananas. Those bananas do not show the production growth found in other households. For erosion, this is not a good sign, and there is no indication that less erosive crops supplanted the bananas, although income potential clearly declines as fewer of these types of bananas are produced. Contrary to conventional expectation that affected households shift into labor-flexible or laborsaving crops such as cassava and sweet potato, we do not find an increase in cassava and sweet potato production among affected households.

**Implications and Conclusions**

This chapter presents an application of PSM to the measurement of the impacts of adult illness and death on crop production in Rwanda. We use a combination of cross-sectional and panel data to construct the counterfactual required to estimate these impacts. This application demonstrates that, given appropriate variables and sample size, PSM enables analysts to estimate the impacts of adult illness and death using cross-sectional data with recall complemented with a small amount of panel information. Although panel data are preferred for the econometric estimation of impacts, governments and development practitioners cannot always wait for the ideal data to inform local policy decisions.

Given the small subsample size of illness and death, we did not differentiate impacts conditional on gender or household position of the deceased, as has been done elsewhere (Yamano and Jayne 2004). Yet this research highlights an important differentiation that has not received much attention to date in the quantitative impact literature, the distinction between production impacts during the illness period as compared with those in the postdeath period.

These results suggest that accurate measurement of the impact of adult death depends on when measurements are taken. Although there have been a few studies that look at different periods after death, the impacts for the illness period have rarely been evaluated. If major shifts occur during the period of illness that are difficult to reverse, such as removal of tree crops, intervention strategies may need to be designed with this specifically in mind. Other research is needed to see if changes during illness also involve asset sales that could lead to permanent changes. If irreversible changes tend to occur during the illness period, it is extremely important

**Table 6.5 Matching estimates of the effects on change in production from 1999 to 2002 for selected crops: Average treatment effect (ATT) on households with a death (in kilograms)**

Crop	Beans	Peas	Maize	Cassava	Irish potato	Sweet potato	Cooking banana	Beer banana	Fruit banana	Coffee
ATT	-6.89	-1.72	-0.83	8.81	48.25	-209.96	-78.58	-198.91	-41.17	-4.97
t-statistic	-0.51	-0.94	-0.04	0.10	0.38	-1.26	-0.75	-3.01***	-2.49***	-0.94
Households with a death	77	77	77	77	77	77	77	77	77	77
Control households	1,046	1,046	1,046	1,046	1,046	1,046	1,046	1,046	1,046	1,046
Average control production change	40.65	3.76	36.82	38.73	73.21	172.70	287.50	361.74	55.69	7.79

Source: DSA data, 2002. Estimates based on propensity score specification found in Table 6.1.

Notes: Controls refers to the number of households without prime-age death who form the basis for the counterfactuals. Radius of 0.01 was used for matching. Significance of t: \*, \*\*, \*\*\* indicate 0.10, 0.05, and 0.01 significance levels, respectively.

for intervention strategies to be designed for this period. This may also point to the important role that antiretroviral drugs may play in giving households greater time to adjust, potentially diminishing the irreversible loss of assets.

Regarding the measured impacts, over the illness period, we find relative increases in sweet potato production for ill households and shifts out of beer bananas and coffee. The latter imply lower cash income, and the sweet potato spreads labor demand and provides subsistence production. If banana and coffee trees are replaced with annual crops, that will increase soil erosion problems over time. Investments in sweet potato productivity, however, would have positive results for the affected households while at the same time contributing to welfare across Rwandan rural households, a clear case for increased agricultural research and extension.

Death appears to induce shifts out of beer and fruit bananas only, indicating the possible longer-term shift out of tree crops when households are under stress and the consequent reduction in cash income and in erosion protection. We did not find significant effects on other crops. This suggests that labor shortages among affected households looking over time are not as great as suggested by some of the theoretical literature because households adjust their labor demands and supplies. With a larger sample, effects conditional on gender and/or household position might be found, for other research indicates that some households are less likely to bring in replacement labor or recuperate from crises. The high population density and land scarcity in Rwanda may be one of the factors conditioning how households respond, limiting their flexibility in agriculture and thus resulting in relatively lower cropping impacts after a death than have been found in other regions.

### **Annex 6.1 Special Issues in Data for Propensity Score Matching**

This data set lends itself to using the PSM and difference-in-differences estimation for several reasons. First, the households were derived from a random sample with clustering, and so both affected and unaffected come from the same population. Second, because the households were all asked the same questions during the same period, we do not experience some of the difficulties found in the traditional matching literature where different sampling and surveys are used for households that participated in training and those that did not (e.g., Smith and Todd 2001). Finally, although the panel on production is brief, it still provides a basis for controlling for household-level time-invariant characteristics. The dataset also includes a fairly rich set of variables on which to match households, including community-level variables, important to achieve unbiased results (Diaz and Handa 2004).

There are some challenges in using these data. A key difficulty is that the number of cases of affected households is relatively small (65 cases of illness and 78 cases of death). Bryson, Dorsett, and Purdon (2002) looked at various studies with small treatment samples and suggested that the method is still valuable when sample numbers are low, although the matching is more difficult. In this case, the radius matching used a radius of 0.01, a fairly broad band. In addition, matching with replacement enabled unaffected households to be matched with more than one affected household if its propensity score was within the bounds.

Estimating the ATT rather than the average treatment effect (ATE) for all households was selected to respond to another potentially difficult issue. PSM is based on the mean stable unit treatment value assumption, in which “the impact of the program on one person does not depend on whom else, or how many others are in the programme” (Bryson, Dorsett, and Purdon 2002, p. 11). In the case of HIV/AIDS in highly affected communities, this would not be true, and looking at the general effects with ATE is clearly not justified.

Another issue is that of the common support region (CSR). Basically, the analysis matches affected households to unaffected households within the ranges of overlap between the predicted propensity scores of the treated and untreated households. Unaffected households with values of the matching characteristics that are much higher or lower than that observed within the affected households are excluded from the analysis. The same is true for affected households. In small datasets, this can mean a fairly restricted number of matches. It also means that interpretation of the results is confined to households within the CSR. If income is one of the characteristics and all the affected households have total incomes below 500,000 Rwandan francs, then the CSR will not extend to higher-income households if their probability of being affected lies outside the range (Bryson, Dorsett, and Purdon, 2002).

PSM relies on having pre-event variables or characteristics that are unaffected by the event under study on which to match the households. In the case of illness in these data, 82 percent of the cases of illness were ill for less than 25 weeks of the previous year (as measured in 2002), such that the production data from 1999/2000 would be from before the onset of severe illness. In the case of a death from illness, using the 1999/2000 production and other data is more tenuous, for the onset of illness would be before 2000, and effects of the illness may already be reflected in those early estimates. This is a common problem for HIV/AIDS researchers because the time span involved can be long, and the effects are felt throughout illness and after death. Given these caveats, the results of the PSM for households with illness and death are reported below.

**Annex 6.2****Table 6.6 Mean characteristics by household type for households in the common support region for characteristics included in the propensity score**

	Households with death	Control households	Households with illness	Control households
Community-level variables				
Central agricultural zone	0.32	0.39	0.38	0.44
Eastern agricultural zone	0.17	0.23	0.46	0.32
Cellule departures greater than arrivals (1 = yes)	0.37	0.40	0.51	0.44
Regular market in cellule (1 = yes)	0.21	0.18	0.25	0.21
Newly forested areas in last 12 months (1 = yes)	0.31	0.38	0.49	0.39
Health center (1 = yes)	0.46	0.34	0.35	0.29
Access to rural credit in cellule (1 = yes)	0.26	0.28	0.25	0.26
Access to farmer association in cellule (1 = yes)	0.87	0.84	0.88	0.85
Use of fertilizers/pesticides in cellule (1 = yes)	0.40	0.45	0.52	0.52
Cellule population (log)	6.81	6.75	6.74	6.71
Churches in cellule (number)	0.51	0.54	0.37	0.40
Characteristics of head before event <sup>a</sup>				
Proportion female	0.50	0.31	0.29	0.31
Completed primary school (1 = yes)	0.17	0.22	0.25	0.24
Head is either married or separated (1999)	0.23	0.42	0.60	0.47
Age of pretreatment head in 1999	43	42	41	43
Household level variables before event				
Household uses manure/pesticides	na	na	0.18	0.18
Household has received remittances	na	na	0.60	0.57
Household has paid for transport (1 = yes)	na	na	0.22	0.10
Distance to primary market (km)	1.83	1.71	2.40	1.77
Number of rooms in house	3.60	3.58	3.77	3.54
Total income in 2000	na	na	141,058	159,603
Length of residence in cellule	10.44	9.40	7.83	8.27
<i>N</i>	78	1,051	65	761

Notes: <sup>a</sup>Some data imputed. Control households represent only those households from the nonillness, nondeath households in the full sample that were matched using propensity score matching, radius of 0.01. "na" indicates variables not included in death estimates.

**Notes**

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1. Beegle's (2003) research in Tanzania is one of the few studies that looks at households with a view to separating effects evidenced recently after a death as compared to longer (more than six

months) after a death. It also looks at labor allocation, a key aspect, infrequently addressed in the research.

2. For further evaluation of strategies and ex post household characteristics, see Donovan et al. (2003).

3. Bryson, Dorsett, and Purdon (2002) provides an excellent review of the use of propensity scores, and Wooldridge (2002) gives the econometric details of the method, as well as additional insights on its use and limitations. Jalan and Ravallion (2003) apply the method in a developing country context.

4. DiPrete and Gangl (2004) provide a valuable comparison between PSM and IV estimations and ways to evaluate each. They are seen as complementary analyses, not necessarily substitutes.

5. Annex 6.1 presents some special data considerations for propensity score matching, as used with these data.

6. See Donovan et al. (2003) for further information on sampling and sample attrition.

7. Annex 6.2, Table 6.6 presents the information on values of the characteristics for the affected and control households, based on those within the CSR.

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