

HIV infection in rural households, Rakai District, Uganda

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Abstract

The Rakai Project conducted a population-based cohort study in rural Rakai District, Uganda, a region with high rates of HIV prevalence. The cohort population described here was followed between 1990 and 1992 and consisted of all residents aged 15 years or more living in 1945 households in 31 community clusters. A detailed census was conducted at baseline in every study household. Census data were updated annually, and all inter-survey deaths, births, and migrations were recorded. Immediately following each annual census, all consenting adults were administered a socio-demographic, behavioural and health survey, and provided a blood sample for HIV testing.

HIV prevalence in the study population was high, with 19.1 per cent of adults aged 15 or more years being HIV-positive. By household, the burden of infection was even more pronounced: 31.3 per cent of households had at least one HIV-infected resident adult. Twenty seven per cent of heads of households were also HIV-positive. Overall, 3.6 per cent of study households experienced the death of an HIV-positive adult per year, and another two per cent lost an HIV-negative adult. HIV-related adult mortality had substantially more effect on subsequent household dependency ratio and on material possessions than the death of an HIV-uninfected adult, in part because the former deaths were concentrated in adults aged 15-49, the most economically active age group in this rural population. Just under 15 per cent of children aged 14 years or less had lost one or both parents, and approximately half of these parental losses are estimated to be associated with HIV infection. Nineteen per cent of study households reported at least one resident child who had lost one or both parents. Although there is evidence that loss of a parent is associated with lower school attendance, orphans overall continue to be absorbed by community households which are headed by adults.

HIV infection is very prevalent among adults in Rakai and the associated mortality imposes a substantial social and economic burden on households in the district.

Unlike most infectious diseases, HIV/AIDS especially affects adults in the prime of life, and in many African countries, large proportions of the adult population are infected. In the absence of very costly therapy, the inevitable outcomes of HIV/AIDS are substantial

morbidity and death. Because of its epidemiology, natural history and demographic distribution, the HIV epidemic can be expected to have substantial effects on households by, for example, increasing the numbers of orphans, altering dependency ratios and influencing economic well-being.

HIV/AIDS is the principal cause of adult mortality in a number of African settings including Abidjan, Côte d'Ivoire (de Cock et al. 1990), and Masaka and Rakai Districts, both situated in Uganda (Mulder et al. 1994; Sewankambo et al. 1994). In rural Mwanza, Tanzania, where only four per cent of adults were found to be HIV-positive, a third of adult deaths have been attributed to HIV infection (Todd et al. 1997). In studies by Mulder et al. (1994), Sewankambo et al. (1994) and Todd et al. (1997), all of which were population-based, mortality among the HIV-infected was found to be 9-10 per hundred person-years of observation (PYO), substantially higher than is generally reported among HIV-positive adults in developed countries.

In Masaka, Kamali et al. (1996) reported that just over ten per cent of children under age 15 years had lost one or both parents: in almost two-thirds of these cases, the father was the deceased parent. The Masaka data suggest that approximately half of recently orphaned children lost their parent or parents as a result of HIV infection. Although orphaned children continued to be cared for by the community, the concern was raised that community and household coping mechanisms could become overextended. Foster et al. (1995) in Mutare, Zimbabwe, found that 18.3 per cent of households included orphans, of whom half were also estimated to have lost one or both parents as a result of HIV infection. As in Masaka, orphaned children in Mutare were being absorbed into existing households, but given that heads of households which included orphans tended to be older and less well-educated, the researchers expressed concerns regarding households' ability to continue providing for all members in the absence of adequate support services.

The mortality data, coupled with existing information on orphanhood, suggest the need for additional research on HIV/AIDS at the population and household level. There are, however, few population-based studies which can provide direct information on HIV in households. In this paper, we present selected data from a community-based HIV cohort study conducted in rural Rakai District, southwestern Uganda.

Rakai District is bordered by northern Tanzania and Lake Victoria. The district has a population of 385,000, living in three geographic strata (Wawer et al. 1991). In the first stratum, main-road trading centres are accessible by tarmac road and service local, domestic and international traffic; these communities have a predominantly market economy which includes bars, discothèques, small hotels or lodges and multiple shops. Communities in the intermediate trading village stratum, situated on secondary dirt roads, have a mixed agricultural and market economy, serve as foci for local trade and communications, and contain small shops but almost no bars or lodges with sleeping facilities. Rural agrarian villages are located off main and secondary roads, and their economy is based almost exclusively on agricultural production, much of it for household consumption or barter. Approximately five per cent of the district's population resides in the trading centres, four per cent in the trading villages, and 91 per cent in the agricultural villages. The majority of Rakai residents are Baganda. As described by Seeley et al. (1993), the descent system among the Baganda is patrilineal and women move into the husband's home upon marriage, in many cases at some distance from their natal home. The extended family group can be dispersed over several villages, as young men do not necessarily set up new households near their parents or brothers.

AIDS was first recognized in the district in the mid-1980s (Serwadda et al. 1985). Data from the 1989-1992 Rakai Project cohort indicate that HIV prevalence in the district is high and varies considerably by geographic stratum: in 1990, prevalence rates in persons aged 15

years and over were 35 per cent in the trading centres, 23.1 per cent in the intermediate trading villages and 11.8 per cent in the rural villages ($p < 0.001$) (Sewankambo et al. 1994). Extrapolating to the district as a whole, we estimated that 13 per cent of persons aged 13 years or more were HIV-infected in 1989-1990 (Wawer et al. 1991), a rate consistent with the results of the 1987 Ugandan National Serosurvey, which reported a prevalence of 12.1 per cent for rural central Uganda (Kaheru 1989), the region in which Rakai is situated.

Mortality among adults with HIV infection, at 119.9 per 1000 person-years of observation, was almost ten times that of uninfected subjects (RR = 9.5, 95%CI = 6.0-14.9) (Sewankambo et al. 1994). The mortality rate among HIV-positive males was almost 50 per cent higher than in HIV-positive females (147 per 1000 PYO compared to 98, $p < 0.05$). In keeping with the higher HIV prevalence in trading centres than in rural communities, HIV-related deaths occurred disproportionately among trading centre residents. Similarly, HIV was more prevalent in better educated persons and in those who worked in the cash economy (Serwadda et al. 1992), and these distributions were also reflected in HIV-related death rates (Sewankambo et al. 1994). Extrapolating from data collected in the Rakai cohort, we estimate that HIV-negative adults, who constitute approximately 87 per cent of all adults in the district, contribute an estimated 2100 deaths per year. HIV-infected adults, who constitute only 13 per cent of the adult population, experience almost 3000 deaths per year in the district. The Rakai setting thus offers the opportunity to observe selected socio-demographic effects of the HIV epidemic on rural households in three geographic settings.

Method

The smallest political unit in Rakai District is the Level One Resistance Committee (RC1), each containing 100 households on average. In 1989, we established the Rakai Project population-based cohort study using two-stage stratified cluster sampling. In the first stage, 21 RC1s were chosen at random from the complete list of district Committees. In order to ensure adequate representation of potentially high-prevalence communities, trading centres and trading villages were oversampled in relation to their relative populations in the district: six clusters were drawn from each of the trading-centre and trading-village strata, and nine were located in agrarian villages. Clusters were created by selecting one household at random in each community; this household and 39 contiguous residences situated in a concentric circle around the index household were enrolled in the study. To ensure adherence to the sampling protocol, survey supervisors drew detailed community maps before sampling. A household was defined as comprising persons who slept under one roof and ate out of a common pot. In the communities under study, households tend to be well defined and to have individual, separate houses.

In 1990, the cohort was enlarged by expanding each of the 21 existing clusters by 20 contiguous households (for a total of 60 households per cluster), and by adding ten new clusters of 60 households each. The new clusters were randomly selected from the trading-centre and trading-village strata, for a total of 11 clusters in each of these strata and nine in the rural, agrarian stratum. In addition, in cases where a member of an existing cohort household set up a new residence (for example, a son or daughter married and established their own family), the new household was also included in subsequent survey rounds. In 1990, 85 such households were included in the annual enumeration and survey, for a total of 1945 study households in that year. If an existing study cluster household moved as a unit to a new location within the community or to another community which contained a study cluster, cohort follow-up was maintained. Each study household received a baseline visit, and was subsequently followed with annual visits over two years (1990-1992). The data presented in this paper are drawn from the baseline and two-year follow-up of the expanded cohort study.

During the baseline and annual follow-up visits, an enumeration team visited all study households and updated a list of all eligible study subjects, defined as adults and children resident in the household for at least three months of the previous year, whether present at the time of the enumeration or not (*de jure* population). The broad classification of residence was used to ensure inclusion of the majority of persons having frequent and substantial contact with household members. Basic demographic data (age, sex, place and household of residence, relationship of each member to the head of the household) were recorded for all cohort subjects, as well as reasons for any absence. Household-level data were also collected on characteristics such as quality of housing and household possessions. Following the enumeration, knowledge and behavioural data, as well as a whole blood sample, were collected from all consenting subjects. In 1990, 9275 *de jure* residents were enumerated in the study households, of whom 50.5 per cent were aged 15 and over. Seventy per cent (6473) of the enumerated population were present in the study clusters at the time of the 1990 enumeration-survey, and we obtained a serological sample and interview data on a total of 5973 persons (90% of those present in the clusters at the time of the survey), of whom 2929 were aged 15 years and over. Of these persons, 1525 were identified through the census as being the head of the household. Thus, 78.4 per cent of household heads within the study clusters were included in the survey. In the remaining 420 households enumerated in 1990, 368 heads of households were absent at the time of the survey and 52 did not consent to participate. The overall levels of absenteeism and refusal among heads of households was thus somewhat lower than in the general adult study population.

Interview information was collected regarding socio-demographic characteristics, behaviour and health status. Venupuncture whole-blood specimens were spun in the field in a portable centrifuge, and the separated serum was frozen in liquid nitrogen. The frozen specimens were transported to the Uganda Virus Research Institute, a World Health Organization HIV reference laboratory in Entebbe, for storage at -20 °C. Initial serum screening was carried out using a commercial ELISA assay (Recombigen EIS, Cambridge Biosciences), and all samples found positive on ELISA were confirmed by Western Blot (Biorad, USA).

In 1991 and 1992, the enumeration and survey were repeated in all study households in the 31 clusters. During the 1991 and 1992 visits, data were also collected on changes in household composition and possessions that occurred during the follow-up year. Events of interest included deaths, births, marriage and in- and out-migrations since the time of the previous enumeration-survey. Follow-up information, a repeat questionnaire or survival status as reported by other household members, was acquired on 93 per cent of persons on whom we had 1990 serological and health data. Follow-up information on individuals was unavailable in cases where a person had migrated and the remaining family reported no contact, or where the entire household was absent and no data could be obtained from extended family members. In addition, information regarding 1991 survival status was available on 86 per cent of the enumerated adults from whom we had not received a serological specimen or interview in 1990 owing to absence or refusal. With respect to households, 1667 (85.7%) of the 1945 enrolled in 1990 remained in the study between 1990 and 1992.

The present data analysis focuses on HIV-prevalence among adults and among heads of households at baseline, as well as on the proportion of households with at least one HIV-positive adult. Follow-up data on mortality at the household level among all adults and among heads of households are also presented. Finally, the proportion of households with resident orphans under 15 is examined.

Results

The age and sex structure of the cohort population was typical of rural African communities. Individuals under the age of 15 constituted 49.5 per cent of the enumerated cohort, and women of reproductive age (15-49) made up 21.3 per cent of the study population, consistent with 1991 National Census data for Rakai. The one under-represented group was young men aged 15-29, an age where mobility and migration related to work, military service and schooling resulted in approximately 25 per cent fewer male residents than females in the same age group. Most of the male absenteeism occurred in the trading centres and trading villages.

Average household size in Rakai rural villages, at 5.3 persons, was larger than in either the intermediate trading villages (4.7) or the trading centres (4.3), and rural households had more children under the age of 15 (mean 2.5) than did trading-centre households (mean 2.0). The adult population in the trading centres was proportionately composed of more women and was younger, with two-thirds of the adults aged 15-29, than were the populations of the intermediate villages or rural agrarian villages, where one-half of adults were aged 15-29. The data are consistent with the different economies of the three strata: work in shops, bars, lodges, truck driving and vending in the trading centres; traditional agricultural practices in the rural villages; and a mix in the intermediate trading villages.

Over a quarter (28.4%) of study households were headed by women, with marked differentials in the distribution of female heads by geographic stratum. In the trading centres, 43.8 per cent of households were headed by women, whereas in the trading villages 22 per cent and in the rural communities 18.5 per cent were female-headed. The majority of female household heads (66.5%) were widowed, separated or divorced; 19.9 per cent were married, and 13.6 per cent were single. Among male heads of households, most (83.8%) were married, another 11.2 per cent were widowed, separated or divorced, and only five per cent were single.

HIV prevalence: individual and household data

As indicated earlier, in 1990, the first year of the expanded cohort study, HIV prevalence among persons aged 15 and over was 35 per cent in the trading centres, 23.1 per cent in the trading villages, and 11.8 per cent in the rural, agrarian villages. Overall, 19 per cent of cohort adults were HIV-positive. Ninety-seven per cent of all adult HIV infection was concentrated in persons aged 15-49 years, the economically active age group. By household, the burden of HIV infection was even greater than is reflected in the population prevalence rates. Table 1 illustrates individual adult HIV-prevalence by stratum (1990 data), compared to the proportion of households having at least one HIV-positive adult. In the trading centres, where 35 per cent of adults were infected, fully 47 per cent of households had at least one HIV-positive adult resident. In rural villages, the proportion of households with a seropositive adult, 20.3 per cent, was almost double the adult HIV-prevalence, 11.8 per cent. In those households with at least one HIV-infected adult, the mean number of seropositive adults was 1.3.

The distribution of HIV infection was also examined among heads of households (Table 1). In the trading centres, and to a lesser degree in the rural communities, HIV-prevalence was higher among heads of households than in the general adult population. Table 2 illustrates HIV-prevalence among heads of households by sex and by marital status. In all strata, female heads of households were more likely to be HIV-positive than male heads, although the difference was significant only in the trading centres. Thus, in the latter communities, 52.8 per cent of female household heads were HIV-positive, compared to 33.7 per cent of male heads ($p < 0.001$); in the trading villages, the respective female and male prevalence rates were 28.7 and 22.2 per cent (not significant); and in the rural villages, the rates were 17.9 and 12.5 per

cent (not significant). This variation in sex-specific HIV rates among household heads reflects differences in HIV-prevalence by the marital status of heads in the different strata. Overall, HIV-prevalence was highest among female heads of households who were currently single (57%) or married (53.5%), and it was 31.2 per cent among female household heads who were currently divorced, separated or widowed (Chi² for trend $p < 0.001$). Far fewer male than female heads of households reported being currently separated, divorced or widowed. However, men in this relationship category had the highest HIV-prevalence among male household heads.

Table 1
HIV prevalence (%) in all study subjects aged 15 years or more and in household heads, males and females combined; and percentage of households with one or more HIV+ adults: baseline 1990 data, by stratum.

	HIV prevalence among all adults 15+(%)	HIV prevalence among household heads (%)	Households with at least one HIV+ adult (%)
Main road, trading centres	35.0	42.1	47.0
Trading villages, secondary roads	23.1	23.6	31.6
Agrarian villages	11.8	13.5	20.3
All (cohort)	19.1	26.9	31.3
District (extrapolated)	13	15	22
Number of observations	2929	1525	1945

For both male and female household heads, positive HIV serostatus was associated with smaller household size. HIV-negative male-headed households had a mean of 5.3 persons, whereas the mean size of households headed by HIV-positive males was 4.4; among women, the mean household size was 4.3 for HIV-negative and 3.2 for HIV-positive women. This difference in household size was seen in all strata, and was due predominantly to differences in the mean number of children by HIV-status of the head of household. HIV-negative male-headed households included an average of 2.6 children, compared to two children in households with HIV-positive male heads. HIV-negative females headed households with a mean number of 2.2 children, whereas HIV-positive women headed households with only 1.5 children on average. In keeping with these observations, households headed by HIV-positive persons had a lower total dependency ratio, defined, in this rural setting, as the mean number of adults aged 50 and over and of children under age 15 per economically active adult aged 15-49. For the cohort overall, the dependency ratio in households headed by HIV-negative males was 1.3, compared to 1.0 in households headed by HIV-positive males; and 1.5 for households headed by HIV-negative women, compared to 1.2 in households headed by HIV-positive women.

Table 2
HIV prevalence of household heads by sex, place of residence and marital status; baseline data, 1990.

	Male household heads (N=1092)		Female household heads (N= 433)		Total both sexes (N=1525)	
	HIV+/N	Per cent	HIV+/N	Per cent	HIV+/N	Per cent
Trading centres						
Single	6/21	28.6	30/45	66.7	36/66	54.5
Married	82/246	33.3	43/65	66.1	125/311	40.2
Div/sep/wid	10/24	41.7	47/117	40.2	57/141	40.4
.						
Total	98/291	33.7	120/227	52.9	218/518	42.1
Trading villages						
Single	4/26	15.4	3/12	25.0	7/38	18.4
Married	72/342	21.0	0/9	-	72/351	20.5
Div/sep/wid	20/64	31.2	32/101	31.7	52/165	31.5
.						
Total	96/432	22.2	35/122	28.7	131/554	23.6
Agricultural villages						
Single	0/8	-	½	50.0	1/10	5.0
Married	37/327	11.3	3/12	25.0	40/339	11.8
Div/sep/wid	9/34	26.5	11/70	15.7	20/104	19.2
.						
Total	46/369	12.5	15/84	17.9	61/453	13.5
All strata combined						
Single	10/55	18.2	34/59	57.6	44/114	38.6
Married	191/915	20.8	46/86	53.5	237/1001	23.7
Div/sep/wid	39/122	32.0	90/288	31.3	129/410	31.5
.						
Total	240/1092	22.0	170/433	39.3	410/1525	26.9

We have previously reported that individuals with higher education were significantly more likely to be HIV-infected (Serwadda et al. 1992); as would be expected, the same trend was observed in heads of households. In the 213 heads with secondary education, 36.6 per cent were HIV-positive, compared to only 15.8 per cent HIV-positive among heads with no education ($p < 0.001$). Household heads with some or completed primary schooling had an intermediate HIV-prevalence of 29.7 per cent. Women heads of household with secondary or higher education were more likely to be HIV-positive (60% prevalence) than men with similar levels of education (31.2% prevalence); this is partly related to the fact that educated female heads of household resided almost exclusively in trading centres where exposure to HIV infection is most pronounced. Households with HIV-infected adults tended, at baseline, to have characteristics associated with higher socio-economic status. Households with a radio, wooden or cement floors, iron roofs and a higher number of rooms per member were significantly more likely to have an HIV-positive head of household.

Selected effects of HIV-related mortality on households

As illustrated in Table 3, a substantial proportion of Rakai study households experienced the death of an adult as a result of HIV infection (1990-1991 data). Just over five per cent of all cohort households experienced an adult death in that study year: two-thirds of these deaths occurred among HIV-positive adults. Four per cent of households lost an economically active adult each year: 82 per cent of these deaths were associated with HIV infection. Similarly, the great majority (71%) of deaths of heads of households were associated with HIV. Extrapolated to the district as a whole, that is, adjusting for the oversampling of trading centres and trading villages in the Rakai cohort, we estimate that 2.4 per cent of all Rakai households experienced an HIV-related adult death per year and that 2.3 per cent of all Rakai households lost an adult in the most economically active age range each year as a result of the epidemic. Of households which did experience adult deaths, 92.9 per cent reported only one adult death during the two-year follow-up, six per cent experienced two adult deaths, and 1.1 per cent three adult deaths.

Table 3
Percentage of all study households experiencing an adult death, 1990-1991 (N=1945).

	Deceased was HIV -	Deceased was HIV+	Any death (HIV+/HIV- combined)
Any adult death (age 15+)	2.0	3.6	5.5
Death of adult 15-49	0.7	3.4	4.1
Death of head of household	0.8	2.0	2.8

In households with no adult death, household size remained essentially unchanged between baseline and follow-up; in households with an adult death, household size declined on average, by 1.7 persons (adults and children combined and inclusive of the deceased person). The probability that a given household would remain in the study community during follow-up was affected both by initial household size and by subsequent adult deaths. Households with only one resident adult were highly mobile, and 32 per cent migrated out of the study communities during follow-up (1990-1992), even in the absence of adult death; virtually all such households migrated or were subsumed following the death of the adult member. Of households with two adults at baseline, 14 per cent migrated out in the absence of any adult death, 24 per cent migrated out following an HIV-unrelated death, and fully 57 per cent moved out of the community following the death of an HIV-positive adult. Households with three adults at baseline were substantially less likely to move: seven per cent with no adult death moved out, seven per cent moved out following a non-HIV death, and nine per cent migrated following the death of an HIV-positive adult member.

As shown in Table 4, among those households which remained in the cohort at the time of follow-up, a greater proportion (14 %) of those which had experienced the death of an HIV-positive adult reported no adult in the age group 15-49 years at follow-up, compared to households with no adult death or an HIV-negative adult death. Similarly, the dependency ratio increased in those households which experienced the death of an HIV-positive adult, compared to households with no adult death or those with the death of a seronegative adult (Table 5).

Table 4
Percentage of households with no resident adults aged 15-49 at baseline and at follow-up, by adult mortality which occurred in the household between 1990 and 1992, for households followed during that period (N= 1667).

	No adult death N = 1483	Death of HIV- adult N = 74	Death of HIV+ adult N = 110
Baseline	6	0	2
Follow-up	7	3	14

Table 5
Dependency ratio, defined as the mean number of children under age 15 plus adults aged 50 or more, per adult aged 15-49, in study households at baseline (1990) and at follow-up (1992), by adult mortality experienced by the household during follow-up.

	No adult death N= 1483	Death of HIV- adult N = 74	Death of HIV+ adult N= 110
Baseline	1.35	1.30	1.16
Follow-up	1.34	1.34	1.47

Households reported substantial financial outlays on HIV-related illness and burial. Two-thirds of households experiencing an HIV-related adult death reported selling property to pay for medical treatment and burial costs. Extended family members outside the immediate household were reported to have contributed to medical and burial costs in 40 per cent of cases. Local community and non-governmental organizations provided additional short-term support for medical costs in 18 per cent of cases, primarily in the form of medication; and support for burial costs in 68 per cent of cases, primarily in the form of food donated for the burial service.

Among households with no adult deaths, the proportion owning basic possessions increased over two years of observation (Table 6). Households experiencing an adult death, particularly if the deceased was HIV-positive, reported at follow-up fewer possessions including such economically important items as bicycles (Table 6). The data suggest a negative economic effect related to medical and burial costs and, possibly, to loss of earnings with the death of an economically active person.

Table 6
Percentage of households reporting selected possessions at baseline (1990) and at follow-up (1992), by adult mortality (age 15+) experienced in the household during follow-up

Possession		No adult death N= 1483	Death of HIV- adult N = 74	Death of HIV+ adult N= 110
Bicycle	Baseline	34	38	39
	Follow-up	41	38	33
Radio	Baseline	30	36	42
	Follow-up	38	35	36

Orphans

Only 1.9 per cent of HIV-uninfected adults aged 15-49 reported having a deceased spouse, compared to 8.3 per cent of HIV-infected adults (RR = 4.4, 95% CI 2.8-7.0). All children under the age of 15, or their guardians, were questioned regarding the status of the child's biological parents. Children who had lost one or both biological parents are considered orphans for the purposes of this paper, in keeping with the definition used in other African studies (Foster et al. 1995; Kamali et al. 1996). In 1990, 4.5 per cent of children had a deceased mother, 7.9 per cent had a deceased father, and 2.4 per cent had lost both parents, for a total of 14.8 per cent under the age of 15 who had lost one or both parents. Nineteen per cent of cohort households reported at least one resident child who had lost one or both parents, with no marked differentials by geographic stratum.

Despite HIV-related and other adult mortality, most Rakai households continue to be headed by adults: 97 per cent of cohort households had at least one resident aged 17 years or more, an age at which persons may be considered fully economically independent adults in this rural area. If age 20 is considered to represent economic adulthood, 94 per cent of all households contained at least one resident at or above this age. Just under one per cent of households were headed by children under the age of 15.

From project data, we estimate that there are approximately 29,000 children resident in the district who have lost at least one parent; 4500 to 5000 of these children have lost both parents. These 29,000 children represent 15 per cent of all children under age 15 and 7.5 per cent of the total population of the district. Furthermore, we estimate that by 1992, approximately half of surviving orphans under age 15 had lost one or both parents to HIV; among the youngest orphans, those under five, as many as two-thirds may have lost at least one parent as a result of HIV.

Within households, there is some evidence that orphaned children are at a disadvantage compared to children with two living parents. Households with orphans tend to be headed by females: 62 per cent of households with orphans have a female head of household, compared to only 30 per cent of households without orphans. Households with orphans tend to have lower adult per capita incomes than do households with no orphans, in part probably as a result of being female-headed: the difference in per capita income is approximately 15 per cent. Fifty-six per cent of orphaned children aged 15 and under are enrolled in school, compared to 64 per cent of children with both parents living ($p < 0.05$).

Discussion and conclusions

Adults in Rakai district have high rates of HIV infection, but the current analysis indicates that the household burden of HIV infection is even higher: 19.1 per cent of all adult cohort subjects were HIV-infected, whereas 31.3 per cent of study households had at least one HIV-positive resident adult. Similarly, HIV prevalence among heads of households, many of whom have substantial economic and organizational responsibility for the household, was higher than in the general adult study population, with 26.9 per cent of household heads being infected. The higher rate of HIV at the household than at the individual level is due to the fact that many households contain only one infected person but multiple HIV-negative residents. For example, among marital couples in the Rakai cohort, approximately 14 per cent were HIV-concordant-positive (i.e. both positive), but almost an equal proportion were HIV-discordant (i.e. only one positive spouse) (Serwadda et al. 1995). With the addition of unmarried HIV-infected adults, these data are compatible with the observed proportion of households with at least one HIV-positive resident. This finding that a high proportion of households have an HIV-positive adult implies that many families are or will be affected

within the coming decade by HIV-related morbidity and mortality. These effects may be exacerbated by the fact that the HIV-positive adult is often a breadwinner and not infrequently the head of the household.

Within the cohort, 28.4 per cent of households were headed by women, and female household heads had higher rates of HIV infection than their male counterparts. Among the 433 women who reported heading their households, the majority (66.5%) were currently widowed, divorced or separated. Although it has been postulated that marital disruption may lead to increased risk of HIV infection (Nabaitu, Bachengana and Seeley 1994), in this subgroup of women reporting current marital disruption, HIV-prevalence was lower, at 31.3 per cent, than among female heads who reported they were single or married, in whom the prevalence was 57.6 per cent and 53.5 per cent, respectively. A substantial number of single women resided in the trading centres, and our previous data indicate that many of these women work in bars and lodges and are involved in some commercial sex transactions (Serwadda et al. 1992). Married women who head a household are more likely to have a husband who is away for work; mobility and migration have also been found to be associated with HIV risk (Serwadda et al. 1992; Nunn et al. 1995), and married female household heads face higher exposure through their husbands.

The number of children under age 15 years was lower, on average, in households headed by HIV-positive adults than if the household head was HIV-uninfected. The overall dependency ratio was also lower in households with HIV-positive adults. The smaller household size and lower dependency ratio in households with HIV-positive heads was related to four factors: a higher proportion of HIV-positive adults who live alone, in particular women working in the cash economy, including bars; the fact that HIV-positive adults are on average younger than HIV-negative adults, and thus have had less time to have children; lower pregnancy rates among the HIV-positive women which we have reported elsewhere (Sewankambo et al. 1994; Gray et al. 1996; Serwadda et al. 1997); and higher mortality among the infants of HIV-positive mothers, which we have also previously reported (Sewankambo et al. 1994). The lower dependency ratio found in households with HIV-infected adults has implications for projections of the overall effect of adult HIV-related deaths on household and on community coping.

In the follow-up period reported in this paper, a substantial proportion of households experienced adult deaths, and two-thirds of these deaths occurred in HIV-infected individuals. In the economically most active age group, over 80 per cent of the deaths observed in these households were associated with HIV. Households experiencing an HIV-related adult death were more likely to have no adults in the economically most active age group at follow-up, compared to households with no death or the death of an HIV-uninfected adult (Table 4). As would be expected from these data, the total dependency ratio increased in households with an HIV-related adult death (Table 5). HIV-related mortality appears to have deleterious effects on household economic well-being, as suggested by the fact that two-thirds of households affected in this manner reported selling household possessions to cover illness and burial costs, and by a reduction of the proportion of such households with selected possessions at follow-up, as seen in Table 6; it also affects stability, as reflected by the higher proportion of households which left the study communities following the death of an HIV-positive adult, particularly if the original household had only two adult members at baseline. Households which experienced adult deaths also lost other family members, a phenomenon noted as well in a separate study in Tanzania (Ainsworth, Ghosh and Semali 1995). Factors which may contribute to the alterations in economic well-being and stability include loss of income, illness and burial expenditures and, potentially, stigmatization of the remaining spouse, resulting in a move outside the community. Only 40 per cent of households reported receiving help from extended family networks with illness and burial costs, a finding compatible with

observations by Seeley et al.(1993), which suggested that support from the extended family could be limited in this economic and cultural context. The burden of HIV infection on household well-being is likely to be increased by the fact that HIV disproportionately affects better-educated individuals and those who work in the cash economy.

Our overall estimate of 29,000 orphaned children in Rakai suggests that seven per cent of the population of the district is composed of children who have lost one or both parents. Since most parental deaths occurred before the study reported above, it is not possible to determine the cause of mortality in most cases. However, from adult death rates at the time of the cohort study described here, we estimate that approximately half of the surviving orphaned children had parents who had died of HIV infection. Although HIV is the leading cause of adult death at this time, HIV transmission in Rakai was probably not common until approximately the late 1970s (Serwadda et al. 1985), and probably did not begin to contribute substantially to adult mortality until the mid-1980s, so that older orphaned children in the cohort study are likely to have lost parents to other causes: almost 20 per cent of orphans in the study population were 12-14 years of age. In addition, many HIV-related adult deaths occur in relatively young age groups before full family size is achieved; the offspring of HIV-infected persons have higher mortality rates and are less likely to survive and be counted as orphans (Sewankambo et al. 1994); and fertility in HIV-infected women is lower than in the uninfected (Sewankambo et al. 1994; Gray et al. 1996; Serwadda et al. 1997). All these factors tend to reduce somewhat the numbers of 'AIDS orphans', although the overall numbers of children who have lost and continue to lose their parents as a result of the epidemic is nonetheless substantial.

Care for orphans represents a significant burden for the population of Rakai: 19 per cent of households reported caring for at least one child under the age of 15 years who had lost one or both parents. Seventy per cent of these orphans had lost their father, but only 46.6 per cent had lost their mother. The higher rate of children who had lost their father is compatible with data which show higher HIV-related mortality in infected men compared to HIV-positive women and more frequent widowhood among women than men, and with data which indicate that within marital couples, husbands are frequently older (Nalugoda et al. 1997), compatible with earlier death of the male spouse. Also, within the rural villages, husbands tend to be HIV-infected before the wives (Serwadda et al. 1995; Konde-Lule et al. 1997), which also increases the probability that the man will predecease his wife. The higher rate of paternal loss has been reported in Masaka district as well (Kamali et al. 1996).

However, despite the severity of the HIV epidemic in the district, the majority of Rakai cohort households continue to be headed by adults aged 15-49 years: in 1990-1991, only one per cent of households were headed by children under age 15, and another six per cent by adults aged 50 years or more. In addition, our observations and reports by village leaders suggest that the phenomenon of 'homeless orphans' is very rare. Nonetheless, the data suggest that orphaned children are at some disadvantage. Households which house orphans are more likely to be headed by women and to report lower incomes, and the data suggest somewhat lower rates of school attendance by children who have lost a parent.

In conclusion, HIV infection has had a substantial impact on the structure and economic welfare of Rakai households, and these effects would not be captured by examining adult HIV-prevalence alone. A very high proportion of Rakai cohort households have HIV-positive adult members, 3.6 per cent experienced an HIV-related adult death each year, and 19 per cent of households report caring for a child under age 15 who has lost one or both parents, of whom approximately half died as a result of HIV. The present analysis illustrates the importance of defining an appropriate 'population at risk'. Although epidemiological studies tend to focus on individuals, the importance of the family and household as the socially relevant unit should not be underestimated and merits further study.

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