Health Transition Review, Supplement 2 to Volume 7, 1997, 113-126

Estimates of the impact of HIV infection on fertility in a rural Ugandan population cohort*

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Abstract

Fertility rates in a population-based cohort of over 3500 women aged 15-49 years living in rural southwest Uganda are described and examined in relation to infection with HIV. Over a six-year follow-up period (1989/90 to 1995/6) the average general fertility rate was estimated as 199 births per thousand woman-years of observation (95 % confidence interval 191 to 207) with a total fertility rate of 6.2 births per woman. The overall prevalence of infection with HIV was 12 per cent and remained relatively stable during follow-up. With the exception of women aged 15-19 years, women who were not infected with HIV had higher fertility than HIV-infected women. The overall age-adjusted fertility rate in HIV-infected women was 0.74 of that of uninfected women (95% confidence interval 0.63 to 0.87, P<0.001) and this result was unaffected by additional adjustment for marital status. When combined with an overall HIV prevalence rate of 12 per cent, this corresponds to a three per cent reduction in fertility rates in the whole population. The lower fertility in HIV-positive women is unlikely to be explained by increased use of contraception, as use of modern contraceptive methods in rural Uganda is low and fewer than ten per cent of women are aware of their HIV-serostatus. More likely explanations are reduced sexual activity due to clinical symptoms associated with HIV infection or lower fertility associated with co-existing infections with other sexually transmitted diseases, such as syphilis. A reduction in fertility caused by HIV infection itself cannot be excluded. The implications of these findings for the use of antenatal clinic data to provide population estimates of HIV prevalence are discussed.

Understanding the effect of HIV[1] infection on fertility in populations in sub-Saharan Africa is vital for predicting the likely demographic impact of the epidemic and for predicting the future socio-demographic burden on communities of increased numbers of children infected by vertical transmission of HIV or subsequently orphaned by the death of their HIV-infected

* We are grateful for the continued support and co-operation of the population of the study area. We thank the Director of the Uganda Virus Research Institute and the Director of Medical Services, Ministry of Health, Uganda, for their support and for their permission to publish the results of this study. We also thank members of the IUSSP Committee on AIDS for comments on an earlier draft of this report. The study was supported by the Medical Research Council (UK) and the Department for International Development of the United Kingdom. Lucy Carpenter is on special leave from a University Lectureship in the Department of Public Health, University of Oxford.

[1] HIV refers to HIV-1 throughout this paper.

mother. There have, however, been relatively few reports of fertility rates in HIV-infected and uninfected women in Africa. Lower fertility among HIV-infected women has been observed in women in Zaire, Uganda and Rwanda (Ryder et al. 1991; Allen et al. 1993; Sewankambo et al. 1994) although the studies have generally been too small to yield statistically significant results. Significantly reduced rates of pregnancy were however observed in HIV-infected women in a cross-sectional study carried out in Rakai district, Uganda (Serwadda et al. 1997). Whilst lower fertility rates have also been described in HIV-infected women in developed countries (Selwyn et al. 1989; Stephenson et al. 1996; De Vincenzi et al. 1997; Thackway et al. 1997) these are unlikely to be applicable to African populations because, unlike most women in developing countries, the women studied knew their HIV status, and modern contraceptive methods and pregnancy termination were more readily available and acceptable.

Estimates of the levels and trends in HIV prevalence and incidence among women in many African countries increasingly rely on sentinel surveillance data collected from antenatal clinics (Kigadye et al. 1993; Batter et al. 1994; Asiimwe-Okiror et al. 1995; Fylkesnes et al. 1997). HIV prevalence rates in women attending an antenatal clinic in Tanzania were found to be lower than those found in a population survey carried out in the same geographical area (Kigadye et al. 1993). This suggests that HIV-infected women may be less likely to give birth than uninfected women. Opportunities for similar comparisons investigating the validity of sentinel surveillance data of childbearing women are, however, rare. If real, the reduced fertility in HIV-infected women has important implications for monitoring the HIV epidemic in developing countries (Boisson et al. 1996). Further studies of fertility rates in relation to HIV infection are required in order to assess the likely magnitude of the potential bias in estimating HIV prevalence from surveillance data.

In this paper we describe fertility rates in a general population cohort in relation to infection with HIV. The cohort is located in Masaka district, southwest Uganda, and includes over 3500 women of childbearing age. Prevalence and incidence of HIV, and of mortality rates during 1990 to 1996, in this cohort have previously been reported (Mulder et al. 1995; Kengeya-Kayondo et al. 1996; Nunn et al. 1997). The present analysis is based on data for the first six years of follow-up, based on annual surveys conducted between 1989/90 and 1995/6.

Methods and materials

The Medical Research Council general population cohort is located in rural southwest Uganda and comprises approximately 10,000 people residing in 15 neighbouring villages in a subcounty in Masaka district. The inhabitants are mainly subsistence farmers who produce small-scale cash crops such as bananas and coffee. The population was first surveyed in 1989-90 and has since been resurveyed annually. Detailed description of the cohort study design and methods is given elsewhere (Mulder et al. 1994). Briefly, the survey procedure at each round commences with updating of detailed village maps to identify new or demolished houses since the previous round. All households are then visited by a census taker who interviews one member of each household to enumerate all *de jure* residents, including joiners and births since the previous round, and to obtain information about leavers and those who have died. Following this, the medical team aims to interview all adult members (aged 13 years and over) and obtain a blood specimen from all consenting individuals. HIV serological status is determined by two independent enzyme-linked immuno-absorbent assays (EIA) and confirmed by Western Blot where necessary.

The present fertility analyses are based on data collected from the first seven survey rounds obtained from four sources. First, at each annual round, a census was conducted in an attempt to identify all newborns (including those who have died) since the last census and

relate them to their mothers if present in the household at the time of census. Second, since the third survey round, census takers have inquired for each woman aged 15-49 years whether they gave birth in the last 12 months, and have recorded the names of any newborns reported. Third, a monthly birth and death register, which has been maintained by village registrars since the third survey round, is used to record births which might otherwise have been missed by the census team (such as babies who were born and died before census). Fourth, at the second and seventh survey rounds, additional questions were included in the questionnaire administered by the medical survey team which asked women about their reproductive histories. Using data from these four sources it was possible to individually link all but ten babies born in the study area to resident mothers. Babies were not found for five mothers residing in the study area who reported giving birth. Five babies born to women aged under 15 years were excluded from all analyses.

Statistical analysis

All resident women aged between 15 and 49 years at one or more censuses contributed to the analyses. Women resident at two consecutive censuses contributed one year, those who joined or left between censuses contributed a half-year, and those who joined and left between censuses contributed one-third of a year to the denominator (woman-years of observation) for the calculation of fertility rates. Woman-years of observation and births occurring between each pair of censuses were stratified according to five-year age groups, marital status and HIV-status as determined at the first of the two censuses. Women who changed age group, marital status or HIV status during follow-up contributed woman-years to more than one stratum. Births were assigned to the stratum corresponding to the age, marital status and HIV status of the mother for the year in which the birth occurred. For joiners, women-years of observation and births recorded before their first census were assigned to the age, marital status and HIV category as recorded at the first survey round at which they were censused. Where possible, HIV serostatus for women resident but not blood-tested at a given round was inferred from serological results obtained at earlier (if previously HIV-positive) or later (if subsequently HIV-negative) rounds.

General fertility and total fertility rates were calculated using standard techniques (Newell 1988). Confidence intervals for general and age-specific fertility rates and rate ratios for fertility in HIV-positive versus HIV-negative women were derived from the quadratic approximation to the Gaussian log likelihood (Clayton and Hills 1993). P-values for comparing rates were based on the chi-square distribution. Rate ratios adjusted for age and marital status, together with approximate 95 per cent confidence intervals and tests of statistical significance, were derived from Poisson regression models. Odds ratios for HIV-infection in women giving birth versus women not giving birth were estimated with adjustment for age using the Mantel Haenszel techniques (Hennekens and Buring 1987). All statistical analyses were performed using the STATA computer package (StatCorp 1995).

Results

The number of women aged 15-49 censused as resident in the study area at each survey round ranged between 2000 and 2250 (Table 1). Altogether, a total of 11,420 woman-years of observation were accrued during the six-year period of follow-up. Just under one-third of women (31 per cent) were aged 15-19 years (average over six years). Information on marital status was available for 98 per cent of women. On average, 31 per cent of all women were single, 52 per cent were married, 4 per cent were widowed and 11 per cent were divorced. Among women aged 15-19 years, 72 per cent were single, 25 per cent were married and 2 per

cent were divorced. The percentage of women remaining single was 28 per cent at ages 20-24, 13 per cent at ages 25-29 and 6 per cent at ages 30 years and over.

Table 1
Study population by age, marital status and year of follow-up among women aged 15-49 at census

	Year of follow-up						Total	
Age group	1	2	3	4	5	6	Number	%
15-19	612	691	702	681	676	654	4016	31
20-24	403	389	406	406	398	404	2406	18
25-29	341	365	369	332	323	276	2006	15
30-34	216	243	255	275	280	299	1568	12
35-39	171	171	165	170	169	188	1034	8
40-44	178	168	191	198	200	168	1103	8
45-49	144	156	155	150	151	151	907	7
Marital status								
Single	694	665	654	657	662	691	4023	31
Married	1110	1140	1192	1134	1142	1085	6803	52
Widowed	70	69	75	78	89	90	471	4
Divorced	140	250	310	282	263	246	1491	11
Not known	51	59	12	61	41	28	252	2
Total number	2065	2183	2243	2212	2197	2140	13040	100
Woman-years of observation	1826	1906	1942	1948	1920	1878	11420	100

HIV serostatus was determined for 78 per cent of women surveyed (average over six years). Lowest HIV coverage was obtained for women aged 15-19 years (70%) and highest among women aged 40 years or more (85%) (Table 2). HIV prevalence was highest among women aged 20-24 years (20%). Prevalence of HIV according to marital status varied according to the age of the woman: for example, among single women aged 25 and over HIV prevalence was 20 per cent compared to 5 per cent for those aged 15-24 years, whereas for married women rates for those aged 15-24 years and 25 years and over were 8 per cent and 16 per cent respectively. Prevalence rates were generally higher in women who had been widowed or divorced. The overall prevalence rate was 12 per cent and remained relatively constant throughout the period of follow-up. While there was some evidence of a decrease in HIV prevalence across survey rounds in women aged 15-24, a reverse pattern of increasing prevalence emerged for women aged 25 years and over (Table 2). Both trends were of only borderline statistical significance (P=0.04).

Table 2
HIV coverage and positivity rates by age, marital status and year of follow-up among women aged 15-49 at census (average across six years of follow-up)

	% (Number) with known serostatus		%HIV +		
	%	(Number)	All women	15-24 yrs	25-49 yrs
Age group					
15-19	70	(2816)	5		
20-24	75	(1816)	20		

25-29	81	(1625)	18		
30-34	84	(1315)	14		
35-39	80	(828)	8		
40-44	85	(938)	9		
45-49	85	(774)	6		
Marital status					
Single	70	(2798)	7	5	20
Married	81	(5525)	11	16	8
Widowed	85	(398)	26	31	25
Divorced	82	(1225)	19	24	18
Not known	66	(166)	23	24	21
Year of follow-up					
1	87	(1803)	12	13	11
2	81	(1772)	12	12	11
3	77	(1732)	12	11	13
4	74	(1645)	11	10	12
5	75	(1641)	12	10	13
6	71	(1519)	12	10	14
Total	78	(10112)	12	11	12

A total of 2274 births were recorded among women resident in the study area. The majority of births (74%) occurred to married women and 15 per cent of births were reported by single women (Table 3). Of the 353 births recorded during the sixth year of follow-up, 219 (62%) were recorded by both the census team and village registrars, 115 (33%) were reported by census alone and 19 (5%) were identified by the village registrars alone.

Table 3
Percentage distribution of births by marital status by round among women aged 15-49 at census

	Year of follow-up						Total
	1	2	3	4	5	6	%
Marital status							
Single	20	19	13	12	11	14	15
Married	74	69	77	77	73	76	74
Widowed	1	3	1	1	2	3	2
Divorced	4	6	10	7	9	6	7
Not known	1	2	0	3	4	2	2
Total (%)	100	99	101	100	99	101	100
Total (Number)	423	432	339	350	377	353	2274

General and total fertility rates are presented in Table 4 by marital status and year of follow-up. Overall, the general fertility rate was 199 per 1000 woman-years (95% confidence interval 191 to 207) and the total fertility rate was 6.2 births per woman. Highest fertility rates were observed among married women (Table 4). Fertility rates declined during the period of follow-up; the decline was statistically significant both for general fertility (X^2 for trend = 12.2, P<0.001) and age-adjusted fertility rates (X^2 for trend= 10.5, P=0.001). The decline in general fertility was particularly marked among single women where rates declined from 136 per 1000 in year 1 to 85 in year 6 (X^2 for trend= 18.0, P<0.001). For married women, the decline in fertility was less marked (X^2 for trend= 3.63, P=0.06) but for widowed, divorced and those with unknown marital status there was no evidence of a trend in rates across time (X^2 for trend= 0.01, P=0.9)

Table 4
General and total fertility rates by year of follow-up and marital status among women aged 15-49 years at census

	General fertility rate per 1000 births				Total
Year of follow-up	Single	Married	Other	All women	fertility rate
1	136.1	312.1	121.1	231.7	7.0
2	147.5	292.0	155.0	226.6	7.0
3	78.7	242.5	108.1	174.0	5.3
4	76.5	260.7	105.7	180.2	5.5
5	77.1	269.7	171.1	196.3	6.2
6	85.2	269.2	117.1	188.0	6.1
Total	100.9	274.0	116.9	199.1	6.2

Figure 1:
Age-specific fertility rates in all women aged 15-49 at census for women and according to HIV status (women with a definitive serological status only)

Figure 1 shows age-specific fertility rates in the total study population and for women with a definitive serostatus. Among HIV-negative women and all women combined, highest fertility rates were observed in women aged 20-24 years. For HIV-positive women, the highest fertility rate was observed at ages 15-19 years. In contrast with HIV-negative women, age-specific fertility rates in HIV-positive women showed a monotonic decline in rate with increasing age.

The general fertility rate was 195 per 1000 woman-years in women testing positive for HIV and 212 per 1000 woman-years in negative women (Table 5). Lower fertility rates were observed in HIV-positive women in each age group with the exception of women aged 15-19 years where fertility rates in HIV-positive women were 1.54 times those of uninfected women (95% confidence interval 1.07 to 2.21). Fertility rates in HIV-positive women were significantly below those of HIV-negative women at ages 20-24, 25-29 and 30-34 years. At ages above 34 years, rate ratios were also below 1.0 but the reduced fertility was not statistically significant: only eight births were observed among HIV-positive women in this age band. The age-adjusted fertility rate ratio for HIV-positive versus HIV-negative women was 0.74 (95% confidence interval 0.63 to 0.87). This result is very highly statistically significant ($P<0.001$).

Table 5
Age-specific fertility rates (ASFR), general fertility rates and rate ratios (RR) for fertility in HIV-positive versus HIV-negative women aged 15-49 at census

	HIV-positive			HIV-negative			RR HIV+ versus HIV-		
Age group	Births	Woman-years	ASFR/1000	Births	Woman-years	ASFR/1000	RR	95% CI	
15-19	31	111.1	279.0	418	2299.4	181.8	1.54	1.07	2.21
20-24	73	282.2	258.7	460	1310.4	351.0	0.74	0.58	0.94
25-29	54	236.6	228.2	392	1233.4	317.8	0.72	0.54	0.95
30-34	16	146.3	109.4	270	1051.7	256.7	0.43	0.26	0.71
35-39	6	49.7	120.7	128	732.8	174.7	0.69	0.31	1.57
40-44	2	74.4	26.9	59	819.3	72.0	0.37	0.09	1.53
45-49	0	33.9	0.0	4	705.7	5.7	0.00	-	-
Total	182	934.2	194.8[a]	1731	8152.7	212.3 [a]	0.74[b]	0.63	0.87

[a] General fertility rate

[b] Rate ratio in HIV-positive versus HIV-negative women adjusted for age

Fertility rate ratios adjusted for age alone, and for age and marital status, are presented according to year of follow-up in Table 6. Lower fertility in HIV-positive women was evident in all six years but was only statistically significantly below that of HIV-negative women in year 3 (P=0.02). In year 4, age-adjusted rates in the two groups were similar (RR=0.93) but diverged again during the last two years of follow-up. Additional adjustment for marital status had little effect on the overall rate ratio estimate.

Table 6
Rate ratios (RR) for fertility in HIV-positive women versus HIV-negative women by year of follow-up. Adjusted for age alone and age and marital status

	Age-adjusted fertility rate ratio (RR)			
Year of follow-up	RR	95%CI		P-value
1	0.72	0.50	1.02	0.07
2	0.81	0.58	1.15	0.24
3	0.60	0.39	0.93	0.02
4	0.93	0.64	1.35	0.70
5	0.74	0.50	1.10	0.14
6	0.69	0.45	1.06	0.09
All years: adjusted for age	0.74	0.63	0.87	P<0.001
All years: adjusted for age and marital status	0.75	0.64	0.88	P<0.001

Data were not collected on age at first sexual intercourse or age at marriage. In order to examine whether HIV-positive women started sexual activity earlier than HIV-negative women we therefore compared the marital status distribution of women aged 13-19 years. In this age group, HIV-positive women were twice as likely to be married as HIV-negative women (Table 7). The difference in marital status distributions was highly statistically significant (P<0.001).

Table 7
Marital status of women aged 13-19 according to HIV status

	HIV-positive		HIV-negative	
Marital status	Number	%	Number	%

Single	55	38	1884	72
Married	71	49	685	26
Widowed	3	2	5	0.2
Divorced	17	12	56	2
Total	146	101	2630	100

X^2 for difference (df=3) = 113.0; P < .001.

Age-specific HIV prevalence rates are presented separately for women who gave birth during the study period and those who did not (Table 8). Overall, women who gave birth had 44 per cent lower odds of being HIV-positive than women who did not give birth, after adjusting for age (OR=0.56, 95% confidence interval 0.48 to 0.67). Lower HIV prevalence among women giving birth was observed in all age groups except ages 15-19 years where the odds of being HIV-positive were 43 per cent higher in women who gave birth.

Table 8
HIV prevalence by age in women who gave birth during period of observation and those who did not

	Number (%) HIV positive					
Age group	Gave birth		Did not give birth		Odds ratio[a]	P-value
13-19	448	(6.9)	2368	(4.9)	1.43	0.09
20-24	533	(13.7)	1283	(22.8)	0.54	<0.001
25-29	446	(12.1)	1179	(20.4)	0.54	<0.001
30-34	286	(5.6)	1029	(16.7)	0.30	<0.001
35-39	134	(4.5)	694	(8.2)	0.52	0.14
40-44	61	(3.3)	877	(9.7)	0.32	0.1
45-49	4	(0.0)	770	(5.7)	-	-
Total	1912	(9.5)	8200	(12.3)	0.56[b]	<0.001

[a] Odds ratio for being HIV-positive in women giving birth versus those not giving birth

[b] Odds ratio adjusted for age

Discussion

In this cohort study of over 3500 women of reproductive age located in rural southwest Uganda, the general fertility rate was 199 per 1000 woman-years (95% confidence interval 191-207) and the total fertility rate was 6.2 births per woman. Fertility rates declined significantly during the six-year period of follow-up (1989/90 to 1995/6), from 232 per 1000 (7 births per woman) to 188 per 1000 woman-years (6.1 births per woman). These rates are somewhat lower, and have declined faster, than those reported in two recent Demographic Health Surveys carried out in Uganda where total fertility rates over a similar period declined from 7.3 in 1989 to 6.8 in 1995 (Statistics Department, Uganda 1996). Fertility rates reported in the 1991 Population and Housing census for the whole of rural Uganda were also higher: TFR=7.3 births (Statistics Department, Uganda 1995). A recent study found that 8.7 per cent of men and 9.6 per cent of women in rural Masaka made use of modern contraceptive methods compared to 1.8 per cent of men and 1.7 per cent of women in rural Lira, located in northern Uganda (Blanc et al. 1996). These findings suggest that contraceptive use in rural Masaka may be higher than average for Uganda and this could explain the lower fertility rates found in the present study population. The decline in fertility observed over the period of

study was particularly evident among single women. This may reflect behaviour change, with single women increasingly postponing childbearing until after marriage, and increased use of contraception among single women. Data on contraceptive use were not collected during the study period, so it is not possible to investigate this issue further.

One of the major objectives of the study was to describe fertility rates in relation to infection with HIV. The overall prevalence of HIV infection in the present study population was 12 per cent and remained relatively stable during the study period. During the six-year period of follow-up, the general fertility rate was 212.3 births per 1000 woman-years in women without HIV infection and 194.8 per 1000 in HIV-infected women. After adjustment for age, the fertility rate in HIV-infected women was estimated as 0.74 of that in uninfected women (95% confidence interval 0.63 to 0.87; $P<0.001$). When combined with an overall HIV prevalence rate of 12 per cent, this corresponds to a three per cent reduction in fertility rates in the whole population.

Additional adjustment for marital status had little effect on estimated reduction in fertility in HIV-infected women but we were not able to adjust for the effects of several other potential confounding factors. In this context, the lack of data on sexually transmitted diseases is notable. Active syphilis, in particular, has been associated with reduced pregnancy rates in African women (Serwadda et al. 1997). As syphilis is also likely to be more common in HIV-infected women, the lack of adjustment would tend to slightly exaggerate the reduced fertility in HIV-infected women found here. We plan to carry out serological testing for active syphilis using stored sera for a sample of women in this population for use in further analyses in order to investigate this further.

Our estimate of 26 per cent lower fertility associated with HIV infection is broadly similar to the reduction of 20 per cent found in a one-year follow-up of a cohort of Ugandan women residing in the neighbouring district of Rakai (Sewankambo et al. 1994) and of 23 per cent among Zairean women followed for three years postpartum, after adjustment for birth control use (Ryder et al. 1991). In contrast, a substantially larger study carried out in Rakai district found that women with HIV infection, but without serological syphilis, had 52 per cent lower pregnancy rates than women without HIV infection or serological syphilis, after adjusting for age, marital status, gravidity, contraceptive use, lactation, history of subfertility and recent sexual history (Serwadda et al. 1997). The difference between the current findings and those of Serwadda et al. is surprising, given the close proximity of the two study populations, and is unlikely to be due to chance. It is possible that some births may have been missed in our study, but we would need to speculate a greater loss among HIV-negative women to explain the more modest effect of HIV on fertility found here. We have no data with which to assess this possibility but it seems biologically implausible. A more likely explanation is that the present population-based fertility estimates do not take account of the period following birth during which women are not at risk of getting pregnant. We would expect adjustment for this period to increase fertility rates in HIV-negative women relative to those of HIV-positives because of the larger number of births in HIV-negative women.

In contrast with the general pattern of lower fertility among HIV-infected women, infected women aged 15-19 had significantly higher fertility than uninfected women (RR=1.54, 95% confidence interval 1.07 to 2.21). This may reflect earlier sexual activity among women who became infected with HIV. Although data were not available on age at first sexual intercourse or age at marriage, HIV-infected women in this age group were almost twice as likely to be married as uninfected women, which lends support to this suggestion.

Despite current uncertainty about the exact magnitude of the effect, our findings support the suggestion that infection with HIV appears to be associated with substantially reduced fertility in sub-Saharan populations. There are several possible reasons why this might be, including biological, social and clinical (Gregson 1994). As far as biological factors

are concerned, it may be that HIV infection itself results in infertility or early foetal loss. HIV infection has been associated with non-ulcerative sexually transmitted diseases in women (Laga et al. 1993) which can result in pelvic inflammatory disease and consequent infertility (Frank 1983; Cates, Rolfs and Aral 1993). Women infected with HIV may also have higher rates of spontaneous abortions and stillbirth due to HIV transmission *in utero* (Langston et al. 1995). While plausible, the role of such biological factors is difficult to address in an epidemiological study such as ours with a large sample size.

As far as social factors are concerned, women infected with HIV may voluntarily reduce their fertility by changing their sexual behaviour or by increased use of contraception. Some data on sexual behaviour were collected during the fourth and fifth survey rounds and we will investigate this issue in further analyses. In the current study, however, the vast majority of women were unaware of their HIV status and greater use of voluntary fertility reduction among HIV-positive women therefore seems unlikely. Moreover, while we did not collect data on use of contraception for the current study, independent data from Masaka district suggest that use of modern contraceptives is less than ten per cent in this population (Blanc et al. 1996).

While many women may not know their HIV serostatus, those with advanced disease (particularly AIDS-defining symptoms, such as weight loss or fever), or those whose partner has recently died of AIDS, may suspect it and alter their sexual behaviour accordingly. Symptomatic women may reduce or stop sexual activity because of symptoms associated with advanced disease while those experiencing significant weight loss may become amenorrhoeic. Data from an ongoing natural history cohort study of a subset of HIV-positive women in the present study population suggest that around half have symptoms compatible with WHO clinical stage 3 or 4, which includes significant weight loss and chronic fever (D. Morgan, personal communication). Both asymptomatic and mildly symptomatic HIV-infected women have been found to experience significantly more episodes of amenorrhoea (Chirgwin et al. 1996). A reduction in fertility caused by HIV infection itself cannot therefore be ruled out.

The use of HIV prevalence in pregnant women to predict prevalence in women in the general population is subject to a number of culturally and socially-specific biases, of which differential fertility in HIV-positive and negative women is an important one (Boisson et al. 1996). The current finding of lower fertility in HIV-infected women has important implications for the interpretation of estimates of HIV prevalence resulting from sentinel surveillance data. With the exception of teenage women, the odds of HIV infection in women who gave birth during the study period were consistently lower than that of women who did not give birth. Odds ratios for HIV infection in women aged 20 or more (Table 8) suggest that HIV prevalence derived from antenatal clinic data may underestimate infection in the population by as much as 50 per cent. Recent surveillance data from Uganda have been interpreted as suggesting that prevalence in urban areas may be declining (Asiimwe-Okiror et al. 1995). Although lower prevalence of HIV infection in women giving birth may have less serious implications for extrapolating trends in antenatal clinic data to the general population, such predictions may not be completely free from bias (Serwadda et al. 1997). Biases associated with extrapolating from HIV prevalence in antenatal clinic attenders to the general population warrant further study.

Conclusion

In this cohort of over 3500 women of childbearing age in rural southwest Uganda infection with HIV was associated with 26 per cent lower fertility, after adjusting for age ($P<0.001$). When combined with an overall HIV prevalence rate of 12 per cent, this corresponds to a three per cent reduction in fertility rates in the whole population. These findings are unlikely

to be explained by differences in marital status, or increased use of contraception among uninfected women, as use of modern contraceptive methods in rural Uganda is low and fewer than ten per cent of women were aware of their HIV-serostatus. More likely explanations are reduced sexual activity due to clinical symptoms associated with HIV infection or lower fertility associated with co-existing infections with other sexually transmitted diseases, such as syphilis. A reduction in fertility caused by HIV infection itself cannot be excluded.

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