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Late marriage and the HIV epidemic in sub-Saharan Africa

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The causes of large variation in the sizes of HIV epidemics among countries in sub-Saharan Africa are not well understood. Here we assess the potential roles of late age at marriage and a long period of premarital sexual activity as population risk factors, using ecological data from 33 sub-Saharan African countries and with individual-level data from Demographic and Health Surveys (DHS) in Kenya and Ghana in 2003. The ecological analysis finds a significant positive correlation between HIV prevalence and median age at first marriage, and between HIV prevalence and interval between first sexual intercourse and first marriage. The individual-level analysis shows that HIV infection per year of exposure is higher before than after first marriage. These findings support the hypothesis of a link between a high average age at marriage and a long period of premarital intercourse during which partner changes are relatively common and facilitate the spread of HIV.

Keywords: HIV; marriage; sexual behaviour; AIDS epidemic; incidence; prevalence; sub-Saharan Africa

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Since the identification of the HIV virus in the early 1980s, much has been learned about how the virus is transmitted and how it attacks the body's immune system and causes AIDS. This knowledge has provided the basis for the development of increasingly effective antiretroviral therapies, and researchers continue to try to develop microbicides and vaccines. Unfortunately, considerably less progress has been made in understanding the epidemiology of HIV. In particular, the social and behavioural determinants of the disease and its geographic distribution are not well understood.

One of the most puzzling features of the HIV epidemic in sub-Saharan Africa is the large variation in its size among countries. The proportion of adults infected ranges from 33 per cent in Swaziland to less than 1 per cent in Mauritania, Madagascar, and Senegal (UNAIDS 2006). Several factors are believed to be conducive to large epidemics: high frequency of sexual intercourse outside marriage, multiple sexual partners, absence of condom use, absence of circumcision of males, and infection with other sexually transmitted diseases (Cameron et al. 1989; Caldwell 2000; Quinn et al. 2000; Shapiro 2002). The evidence for an important effect of genital ulcer disease and the circumcision of males is strong (Cameron et al. 1989; Halperin and Bailey 1999; Weiss et al. 2000; Auvert et al. 2001; Bailey et al. 2001; Buvé et al. 2001). In contrast, it has proved difficult to demonstrate that variation in sexual behaviour has a prominent role in the epidemic even though heterosexual intercourse is the main mode of transmission of HIV in sub-Saharan Africa. As noted by Cleland et al. (2004a, p. ii1): 'Thus far behavioral data have had relatively weak explanatory power for elucidation of cross national differences.'

The present study examines the hypothesis that late average age at marriage is another factor contributing to the spread of HIV because late marriage leads to a long period of premarital sexual activity. Throughout the less developed world marriage is the central social institution that regulates and sanctions sexual behaviour. This suggests that age at marriage and sexual behaviour before and after marriage could play a role in the spread of HIV, but despite a few notable efforts (Orubuloye et al. 1994; Caraël 1995; Cleland and Ferry 1995; Bracher et al. 2003; Clark 2004; Cleland et al. 2004b; Spark-du Preez et al. 2004), these factors have been neglected in past research. One reason for this neglect is that the role of the timing of marriage

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in the epidemic is not obvious and the evidence about its role appears to be conflicting. Ecological data indicate that those countries in southern Africa with a very late age at marriage also have large epidemics. However, some recent studies suggest that young married women are at higher risk of infection than unmarried sexually active women (Auvert et al. 2001; Clark 2004). These issues will be examined below, using both ecological data for sub-Saharan African countries and individual-level data for Kenya and Ghana.

Data and methods

The ecological analysis relies on country-level epidemiological and demographic data from 33 countries in sub-Saharan Africa. Estimates of HIV prevalence among women aged 15–49 in 2005 were taken from UNAIDS (2006). Estimates of median ages at first marriage and at first sexual intercourse were calculated from nationally representative Demographic and Health Surveys (DHS). In a typical DHS survey several thousand women of reproductive age (15–49) are interviewed and information is collected on a wide array of demographic, behavioural, and health issues. Median ages at events for women were calculated from current-status information from all countries for which the individual data files were available for analysis. The reported proportions having ever experienced the event at the time of the survey by single age were calculated and then smoothed using a three-year moving average. The median is the age at which this proportion reaches 50 per cent. Following DHS convention, the term 'marriage' refers to both formal marriage and consensual union. (Estimates of current median ages at first sexual intercourse and first marriage were calculated from the individual data files for 28 countries. In four other countries the medians for women aged 25–29 published in the first country report are used because data files were not available. For Swaziland no DHS was available and the median age at first marriage was calculated from proportions ever-married by age from United Nations (2000) and the median age at first sexual intercourse was set equal to the average of the medians in the four other countries in southern Africa.)

In countries with multiple DHS surveys, only data from the latest available year are used. As a result, the year in which the median age at first sexual intercourse and first marriage are estimated from the DHS ranges from 1986 to 2004. This is earlier than the year of the HIV estimate—2005. This difference is not likely to be a significant problem for two reasons. First, the timing of first sexual intercourse has, on average, changed little over time. In the 17 sub-Saharan African countries with at least two DHS surveys the trend in the median age at first sexual intercourse showed a negligible average decline of -0.001 years per year between the two most recent surveys. The corresponding trend in the median age at first marriage was slightly positive with an average increase of 0.057 years per year. Second, the time of infection with HIV is generally several years before the year in which HIV prevalence is measured, because, on average, individuals live for about a decade between the time of infection and the date of death from AIDS.

Individual-level analysis in the present study relies on DHS surveys conducted in Kenya and Ghana in 2003 (Central Bureau of Statistics et al. 2004; Ghana Statistical Service et al. 2004). These surveys were among the first to measure HIV status in a nationally representative sample of women and men. In most other countries in sub-Saharan Africa national estimates of HIV prevalence have been derived from sentinel surveillance of pregnant women attending antenatal clinics, which may result in bias for a number of reasons (Zaba et al. 2000, 2005b). Survey estimates too may contain some bias because a small proportion of respondents decline to be tested. In the Kenya DHS 14.4 per cent of 4,303 eligible women refused to be tested for HIV and in the Ghana DHS 5.7 per cent of the 5,940 eligible women refused. However, comparisons of women who did and did not consent indicate little or no evidence for a consistent relationship between consent status and variables associated with higher HIV risk (Central Bureau of Statistics et al. 2004; Ghana Statistical Service et al. 2004). Survey estimates of prevalence are therefore widely accepted as reasonable and preferable to estimates derived from antenatal clinic data (UNAIDS 2006). In addition, the ability to link HIV status to other information collected in standard DHS surveys provides a unique opportunity to examine the socio-economic, demographic, and behavioural correlates of HIV infection (Zaba et al. 2005a). Logistic regression analysis is used to estimate the effects of marital status on the risk of infection.

Results of ecological analysis

The median ages at first sexual intercourse for women in the 33 countries in sub-Saharan Africa

fall within the relatively narrow range of 16.3–20.8 years. Because some underreporting of sexual intercourse and over-reporting of age at first sexual intercourse among never-married women is likely to have occurred, these medians are probably slight overestimates, in particular in countries with the highest reported medians (Caraël and Holmes 2001; Zaba et al. 2004). As shown in Figure 1, the median age at first marriage has a much wider range—from 16.3 years in Niger to 28.9 years in Namibia. The four highest median ages at first marriage are found in Botswana (25.7), Swaziland (25.8), South Africa (26.7), and Namibia (28.9). These four countries have among the largest HIV epidemics in the world.

Simple correlation analyses were undertaken as a first step in the assessment of potential roles for the timing of first sexual intercourse and first marriage. Figure 2 plots HIV prevalence for the 33 countries by the median age at first sexual intercourse. The correlation between these two variables is not statistically significant. In contrast, as shown in Figure 3, the correlation between HIV prevalence and the median age at first marriage for these countries is positive and highly significant ($r = 0.61$, $p < 0.001$). These findings suggest that epidemic size is related to the interval between age at first sexual intercourse and age at first marriage. Figure 4 plots HIV prevalence by the difference between median ages at first marriage and first sexual intercourse. The correlation is again positive and highly significant ($r = 0.63$, $p < 0.001$).

The association evident in Figure 4 may be due in part to the confounding effect of other risk factors. One of the best established of these factors is circumcision of males. The correlation between HIV prevalence and the proportion of males circumcised is 0.63 ($p < 0.001$) for the 33 countries. To

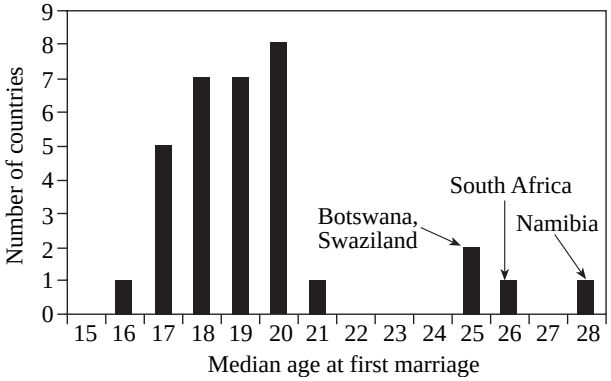

Figure 1 Distribution of median age at first marriage for 33 countries in sub-Saharan Africa
Source: DHS data files, latest available year 1986–2004

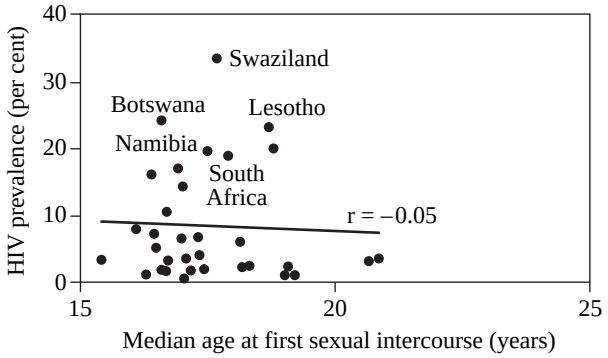

Figure 2 HIV prevalence by median age at first sexual intercourse for women, 33 countries in sub-Saharan Africa
Source: DHS data files, latest available year 1986–2004; UNAIDS 2006

determine the separate roles of delayed marriage and circumcision, a multivariate regression is calculated in which HIV prevalence is the dependent variable and the explanatory variables are the proportion of males circumcised and the difference between the median ages at first sexual intercourse and first marriage. The results from this regression are summarized in Table 1. Both explanatory variables have highly significant effects on HIV prevalence in the expected direction: an additional year of premarital sexual intercourse raises HIV prevalence by 1.52 per cent ($p < 0.001$) and a 10 per cent increase in circumcision reduces prevalence by 1.28 per cent ($p < 0.001$). These two risk factors together explain 64 per cent of the between-country variation in HIV prevalence.

The results in Figures 3 and 4 indicate that countries with late marriage and high HIV prevalence are concentrated in southern Africa (the exception is Lesotho, which is surrounded by South Africa and has high prevalence but not late marriage). To

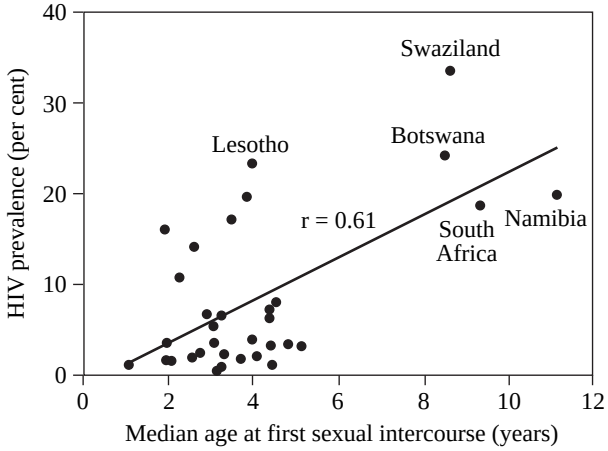

Figure 3 HIV prevalence by median age at first marriage for women, 33 countries in sub-Saharan Africa
Source: As for Figure 2

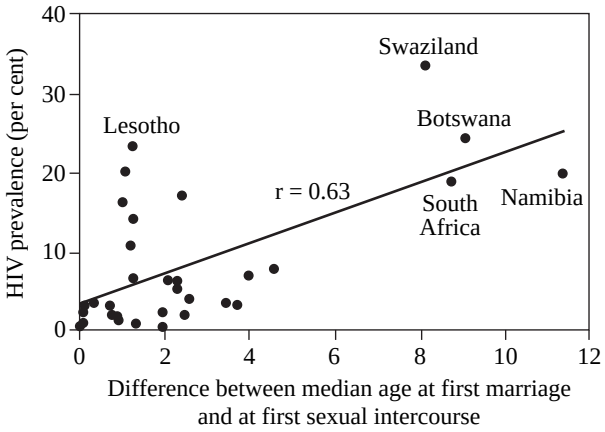

Figure 4 HIV prevalence by difference between the median age at marriage and median age at first sexual intercourse, 33 countries in sub-Saharan Africa
Source: As for Figure 2

examine regional differences within sub-Saharan Africa, Table 2 presents unweighted averages of various indicators for three regional groupings of the 33 countries: West ($N=12$), East/Middle ($N=16$), and South ($N=5$). HIV prevalence is lowest in the West (2.5 per cent), intermediate in the East/Middle (7.9 per cent), and highest in the South (23.8 per cent), and the differences between regions are all statistically significant. As expected from the regression results, the South also has a significantly higher median age at first marriage (25.4 years) than the East/Middle (19.2 years) and West (19.1 years). In addition, the South has a significantly lower rate of circumcisions (21.2 per cent) than the other regions. There are no significant differences between East/Middle and West in the median age at first sexual intercourse or in the median age at first marriage. However, the East/Middle has a significantly lower circumcision rate than the West (77.8 per cent vs. 46.9 per cent) and this may in part explain the higher HIV prevalence in the East/Middle.

Table 1 Regression estimates (OLS) of effects of years of premarital sexual intercourse and circumcision of males on HIV prevalence (per cent) in 33 sub-Saharan countries

	Coefficient	p-Value
Difference between median ages at first sexual intercourse and first marriage (years)	1.52	<0.001
Percentage of males circumcised	−0.128	<0.001
Constant	11.4	<0.001
N	33	
R^2	0.64	

Source: DHS data files; Wendell and Werker 2004; UNAIDS 2006.

The preceding ecological analysis focused on inter-country and inter-regional differences in the timing of marriage and HIV prevalence. There is another ecological dimension that can shed light on this relationship: urban vs. rural within countries. Although reliable estimates of urban and rural HIV prevalence do not exist, it is well established that urban prevalence is significantly higher than rural prevalence in many countries (UNAIDS 2006). The question then is whether the association between late age at marriage and the HIV epidemic also exists for urban–rural differences. Figure 5 presents averages of the median ages at first sexual intercourse and first marriage in urban and rural areas for 32 countries (estimates are not available for Swaziland). The results show that the median age at first marriage in urban areas (20.4 years) exceeds that of rural areas (18.5 years) by 1.9 years, on average. An urban–rural difference in median age at first sexual intercourse also exists (17.9 vs. 17.0), but it is smaller than for age at marriage. As a result, the interval in which premarital intercourse can occur is significantly larger in urban than in rural areas (1.9 vs. 0.9 years, $p<0.01$).

All these ecological results are consistent with the hypothesis that a long period of premarital sexual intercourse contributes to the spread of HIV. But ecological evidence needs to be used with caution. It does not prove a causal relationship—the observed associations could be due in part to unobserved country-specific factors. Therefore, instead of pursuing the ecological analysis any further, the following analysis investigates the issue with individual-level data.

Results of individual-level analyses in Kenya and Ghana

The discussion of results will focus on Kenya, but comparable statistics for Ghana will be included in the tables and figures. Estimates for Kenya are more robust than for Ghana because Kenya's HIV prevalence is more than twice the level in Ghana.

The median age at first sexual intercourse for Kenyan women in 2003 is 18.1 years, and by the mid-20s nearly all women report having ever had sexual intercourse. The median age at first marriage is 20.5 years, and after age 30 all but a few per cent of women have ever married. These medians changed little over the decade between the 1993 and 2003 DHS surveys. The proportion previously married is very small before age 20 and rises slowly with age. In Ghana the median ages at first sexual intercourse

Table 2 HIV prevalence among women aged 15–49 in 2005, median ages at first sexual intercourse and first marriage, and proportion of males circumcised. Unweighted country averages by region

	Region			
	West	East/Middle	South	Total
HIV prevalence (per cent)	2.5	7.9[1]	23.8[1]	9.7
Median age at first sexual intercourse (years)	17.2	17.7	17.7	17.5
Median age at first marriage (years)	19.1	19.2	25.4[1]	20.1
Difference, first sexual intercourse and first marriage (years)	1.9	1.4	7.7[1]	2.6
Circumcised males (per cent)	77.8	46.9[1]	21.2[1]	54.3
N	12	16	5	33

[1]Significantly different from West Africa ($p < 0.05$).
Source: DHS data files; Wendell and Werker 2004; UNAIDS 2006.

and first marriage are 18.2 and 20.1, respectively, indicating a slightly shorter period of premarital intercourse than in Kenya.

Current HIV status

Overall 8.7 per cent of women aged 15–49 in the DHS sample tested positive for HIV. HIV prevalence is higher for currently married than for never-married women (8.0 vs. 4.7 per cent). The formerly married have still higher levels of infection (23.7 per cent). One reason for the low prevalence among never-married women is that a proportion of them have never been sexually active. HIV prevalence among the never-married who have had sexual intercourse (8.7 per cent) is slightly higher than among the currently married (8.1) and slightly lower than among the ever-married (10.7 per cent). These estimates are difficult to interpret because they are not adjusted for differences in age distributions.

HIV prevalence by age and by partnership status among women who ever had sexual intercourse is presented in Table 3. HIV prevalence shows a typical inverted U-shape pattern by age, reaching a maximum at 13.3 per cent in the age group 25–29. HIV prevalence varies considerably by partnership status, from a low of 7.6 per cent among formally married women to a high of 30.2 per cent among widows. Compared to the reference group of the formally married, the adjusted odds ratios for all other relationship groups are higher than one, but these effects are only significant for the widows and separated groups. The last column of Table 3 presents odds ratios for partnership status adjusted for age and years since first sexual intercourse. The results are very similar to those for odds ratios adjusted for age only.

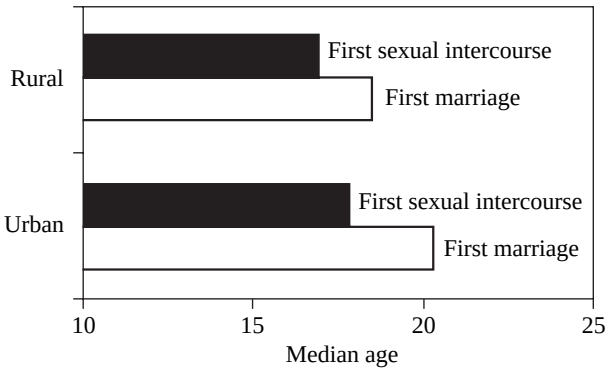

Figure 5 Urban and rural median age at first sexual intercourse and first marriage, average of 32 countries in sub-Saharan Africa
Source: DHS data files, latest available year 1986–2004

These results for the connection between current partnership status and current HIV status should be interpreted with caution. The problem is that the status at the time of infection is not known. Women who test positive at the time of the survey have been infected at some earlier time, which may be as much as a decade previously. This implies that a substantial proportion of women in one status (e.g., currently married) might have been infected while they were in another status (e.g., never-married). To explain present HIV status it is necessary to look at past behaviour.

Past exposure to risk of infection

The great majority of HIV infections in sub-Saharan Africa are the result of heterosexual transmission. One would therefore expect the probability of a woman being infected at a given age to be positively related to the number of years she had been sexually active. This issue will now be explored with a multivariate regression analysis of HIV status of women aged 15–29. Years since first sexual intercourse is the main explanatory variable of interest

Table 3 HIV prevalence and adjusted odds ratio by age group and partnership status among women who had ever had sex, Kenya and Ghana 2003

Age group	Prevalence (per cent)	*N*	Odds ratio (95% CI)	
			Adjusted for age	Adjusted for age and years since first sexual intercourse
Kenya				
15–19	4.6	309		
20–24	10.3	565		
25–29	13.3	507		
30–34	11.8	435		
35–39	11.8	345		
40–44	9.5	275		
45–49	3.9	201		
Partnership status				
Never-married	8.7	403	1.49 (0.87–2.55)	1.55 (0.87–2.8)
Married (formal)	7.6	1,721	1	1
Living together	11.3	176	1.52 (0.86–2.68)	1.45 (0.82–2.57)
Widowed	30.2	133	7.96 (4.76–13.29)	8.14 (4.7–14.1)
Divorced	16.5	41	2.37 (0.90–6.26)	2.62 (0.99–6.92)
Separated	19.9	162	2.99 (1.83–4.87)	3.17 (1.91–5.27)
Total	10.1	2,636		
Ghana				
15–19	1.3	411		
20–24	2.3	766		
25–29	3.5	838		
30–34	4.2	703		
35–39	4.7	647		
40–44	3.0	504		
45–49	2.5	437		
Partnership status				
Never-married	2.5	651	1.58 (0.73–3.39)	1.54 (0.69–3.42)
Married (formal)	2.7	2,772	1	1
Living together	4.5	420	1.98 (1.13–3.49)	2.07 (1.17–3.67)
Widowed	6.7	95	3.05 (1.29–7.20)	3.01 (1.20–7.56)
Divorced	4.5	167	1.65 (0.68–3.97)	1.75 (0.73–4.22)
Separated	7.6	201	3.26 (1.69–6.27)	2.69 (1.29–5.63)
Total	3.2	4,306		

Source: Kenya DHS 2003 (Central Bureau of Statistics et al. 2004) and Ghana DHS 2003 (Ghana Statistical Service et al. 2004).

and the analysis includes controls for the confounding effects of age, ever-married status, years of education, and place of residence. The results from this regression are summarized in Table 4, model 1. The odds ratio for each year since first sexual intercourse is significantly higher than one, which implies that prevalence rises with duration of exposure. The effects of marital status (ever-married), rural/urban residence, years of education, and age are not significant.

The DHS surveys do not provide information about marital status at the time of infection and there is therefore no direct way of determining whether exposure is riskier before or after marriage. But it is possible to shed light on this issue by dividing the interval of exposure since first sexual intercourse into two components: years of exposure before marriage (i.e., between first sexual intercourse and first marriage) and after first marriage (i.e., between age at first marriage and the respondent's current age). This is the approach used in a second regression which includes these two new explanatory variables instead of years since first sexual intercourse (marital status is dropped owing to co-linearity). The results (Table 4, model 2) show that the odds ratios for each additional year of exposure before and after marriage are both significantly higher than 1.0. (Repeating the regressions including only currently or ever-married women gave very similar results, which are not presented.)

Table 4 Odds ratios for effects of duration of exposure to infection on HIV status among sexually active women aged 15–29 in 2003 in Kenya and Ghana

	Odds ratio (95% CI)	
	Model 1	Model 2
Kenya		
Years since first sexual intercourse	1.16 (1.07–1.26)	
Exposure before first marriage (years)		1.21 (1.12–1.31)
Exposure after first marriage (years)		1.11 (1.02–1.21)
Urban residence	1.45 (0.92–2.29)	1.37 (0.86–2.18)
Years of education	1.05 (0.99–1.12)	1.02 (0.96–1.09)
Age	2.22 (0.98–4.99)	2.36 (1.08–5.19)
Age squared	0.98 (0.97–1.00)	0.98 (0.97–1.00)
Ever-married	1.44 (0.78–2.65)	
N	1,364	1,364
Ghana		
Years since first sexual intercourse	1.15 (1.00–1.32)	
Exposure before first marriage (years)		1.22 (1.07–1.40)
Exposure after first marriage (years)		1.08 (0.94–1.24)
Urban residence	1.14 (0.54–2.39)	1.02 (0.48–2.17)
Years of education	1.00 (0.92–1.08)	0.98 (0.91–1.05)
Age	0.63 (0.20–1.98)	0.54 (0.19–1.58)
Age squared	1.01 (0.99–1.03)	1.01 (0.99–1.04)
Ever-married	0.89 (0.32–2.50)	
N	2,009	2,009

Source: As for Table 3.

This indicates that increased duration of exposure raises HIV prevalence regardless of whether the exposure occurs before or after marriage. The annual risk of infection is significantly higher for exposure before than after marriage (odds ratios of 1.21 vs. 1.11 in Kenya and 1.22 vs. 1.08 in Ghana). This finding is consistent with a recent study by Zaba et al. which used a similar multivariate analysis with data from an antenatal clinic (ANC) surveillance study in Tanzania (7,000 women). The study found that each year of exposure to premarital intercourse was associated with an odds ratio of 1.12 and that each year of marital exposure gave an odds ratio of 1.08 (Zaba et al. 2005a). Their estimates and ours are summarized in Figure 6, which plots odds ratios for HIV infection by marital status for Kenya and Ghana and compares them with the estimates from the Tanzanian ANC study.

The main finding from these regressions is that the odds ratios for HIV infection before first marriage exceed those after marriage in all three populations. This difference reflects a higher incidence of HIV infection among women before marriage than after marriage. But when interpreting the results in this way, it should be kept in mind that the estimates in Table 4 are derived from information on women who survived to be interviewed in the DHS survey. These odds ratios are downwardly biased estimates of the true odds ratios at the time of infection because mortality between the time of infection and the time of the survey is higher for infected than for uninfected individuals. Differences in odds ratio by marital status (the main focus of this study) are affected by this bias because the average age at infection before marriage is somewhat lower than the average age at infection among the ever-married.

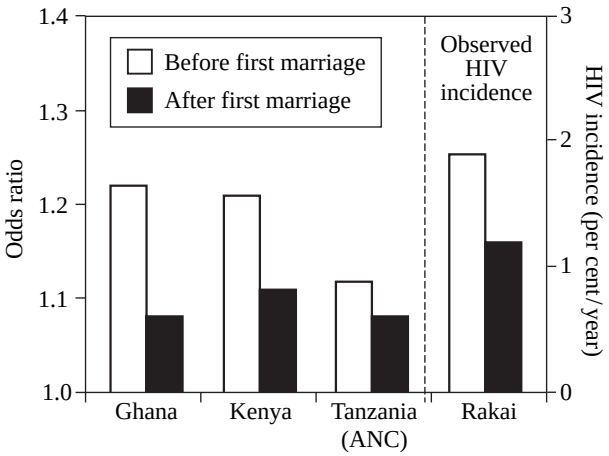

Figure 6 Odds ratios for HIV infection associated with a year of exposure before and after first marriage in Ghana, Kenya, and Tanzania, and HIV incidence in Rakai 1994–2004

Source: Ghana DHS 2003; Kenya DHS 2003; Gray et al. 2004; Zaba et al. 2005a, Table 4

As a result, the downward bias is larger among the never-married than among the ever-married. This bias makes it more difficult to establish the effects of marital status, with the consequence that the actual differences between odds ratios before and after first marriage are probably larger than the differences estimated from the regressions in Table 4.

The marital status differentials in odds ratios for HIV infection in Kenya and Ghana and in the Tanzanian ANC study are consistent with differentials in HIV incidence observed in a unique prospective study in the Rakai district of Uganda. Direct estimates of HIV incidence by marital status are available from annual surveillance data from 1994 to 2004 on a population of approximately 12,000 adults aged 15–49 in 50 rural communities in Rakai. Gray et al. report a current incidence of 1.9 per cent per year for sexually active never-married women and 1.2 per cent per year for currently married women (Gray et al. 2004). Figure 6 (right axis) plots these estimates of current HIV incidence rates for never-married and currently married women in Rakai and compares them with the odds ratios for Kenya, Ghana, and the Tanzanian ANC study. In these four populations the risk of HIV infection per year of exposure among currently or ever-married women is substantially lower than that among sexually active never-married women.

Discussion

Two risk factors seem likely to explain the higher risk of HIV infection among sexually active never-married women: a higher rate of partner change and higher infectivity of partners.

Epidemic models have demonstrated the critical role of a high rate of acquiring new partners in the spread of epidemics (Anderson 1999). For uninfected individuals frequent partner change raises the risk of encountering an infected partner, and for infected individuals any new partner implies a new chance to spread the infection. Concurrent partnerships appear to be particularly conducive to the spread of HIV through networks of individuals (Morris and Kretchmar 1997; Halperin and Epstein 2004). According to the DHS in Kenya the average number of partners in the past year was lower for never-married than for currently married women (0.59 vs. 0.98 partners/year), but for nearly all married women the partner is the husband. Among currently married women, the proportion of women who had a non-spousal partner in the past year was only 2 per cent, which is much lower than among never-married women who ever had sexual intercourse (57 per cent). The difference between married and never-married women is probably smaller than these estimates suggest, because underreporting of non-marital partners tends to be higher among married than among single women (Nnko et al. 2004).

The infectivity of partners is not measured in the DHS, but a brief discussion of this issue may be helpful. The level of infectivity (i.e., the rate of transmission from an infected to an uninfected individual per sexual contact) depends strongly on time since infection. Infectiousness is very high for a brief period of a few months after acquiring HIV (Anderson 1996, 1999; Koopman et al. 1997; Shiboski and Padian 1998; Pilcher et al. 2004; Wawer et al. 2005). Following this initial episode of high infectivity, the rate of transmission declines to very low levels for most HIV-positive individuals for a period of years, during which HIV infection is latent and disease is not evident. This pattern was clearly documented for Rakai. The average rate of transmission there between an infected and uninfected individual was estimated at 0.0012 infections per sexual act in discordant couples, but this rate was an order of magnitude higher in the first 2.5 months after infection (0.008 per coital act) than in the latent period before the onset of AIDS and death (0.0007 per act) (Wawer et al. 2005). Infectiousness rises again years after infection as the onset of AIDS approaches, but reduced frequency of sexual intercourse owing to illness and changes in the virus within the host limit the epidemiological implications of this increase (Anderson 1996; Wawer et al. 2005). Infected individuals are therefore most infectious during the first few months immediately following infection.

This pattern of sharply declining infectiousness over time among infected individuals has several significant implications for the evolution of the epidemic. First, model simulations demonstrate that this pattern dominates the transmission dynamics both early and late in the course of epidemics (Koopman et al. 1997). Second, it probably partly explains the paradoxical finding by Kelly et al. that the incidence of HIV declines as husbands become older (Kelly et al. 2003). Older husbands tend to have higher prevalence levels than their younger counterparts, but they are also less infectious because they have been infected for a longer period. Third, and most important for present purposes, the pattern of declining infectivity provides a potential partial explanation for the higher odds ratios for HIV infection among never-married than among

ever-married women as discussed above. The partners of currently married women are on average older than the partners of unmarried women. For example, for women aged 15–19 years in Rakai, the proportion of male sexual partners who were less than 5 years older equalled 75 per cent among single women but only 40 per cent among married women (Kelly et al. 2003). The period after infection is longer for older than for younger infected men and this longer duration is associated with reduced infectivity.

These two risk factors elevate the risk of infection among unmarried women compared to married women. There are other risk factors that have the reverse effect. In particular, married women typically have higher frequency of sexual intercourse and lower condom use than their unmarried counterparts (Clark 2004). As noted, the HIV status of the sexual partner is another relevant risk factor. The DHS provides the HIV status of male partners among couples (but not for unmarried women). For uninfected married women aged 15–19, no male partner was found to be HIV-positive in either Kenya or Ghana (Central Bureau of Statistics et al. 2004; Ghana Statistical Service et al. 2004). Unfortunately, sample sizes are too small to draw firm conclusions from this finding.

In general, one set of risk factors puts unmarried women at elevated risk (e.g., frequent partner change, higher infectiousness of partners), while another set raises the risk for married women (e.g., higher frequency of sexual intercourse, lack of condom use, higher infection level of partner). These two sets of factors are partially offsetting. The above findings on differences in odds ratios for HIV infection by marital status suggest that the effects of the second set do not fully offset the effects of the first, thus leaving unmarried sexually active women with a net elevated risk of infection.

The overall number of infections in a population is determined by the number of women at risk in each marital status as well as by the incidence of infection per year in each status. Over the life cycle women spend, on average, more years in marriage than they spend being sexually active before marriage and the annual risk of infection within marriage is substantial, even though it is lower than before marriage. As a result, more infections occur within than before marriage, despite differentials in incidence. Nevertheless, the higher the proportion of sexually active years women in a population spend before rather than after first marriage, the higher the average risk of infection in the population. Other things being equal, a later age at marriage raises the proportion of women in the premarital status with relatively high infection risk, thus facilitating the more rapid spread of infection.

Clark (2004) argues that early marriage puts young adolescents at risk of HIV infection and that efforts should be made to assist this vulnerable group to protect themselves. This argument is persuasive and can readily be reconciled with the findings of the present study. The key issue is the timing of first marriage in relation to the timing of first sexual intercourse. If a young girl marries before the age at which she would otherwise become sexually active (around age 18 in much of sub-Saharan Africa), she is exposed to an elevated risk of infection that would not occur in the absence of the early marriage. Reinforcing this elevated risk is the fact that young wives are usually expected to bear a child soon after marriage and have little bargaining power to insist on condom use if they suspect that their husbands are unfaithful. However, if marriage is delayed significantly beyond the average age at first sexual intercourse, the prevalence and duration of premarital intercourse rise, thus putting women and men at elevated risk for the reasons given above.

Conclusion

The ecological evidence reviewed here indicates that sub-Saharan countries with a high age at marriage and a long period of premarital intercourse tend to have large HIV epidemics. Low rates of circumcision of males are also conducive to the spread of the epidemic. Together these two risk factors explain 64 per cent of the variation in HIV prevalence in 33 sub-Saharan countries.

The individual-level analysis of DHS data in Kenya and Ghana finds that being married is less risky per year of exposure than being sexually active and never married. The elevated risk of infection among never-married sexually active women is probably caused by a higher rate of partner change and higher levels of infectivity of partners of never-married than of married women. These findings support the hypothesis that a high average age at marriage in a population is a factor contributing to the spread of HIV because a higher age at marriage is associated with a longer period of premarital exposure to the risk of infection. Very early marriage also raises the risk of infection for young girls, because they would otherwise not be at risk, but marriage after the age at first sexual intercourse raises exposure to risky premarital intercourse. This

appears to be a key factor in countries with the largest epidemics. For example, in several southern African countries the average interval between age at first sexual intercourse and first marriage is about a decade. During this decade frequent partner change and high infectiousness of partners contribute to the rapid spread of HIV.

Notes

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