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ORIGINAL ARTICLE

Relative risk of HIV infection among young men and women in a South African township

C MacPhail MSc[1], **B G Williams** PhD[1] and **C Campbell** PhD[2]

[1]*Miningtek, CSIR PO Box 91230, Auckland Park 2006, South Africa,*
[2]*Department of Social Psychology, London School of Economics, Houghton Street, London WC2A 2AE, UK*

Summary: The prevalence of HIV infection in Africa is substantially higher among young women than it is among young men. Biological explanations of this difference have been presented but there has been little exploration of social factors. In this paper we use data from Carletonville, South Africa to explore various social explanations for greater female infection rates. This paper reports on data from a random sample of 507 people between 13 and 24 years old. Subjects were tested for HIV, as well as other sexually transmitted infections (STIs), and answered a behavioural questionnaire. The age-prevalence of HIV infection differs between men and women with considerably higher rates of increase with age among young women. The age of sexual debut did not differ significantly between men and women (15.9 and 16.3 years, respectively) and below the age of 20 years there was no difference in the number or distribution of the number of sexual partners reported by men or women. The risk of infection per partnership was substantially higher among women than among men. Women have sexual partners who are, on average, about five years older than they are with some variation with age. Scaling the age-prevalence curve for men by the age of their sexual partners gives a curve whose shape is indistinguishable from that for women but is about 30% lower for men than for women. In terms of social explanations for HIV rates among women, the data indicates that this difference can be explained by the relative age of sexual partners, but not by other factors explored. In addressing the epidemic among young women it will be essential to deal with the social factors that lead young women to select their partners from older-age cohorts and that shape their sexual networking patterns.

Keywords: HIV, age prevalence, gender differences, young people, young women, partner age differences

INTRODUCTION

In many countries, but especially in those of sub-Saharan Africa, the prevalence of HIV continues to increase and among women attending ante-natal clinics has reached 36% in both Botswana[1] and in KwaZulu/Natal, South Africa[2] for example. While the spread of infection has been contained in Thailand and Senegal and the prevalence of infection in Uganda has fallen over the last 10 years[3], few other countries have succeeded in stemming the tide of infection. At the same time, HIV prevention is receiving unprecedented support from world leaders[4] and in his 'call to action' the Secretary General of the United Nations stressed the importance of preventing young people from becoming infected, noting also that adolescent girls are six times more likely to be infected than are adolescent boys[5]. It is now widely acknowledged that young people, and especially young women between the ages of 15 and 25 years-of-age, constitute a particularly important group for HIV prevention.

The focus on adolescents and young adults arises for three reasons. First, the age-specific incidence of infection is highest among this group[6]. Secondly, there is increasing evidence that the incidence of infection is higher among young women than it is among young men[7]. Thirdly, the rapid rate of increase of infection with age among young

Correspondence to: Catherine MacPhail
E-mail: cmacphai@csir.co.za

women in particular means that this group provides the best evidence for the impact of interventions, as illustrated by the decline in infection among 13–19-year-old women in Masaka, Uganda between 1990 and 1997[8].

Two sorts of explanation have been offered to explain the different patterns of infection in men and women: biological explanations relating to differences in male and female genital physiology and the consequent differences in susceptibility to infection, and social or behavioural explanations related to the nature and patterns of sexual relationships among young people. A number of studies have shown that male-to-female transmission is more likely (per sex act) than the reverse[9–18]. Rehle *et al.* having reviewed the available data for their Avert Model, reckon that male-to-female transmission (per sex act) is approximately twice as likely as female-to-male transmission if no other sexually transmitted infections are present[19]. If either partner has a genital ulcer they set the male-to-female transmission probability at four times the female-to-male transmission. Nicolosi *et al.* reporting on a study carried out across 16 clinical settings in Italy[20,21], conclude that male-to-female transmission is 2.3 times more likely than female-to-male transmission (confidence limits 1.1–4.8), and in a study carried out in nine European countries, male-to-female transmission was 1.9 times more likely than female-to-male transmission (confidence limits 1.1–3.3)[22]. Similar results have been obtained in other studies[23,24]. A recent study of initially discordant couples in Uganda found a transmission rate from men to women that was only 0.78 times that from women to men, but 95% confidence limits on their estimate have a range of 0.62–2.68, so that these data too are consistent with male-to-female transmissibility being about twice female-to-male transmissibility.

Two major biological reasons have been put forward to explain this asymmetry in transmission. First, differences in the genital contact surfaces mean that coital tearing and injury are more common in women[26,27]. Secondly, in unprotected sex, women are exposed to infectious fluids for longer than are men; men are in contact with body fluids containing the virus for the duration of the sex act only, while women remain in contact with semen for much longer[20].

While these biological factors are clearly important, a number of studies suggest that social and behavioural factors may also be important. In attempting to address the social issues implicated in higher HIV rates among women than among men, we consider the influence of the age at first sex, the probability of infection per partnership, the total number of sexual partners and the age difference between partners.

In this paper we first examine the age-prevalence of HIV infection among men and women in Khutsong township in the Carletonville district of South Africa, and we compare the age-prevalence of infection with similar data from Mutasa, a rural area in Zimbabwe[7]. The difference in the age-specific prevalence is particularly striking among young people, with rates in young women greatly in excess of the rates in young men of the same age. We then examine various factors that may help to explain these gender differences. These include the age at sexual debut, gender difference in the number of sexual partners, and the age differences between sexual partners.

In a review of the gender differentials in HIV prevalence and AIDS-related mortality in Africa, Gregson and Garnett draw several important conclusions[7]. They show that the prevalence of infection in women is generally higher than in men, especially in urban settings: in 28 studies carried out in Uganda, Tanzania, Zambia and Zimbabwe the median prevalence of infection was 30% (interquartile range 20–40%) higher in women than it was in men. They also show that while the prevalence of infection is very much higher in women than in men below the age of 30 years, above this age the prevalence of infection in men tends to be higher than in women. They conclude that the higher levels of infection among young women, as compared to young men, should be used to highlight women's greater biological and socioeconomic vulnerability, and list several factors that might contribute to gender differences in the patterns of infection, including the age structure of the population, age differences between sexual partners, levels and heterogeneity in rates of sexual partner acquisition, and relative rates of male-to-female and female-to-male transmission. Unfortunately the data needed to explore some of these factors were not available to them and in this paper we use data from Carletonville, South Africa, to explore some of these issues.

METHODS

Study site

The data presented in this paper are part of a broader study of the biological, psychological, behavioural and social determinants of HIV transmission in the mining district of Carletonville, South Africa[28], which is being conducted in the context of a major HIV prevention intervention in the district[29]. The young people who form the focus of this study are residents of Khutsong township, part of the Carletonville district, which has a population of approximately 150,000 residents. The township has a number of different housing types that reflect the socioeconomic profile of the community. In the formal sector there are both private homes and council houses, the former owned by their residents and the latter, which were owned by the local municipality, now being bought by their tenants. The informal sector consists of unplanned squatter settlements that have mushroomed around the formal township,

housing either South African citizens or illegal immigrants from other African countries. There are also site-and-service areas in which plots provided with water, electricity and sewerage are sold, allowing residents to construct shack dwellings with the understanding that formal owner-constructed units will be developed at a later stage. The hardships of unemployment for many and the limited income for the majority of respondents are compounded by the structure of township life.

Khutsong has few entertainment or retail facilities other than informal bars and *spaza* shops (informal points of sale for basic foodstuffs, usually within private homes or roadside shacks). In addition, the township is characterized by high levels of violence, particularly towards women, and gang-related fighting between different ethnic groups.

Survey

In August 1998 a cross-sectional study was conducted in Khutsong. Carletonville district has a population of about 150,000 people, in addition to which approximately 70,000 migrant mineworkers are housed in 12 single-sex hostels close to the mineshafts to the south of Carletonville town[30]. The survey was designed to collect data on men and women aged 13–60 years. Households were selected by a two-stage random sampling technique. Index houses were randomly selected from a map obtained from the local municipal offices. Using each index house as a starting point, a systematic sample of households was taken. The sampling scheme was designed to be self-weighting. All men and women aged 13–60 years who slept in the selected households the night before the study team visit were eligible for inclusion in the study. Eligible participants were transported to a local facility for the interviews and the collection of blood and urine samples. If eligible participants were not at home, the study team made up to three repeat visits before abandoning that household. Altogether 475 men and 712 women were included in the study and 173 people (13%) refused to participate. Neither the sex ratio nor the age distribution of those who refused to participate differed from that among those who agreed, so that this is unlikely to introduce significant bias.

Questionnaire

A UNAIDS questionnaire was adapted to the local situation and to the age of subjects enrolled in the sample[31]. A consent form was presented to participants in their first language and those who agreed to participate were asked to sign the form. The interviewers completed the questionnaire during a private interview in the preferred language of the interviewee. Data were collected on background and behavioural characteristics, as well as a medical and sexual history.

Biological tests

Following the interview, blood and first-catch urine specimens were collected. A single Capillus HIV-1/HIV-2 latex aggregation test (Cambridge Biotech Corporation, Galway, Ireland), which has a sensitivity and specificity of greater than 99.9% and 99.6%, respectively, was subsequently used to screen the sera for HIV infection. Tests were also done for syphilis serology, gonorrhoea and chlamydia[32]. All participants were offered free treatment for STIs that were detected as a result of the laboratory tests and once this had been done all individual identifiers were removed from the forms and the HIV testing was carried out. All participants were offered a separate enzyme-linked immunosorbent assy (ELISA) test with pre- and post-test counselling to be arranged through the normal clinic channels if they wished to know their HIV status.

Data management

Laboratory results and data generated from questionnaires were entered twice into a database (Microsoft Access, Redmond, USA) by different people. The two entries were compared and discrepancies were corrected. The data were then extensively checked for inconsistencies. The files were then imported into the Statistical Package for Social Sciences (SPSS 8.0 for Windows, Chicago, USA) and prepared for statistical analysis.

Ethical considerations

Ethical clearance for the study was granted by the University of Witwatersrand Ethical Committee, South Africa (Protocol M 970235). Participants gave their written consent to the study and all information was treated confidentially. Biomedical results were linked to questionnaire information through a system of code-numbers that remained anonymous.

Statistical methods

Where parametric distributions were fitted to the data this was done using maximum likelihood methods with binomial errors[33–35]. To test for differences between distributions of the age at first sex, a Kolmogorov–Smirnov (K–S) test was used. Principal axis regression was used to determine the relationship between the ages of male and female sexual partners. For comparisons of the number of sexual partners by gender, χ^2 tests were used.

RESULTS

Since we are concerned with young people in particular, we consider the characteristics of those under the age of 25 years separately. Of the 507

under the age of 25 years 45% (n=230) were men and 55% (n=277) were women. Of those aged 15–24, 21% lived in private houses, 25% in council houses, 27% in site-and-service schemes and 25% in squatter settlements. The majority (55%) of those interviewed were students at local schools or were engaged in some form of tertiary education. Among those no longer studying there were high levels of unemployment (30%), as is common among many young township residents. Membership of various associations was quite common, with the majority being members of either sports clubs (42%) or youth organizations (29%). Finally, of the young people represented in the sample, 70% reported having had penetrative sexual intercourse (defined as sex in which the penis enters the vagina, anus or mouth).

Figure 1 shows the age-prevalence of infection for men and women in Carletonville and, for comparison, the corresponding data from a survey carried out in a rural area of Zimabwe[7]. Both sets of data have been fitted to log-normal functions[6,36]. In both communities the prevalence of infection increases very rapidly with age (especially among young women), peaks at older ages among men than among women and declines thereafter. These two sites represent quite different communities—Carletonville is an urban mining centre drawing in migrant workers from South Africa and the neighbouring states (but not Zimbabwe), Mutasa is a rural area in the Honde Valley in the Eastern Highlands of Zimbabwe. While the age-prevalence curves differ between men and women, the similarities between the shapes of the curves for Carletonville and Mutasa are striking. Infection rates increase much more rapidly among women than among men in both sites: in Mutasa, at the age of 20 years the prevalence among men and women is 2.7% and 17.8%, respectively (odds ratio (OR)=7.8, $P<0.0001$), in Cartonville 7.9% and 39.3%, respectively (OR=7.5, $P<0.0001$). The infection peaks at an older age among men than it does among women in both sites: 31.6 years and 26.2 years, respectively, in Carletonville (difference=5.4 years, $P<0.0001$), and 35.0 and 28.9 years, respectively in Mutasa (difference=6.1 years, $P<0.0001$). However, they do differ in one important respect: in Carletonville the peak prevalence among women (57.9%) is significantly higher than among men (44.5%) (OR=1.7, P=0.0057), while in Mutasa the peak prevalence among women (35.3%) is very close to that among men (34.7%) (OR=1.03, P=0.81).

Figure 2 shows the data for young men and women in Carletonville to illustrate more clearly the differences in the infection rates among young people. At 15 years-of-age, for example, an

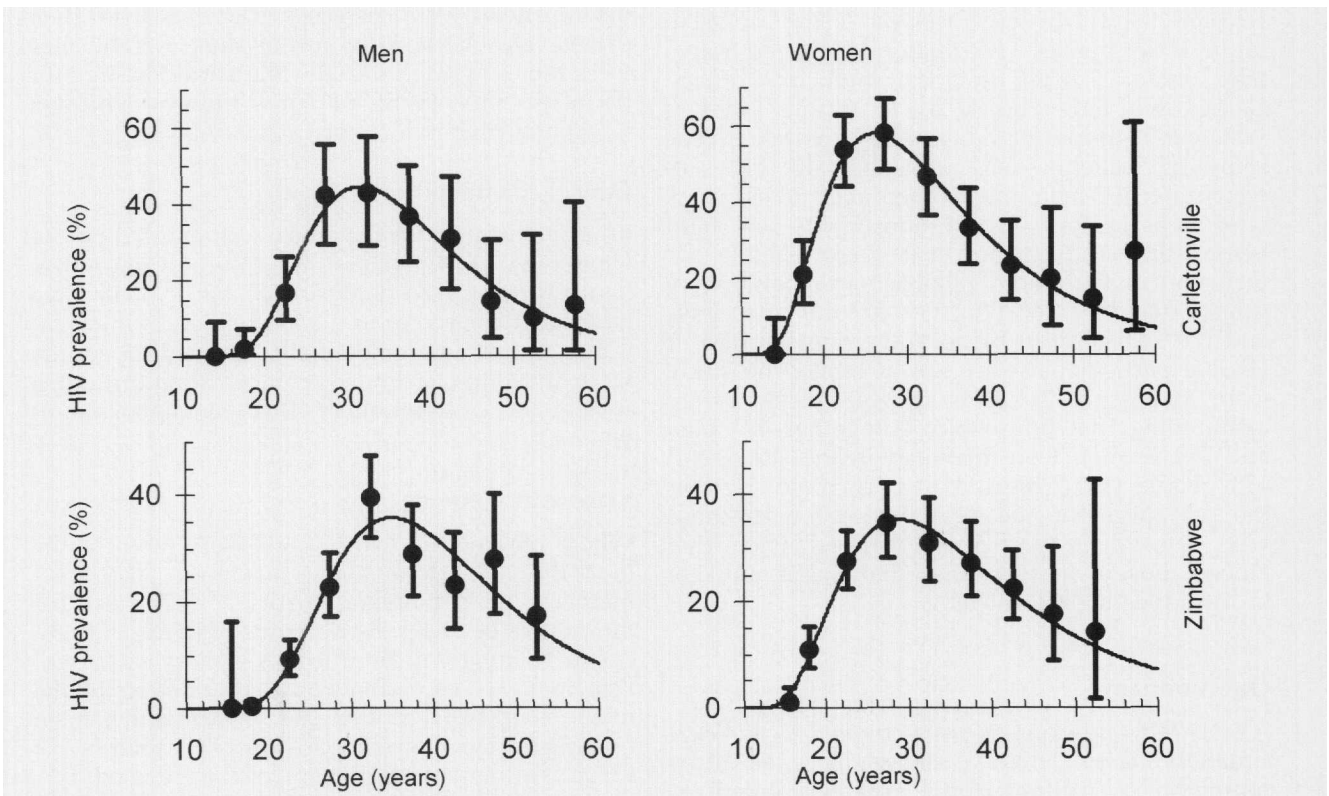

Figure 1. Prevalence of HIV infection among men (left) and women (right) in Carletonville (top) and Mutasa (bottom), both in 1998. The data are fitted to log-normal functions offset by 20 years with the following parameter values. Carletonville men: mode=31.6±1.7 years, peak prevalence=44.5±7.5%; Carletonville women: 26.2±1.1 years, peak prevalence=57.9±5.8%; Mutasa men: 35.0±0.9 years, peak prevalence=34.7±3.5%; Mutasa women: mode=28.9±1.1 years, peak prevalence=35.3±3.6%

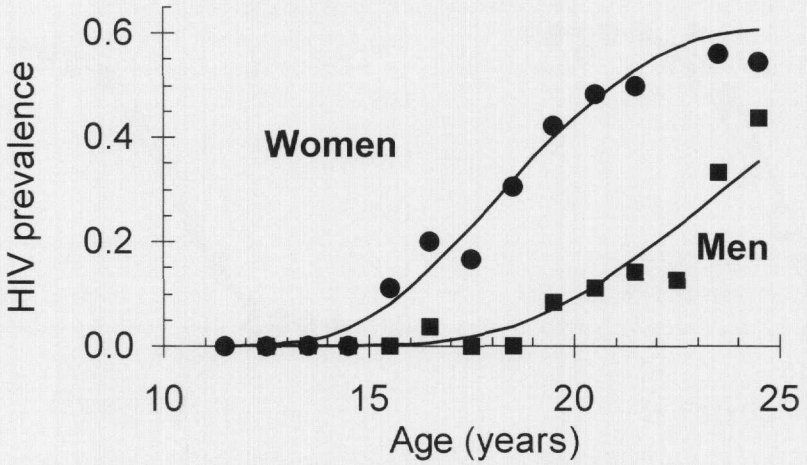

Figure 2 Prevalence of HIV infection among 13–25-year-old men (squares) and women (circles). The fitted curves are as in Figure 1

estimated 0.2% of men and 8% of women are HIV-positive; at 20 years-of-age 11% of men and 47% of women are positive. The slope of the age-prevalence curve gives a lower bound for the age-specific incidence[6] and on this basis the incidence peaks at 15% or more among 18-year-old women and 9.6% or more among 24-year-old men.

We now turn to examining some of the social factors Gregson and Garnett outlined as possible explanations for the differences in male and female infection rates[7]. The factors considered include age at sexual debut, number of sexual partners and age difference between sexual partners. Finally, we discuss some other factors that may play a role in increased female infection rates and which require further investigation.

Age at sexual debut

A number of studies have been conducted on the relationship between the age of sexual debut and subsequent sexual activity and STD infections. The potentially harmful effects of a young age at first coitus are felt more among young women than among young men[37]. A study indicated that women were more likely than men to regret first coitus before the age of 16 years and that they were more likely to have been an unwilling sex partner. The study also indicated that the risks associated with a young age at first sex were disproportionately felt among women in contrast to men. A further study carried out among young people attending planned-parenthood clinics in Pennsylvania compared young women who first became sexually active between the ages of 10 and 14 years with those who became sexually active after the age of 14 years. Those who started sex earlier were more likely to have had a greater number of sexual partners in the previous year, to have had sex with men who were at increased risk for the transmission of HIV and were more likely to have had STDs in the preceding five years, than those who did not[38]. A study carried out among Ethiopian women found that a young age at first sex was associated with increased prevalence of STDs and pelvic inflammatory disease, as well as being strongly associated with an increased number of sexual partners[39]. It is important to note that the consequences of early sexual debut will always be confounded by association with subsequent sexual behaviour.

The age at sexual debut of young people in Carletonville was assessed in two ways. Respondents were asked firstly if they had ever had penetrative sex. Plotting the proportion who answered yes as a function of age gives the circles in Figure 3a and 3b. The associated line is the maximum likelihood fit to the data using a cumulative normal distribution function. Respondents were also asked how old they were when they first had sex. This gives a probability density function (PDF) from which the cumulative distribution is readily obtained and is given by the diamonds in Figure 3 (it is important to ensure that the right denominators are used since the number of people sampled who are less than a given age increased with age). The line associated with the diamonds is the cumulative distribution obtained from the maximum likelihood fit to the PDF. Since these are two independent estimates of the same function they should give the same values, unless of course there has been a shift in the age at first sex over the last 5–10 years. It is important to note however, that the first (circle) curve is likely to be less biased, given the nature of the question, than the second (diamond) curve, since the second curve relies on recall. However, the number of people indicating that they first had sex at an early age will be greater than the number of young people of that age in the sample, so that the second curve will be statistically more precise than the first.

Comparing the two curves for men in Figure 3a, they do differ significantly (K–S test, $P<0.0001$), but the difference in the mean values is only 6 months. Either men exaggerate downwards by

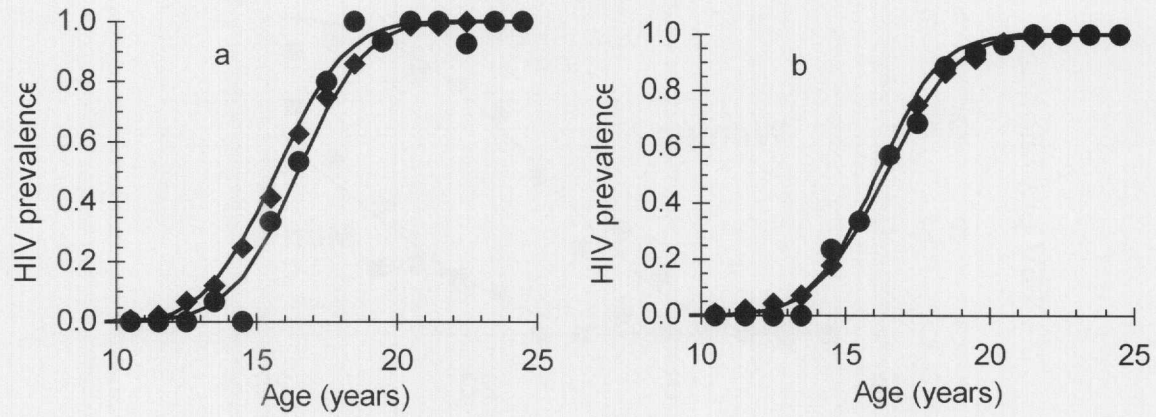

Figure 3. Cumulative distributions of reported age at first sex for men (left) and women (right). The circles are in answer to the question. 'Have you ever had penetrative sexual intercourse? By penetrative sex I mean when the penis enters the vagina, anus or mouth,' and the diamonds in answer to the question, 'How old were you when you had penetrative sexual intercourse for the first time?'. The fitted curves are cumulative normal distributions with the parameter values given in the text

about 6 months when asked, or the age at sexual debut has increased slightly in recent years, or some combination of the two. In any event the difference is small. Figure 3b presents the data for women. For women we see that there is much closer agreement between the two estimates that are not significantly different (K–S test, P=0.942). From the age distribution of the proportion of those who said that they had had sex, the mean age at first sex is 15.9 years (12.0–19.9 years for 95% of the population) for men and 16.3 years (12.8–19.8 years for 95% of the population) for women. The age at sexual debut cannot explain the dramatic differences in the age-prevalence of HIV infection among men and women in Carletonville.

Number of sexual partners

The increase in the risk of HIV infection with increasing numbers of sexual partners has been well documented. In a case–control study carried out among patients attending an STD clinic in Italy, a strong correlation was found between HIV infection and the number of sexual partners although the risk of infection did not increase linearly (at low prevalence) with the number of sexual partners because there was a substantial amount of transmission associated with drug use[40]. Among young people in US public high schools an increased number of sexual partners was associated with other risk behaviours such as illegal drug use, recklessness and aggression, and was particularly problematic in the context of the low levels of condom use in this group[41].

If young women have proportionately more sexual partners, this too could put them at higher risk of infection than men and Figure 4 shows the proportion of men and women who have various numbers of sexual partners for those aged 15–20 years and for those aged 20–25 years. For the younger age-group there is a small, and significant (P=0.0025), difference between the proportions of men and women who have different numbers of sexual partners. Girls are less likely to have had no partners and more likely to have had one or two partners than boys, but none of the individual comparisons is significant and the overall distributions are very similar. For the older age-group women are more likely than men to have had between one and four partners and less likely than men to have had eight or more partners. This is unlikely, therefore, to explain the differences in the infection rates, especially among those under the age of 20 years where the differences are most marked.

Those with more sexual partners are more likely to be infected than those with fewer sexual partners and Figure 5 shows the prevalence of infection as a function of the number of sexual partners. Among women who report having had one sexual partner, 24% are infected, for those with two partners the figure rises to 45%. For men, on the other hand, the risk increases much more slowly. Among those with one sexual partner 8% were infected (fitted curve in Figure 5) and the prevalence only reaches 27% among those who have had eight or more partners. The risk of infection per partnership is about three times greater for women than it is for men. Since the risk of infection per partnership will depend on a persons' vulnerability to infection and the prevalence of infection among their sexual partners, we turn to an examination of the sexual mixing patterns of young people in Carletonville, with particular reference to age.

Age difference between sexual partners

The age difference between sexual partners is of particular importance among young people. Young women tend to have older partners, who in turn are more likely to have had multiple partners some of whom may be commercial sex workers, and

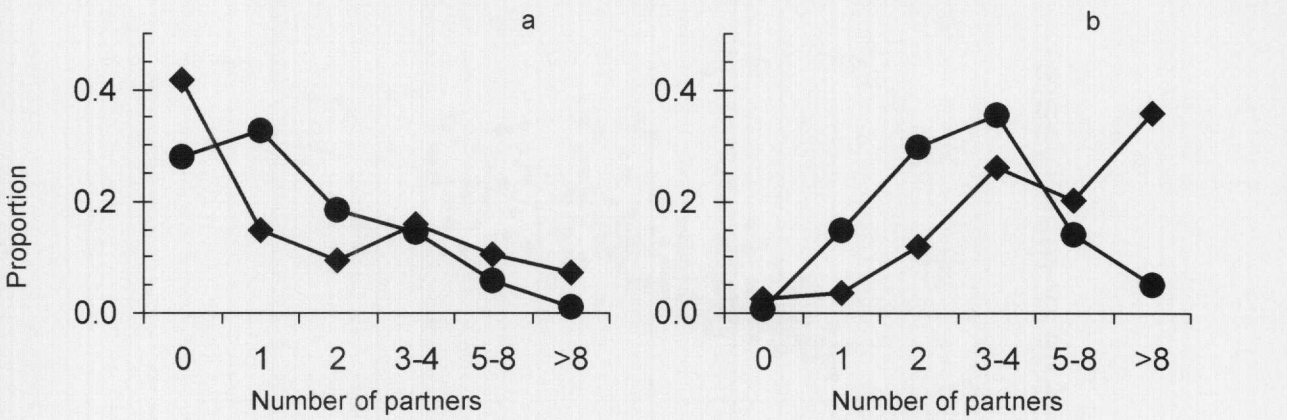

Figure 4. The proportion of men and women who have different numbers of sexual partners. People aged 15–19 years (left), people aged 20–24 years (right). χ^2 test of association between gender and number of partners: (left) P=0.0025, (right) P<0.00001. The circles represent females and the diamonds represent males

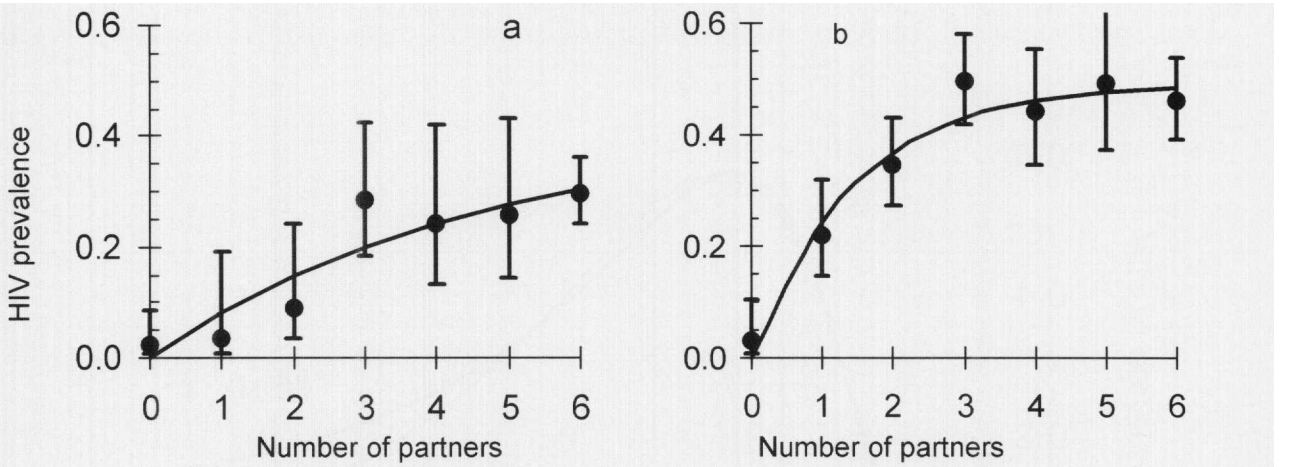

Figure 5. The prevalence of HIV-infection plotted against the reported number of sexual partners for men in Carletonville (left) and women in Carletonville (right), in 1998

therefore more likely to be infected with HIV than men of their own age[42–44]. The economic dependence of women on men in Africa has important consequences for their sexual health. In Soweto, the largest black township in South Africa, the commercialization of sex in communities where unemployment is high[45], encourages young women to exchange sex for gifts of money, clothing, or for living expenses[46]. Men able to provide these commodities are frequently significantly older than their female partners. Konde-Lule *et al.* consider the impact that the commercialization of sex has on the age difference between partners in rural Uganda[47]. While the partners of male students tend to be restricted to women of their own age or younger, female students often have older partners who are traders or salaried workers who support them financially.

When examining the data from Carletonville, women, as expected, have sexual partners who are older than themselves with women aged 20 years having partners whose average age is 25.2 years. This pattern continues beyond the age-groups discussed in this paper, with those women aged 30 having partners whose average age is 36.4 years, and those aged 40 having partners whose average age is 44.2 years. Since women have sex with men who are older than them and men have sex with women younger than themselves, young women are more vulnerable to infection than young men of their own age. This vulnerability is the result of selecting partners from an older age-group in which the HIV infection rates for men are higher than among men their own age.

To explore the extent to which this can explain the difference in the age-specific prevalence, we used the relationship given by the fitted line in Figure 6 to scale the age-prevalence curve for men in Figure 1, so that we can plot the prevalence of infection in men against the average age of their

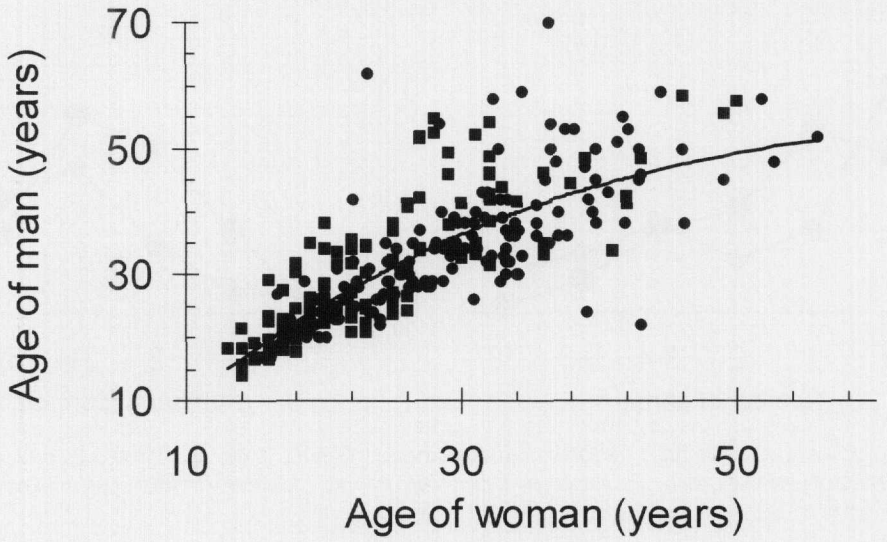

Figure 6. Reported ages of respondents and of their most recent casual male or female sexual partners (n=104). Squares: men and their female partners; circles women and their male partners. The fitted line has the form $y=a+bx+cx^2$ where x=ln(women's age), y=ln(man's age), a=2.935±2.093 (P=0.0064), b=3.068±1.292 (P=0.00001), c=0.338±0.198 (P=0.00094). The outer lines are 95% confidence limits for the fitted line

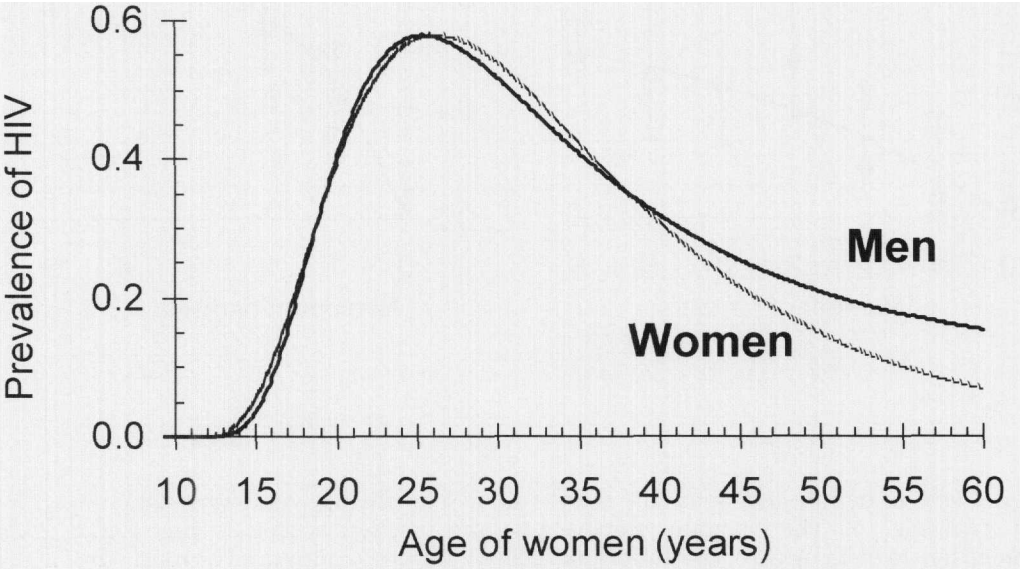

Figure 7. The age-specific prevalence of infection in women (dashed line, from Figure 1) and the prevalence of infection in men plotted against the average age of their sexual partners after scaling the prevalence up by a factor of 1.3

sexual partners. In Figure 7 we have plotted the prevalence of infection in women against their age and the prevalence in men against the age of their sexual partners and scaled the prevalence in men up by a factor of 1.3. The agreement between the two curves is excellent and it is important to note that the only free parameter in the fit is the factor of 1.3 by which we have increased the prevalence in men. The shapes of the curves are entirely determined by the raw prevalences and the completely independent estimates of the relationship between the ages of men and women and their sexual partners.

DISCUSSION

A wide range of studies have shown that the age-specific prevalence of HIV infection in South Africa is quite different among men and among women[7,36]. In particular, the prevalence of infection increases much more rapidly among young women than it does among young men, implying that the incidence of infection is much higher among young women that it is among young men. Understanding this difference is important for many reasons, not least because if, as in Carletonville, half of the young women are infected with HIV by

the age of 25 years, protecting young women from infection is of major importance. At the same time, since the slope of the age-prevalence curve for young people provides a sensitive measure of incidence, it is hoped that declines in the rate of increase of prevalence with age among young women will provide a sensitive marker of the success or otherwise of intervention programmes. But if we are to design interventions specifically targeted at helping young women to protect themselves from becoming infected with HIV and to use the rates of infection among young women as a measure of the effectiveness of control programmes, then it is essential to understand the reasons for the high incidence among this group.

While acknowledging biological reason for female susceptibility to infection, in this paper we have explored a number of possible social explanations for this difference in the relative rates of infection in young men and women. The age at sexual debut or the number of sexual partners among young men and women do not differ significantly and are therefore unlikely to provide an explanation for the different age-patterns of infection in this setting. The age difference between sexual partners does have a major effect and this could explain much of the observed difference in the shapes of the age-prevalence curves, which then differ only by a scaling factor.

After transforming the age-prevalence curve for men according to the age of their female sexual partners the prevalence of infection among women is 30% higher than it is in men and this is consistent with the assumption that transmissibility from men to women is greater than from women to men. Suppose that we assume homogeneous mixing and ignore age-structure. Suppose also that the transmissibility from men to women is greater than the reverse by a factor of ϕ, say. Then we can show (Appendix) that early in the epidemic the prevalence among women will be $\phi^{1/2}$ times the prevalence in men, but that in the steady state the prevalence in women will be almost the same as in men. If, as noted above, ϕ is about two then we should expect the overall prevalence in women to be 40% greater than in men early in the epidemic and about 12% greater than men later in the epidemic (Appendix). Furthermore, the main difference between the age-prevalence curves for Carletonville and Mutasa (Figure 1) is that the peak prevalence among women is higher than it is among men in Carletonville but not in Mutasa. Since the epidemic in Zimbabwe is more advanced than in South Africa this might reflect the natural dynamics of HIV epidemics. It would be of interest to apply the analysis carried out in this paper to the data for Mutasa.

This paper has been concerned with social explanations of the difference in HIV infection rates between men and women. However, research that was beyond the scope of the data collected in this paper may provide more insight into the complex interaction of biological and social factors in Carletonville. In South Africa, where rape and violence against women are common, imbalances in power relationships between men and women[48–50] can lead to a blurring of the distinction between 'normal' heterosexual intercourse and rape[51]. Among pregnant teenagers in a Cape Town township, 60% said that they had been beaten by their male partners, and women who had been sexually active for an average of two years said that they had been beaten an average of 10 times[52]. Our research in Carletonville shows that many young women are initiated into sexual activity under duress, through either coercion or violence, and that continuing sexual violence thereafter is not uncommon[10]. It is possible that high levels of sexual violence may result in women being at particularly high risk of HIV infection during their first sexual encounter due to trauma to the vaginal membranes. Further research would provide interesting insights into more close relationships between social and biological factors predisposing women to greater risk of HIV infection.

CONCLUSION

Garnett and Gregson have shown that in numerous African countries the rates of HIV infection among women are greater than among men[7]. Unfortunately, their major data source in Mutasa, Zimbabwe, did not provide information on social factors that could explain observed differences between male and female rates of infection. Due to the similarities in the prevalence curves between Mutasa and Carletonville, we have attempted to answer some of the questions they have raised using the Carletonville data. On the basis of the data presented here, we would argue that the increased risk of infection for young women as compared to young men is due in part to women's greater biological vulnerability to HIV as compared to men, as has already been documented elsewhere, and in part to social factors that lead young women to select more of their partners from an older age-cohort and which determines patterns of sexual networking.

The data from Carletonville indicate that factors such as the age at first sex and the number of lifetime partners are not sufficiently different between the sexes to explain the differential rates of infection. Rather, the age difference between male and female partners indicates that sexual networking patterns in this area incline young women to infection through their choice of male partners. The choice of older male partners (possibly for financial security) increases the likelihood of young women selecting HIV-positive partners, as prevalence is higher in this male age-group than in those individuals of the same age as the women. The data also provide an indication that it is not the number of partners that create risk for women but rather their risk of infection per

partnership. While the heightened risk of infection per partnership among women compared to men may serve to confirm theories of increased biological susceptibility, there are further social issues that may partially explain this phenomenon.

There is increasing evidence both from our own work and from other studies that it is not unusual for sexually inexperienced young women to be forced into unwanted sexual encounters and this may exacerbate their biological vulnerability due to the increased likelihood of female genital damage in forced or coercive sex. While the data presented here suggest that the differences in infection rates can be explained without appealing to forced or coercive sex, this is an issue that needs to be explored in greater detail. Many authors have pursued investigations of gender violence against women but most commonly in relation to the effects that this has on the ability to demand condom use within sexual relationships, or female ability to refuse unwanted sex. Further investigation is required into the role that unwanted or coercive sex may have in increasing young women's already heightened vulnerability to HIV infection.

Our study highlights the urgent need to develop effective programmes to reduce the spread of HIV/AIDS among young people and especially to protect young women. While it is always difficult to measure incidence, especially in the short term, the very high incidence of infection implied by these data also mean that it is among this age-group that there is the best hope for detecting a reduction in incidence if effective control programmes are implemented.

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APPENDIX

We investigated the effect of the asymmetry in male-to-female transmission of HIV by starting from the following equations:

$$\frac{df}{dt} = \phi m(1-f) - \delta f \tag{1}$$

$$\frac{dm}{dt} = \mu f(1-m) - \delta m \tag{2}$$

where m and f are both functions of t. At the beginning of the epidemic $t \to -\infty$, $m \to 0$ and $f \to 0$, so that the terms in brackets $\to 1$. Solving Equations 1 and 2 the positive eigenvalue is $\lambda = (\mu\phi)^{1/2} - \delta$, so that the proportions of infected men and infected women increase at this rate, and the ratio of the number of infected women to men is $(\phi/\mu)^{1/2}$. If $\phi/\mu \approx 2$ then the ratio of the number of infected women to men at the start of the epidemic is 1.41. To determine the prevalence ratio at the steady state, we set Equations 1 and 2 to zero and solving gives the steady state prevalences:

$$\hat{f} = \frac{\mu\phi - \delta^2}{\mu\phi + \mu\delta} \tag{3}$$

and:

$$\hat{m} = \frac{\mu\phi - \delta^2}{\mu\phi + \phi\delta} \tag{4}$$

so that the ratio of the steady state prevalence in men and women is:

$$\frac{\hat{f}}{\hat{m}} = \frac{1 + (\delta/\mu)}{1 + (\delta/\phi)} \tag{5}$$

Now the incidence of infection among 18-year-old women is about 15% per year and the prevalence of infection among their (23-year-old) male partners is about 25% so that $\phi \approx 0.75$, so that $\mu \approx 0.37$. If the life-expectancy after infection with HIV is about 7 years then $\mu \approx 0.1$ so that the ratio of the prevalence in women to that in men at the steady state will be about 1.12.

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