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Abstract

This paper presents the results of a cross-sectional biomedical and social survey, conducted in a major goldmining centre with a high prevalence of HIV infection. It also provides the baseline data for a comprehensive intervention programme. Our sample comprised a stratified random group of migrant mineworkers and of the resident adult population living in the community close to the mines and a small convenience sample of sex workers. In total, 2231 people between 13 and 59 years of age were interviewed using a structured questionnaire covering a wide range of psychological, behavioural and social issues. Blood and urine samples were collected and tested for the presence of HIV and syphilis antibodies and infection with *Neisseria gonorrhoeae* and *Chlamydia trachomatis*. The prevalence of HIV was high in all groups: 22% of the men and 37% of the women in the community, 29% of the mineworkers and 69% of the sex workers, were infected with HIV. The prevalence of other sexually transmitted infections (STIs), and especially syphilis, was also high in all four groups of people. Levels of migrancy were highest among mineworkers and sex workers. Migrants had a higher prevalence of casual partners than more permanent residents. More than 43% of the men in the study were circumcised and circumcision appears to offer some protection from HIV infection but not from other STIs. Knowledge about HIV was high but perceived vulnerability was low, which contributed to a high prevalence of unsafe behaviours. Social capital was also associated with HIV infection, with membership of sports clubs, youth clubs, burial societies and churches offering a protective effect against infection, while membership of stokvels (rotating credit associations) was associated with an increased chance of infection. Successful and sustainable intervention programmes must include a range of activities tailored to the needs of the community. Community-based peer education, focus group discussion and involvements of stakeholders should be complemented with syndromic management of STIs as well as periodic presumptive treatment of the sex workers, a partner notification system and training for local physicians.

Keywords

survey, history, results, hiv/aids, major, biomedical, south, africa:, social, centre, goldmining, natural

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The natural history of HIV/AIDS in a major goldmining centre in South Africa: results of a biomedical and social survey

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This paper presents the results of a cross-sectional biomedical and social survey, conducted in a major goldmining centre with a high prevalence of HIV infection. It also provides the baseline data for a comprehensive intervention programme. Our sample comprised a stratified random group of migrant mineworkers and of the resident adult population living in the community close to the mines and a small convenience sample of sex workers. In total, 2231 people between 13 and 59 years of age were interviewed using a structured questionnaire covering a wide range of psychological, behavioural and social issues. Blood and urine samples were collected and tested for the presence of HIV and syphilis antibodies and infection with *Neisseria gonorrhoeae* and *Chlamydia trachomatis*. The prevalence of HIV was high in all groups: 22% of the men and 37% of the women in the community, 29% of the mineworkers and 69% of the sex workers, were infected with HIV. The prevalence of other sexually transmitted infections (STIs), and especially syphilis, was also high in all four groups of people. Levels of migrancy were highest among mineworkers and sex workers. Migrants had a higher prevalence of casual partners than more permanent residents. More than 43% of the men in the study were circumcised and circumcision appears to offer some protection from HIV infection but not from other STIs. Knowledge about HIV was high but perceived vulnerability was low, which contributed to a high prevalence of unsafe behaviours. Social capital was also associated with HIV infection, with membership of sports clubs, youth clubs, burial societies and churches offering a protective effect against infection, while membership of stokvels (rotating credit associations) was associated with an increased chance of infection. Successful and sustainable intervention programmes must include a range of activities tailored to the needs of the community. Community-based peer education, focus group discussion and involvements of stakeholders should be complemented with syndromic management of STIs as well as periodic presumptive treatment of the sex workers, a partner notification system and training for local physicians.

Introduction

South Africa is facing one of the most severe epidemics of HIV (human immunodeficiency virus) in the world. About 23% of women attending public antenatal clinics were infected with HIV at the end of 1998, a 34% increase from the previous year.¹ The prevalence of HIV infection among women attending antenatal clinics has increased in all provinces and in all age

groups, although there were marked variations. The prevalence peaks among 25-year-old women, of whom about 27% were HIV positive. The best current estimate suggests that the prevalence will level off at about 30%.²

The gold-mining complex of Carletonville in which the study is located is the largest gold-mining area in the world. The approximately 400 square kilometres include Carletonville, the main town, Khutsong, a historically black township to the north-west, and goldmines to the south and west. The population of the town is about 20 000; the population of the township is estimated to be in the region of 150 000 people, some 60 000 to 80 000 migrant mineworkers live for the most part in single-sex hostels in the mine compounds (Demographic survey data commissioned by the municipal authorities, 1996). A study amongst hostel dwellers in South Africa revealed that approximately one third admitted to having sex with sex workers (SWs) and casual partners and only 15% said that they consistently used condoms.³ In addition, the well-developed infrastructure of South Africa facilitates the spread of the infection to other parts of the country as well as to the home countries of the migrant workers. Depending on the distance to their homes, most mineworkers return home between once a month and once a year. In addition, many return home between contracts and return to the mine for re-employment should they pass their medical and fitness examinations.

The survey reported on in this paper was the first of a series of population-based, cross-sectional surveys conducted in the context of a comprehensive HIV/STI intervention programme. The survey and the intervention cover an entire community that includes migrant gold-mine workers, sex workers and male and female members of the local community.

The intervention began with community-based peer education, condom distribution, and the syndromic management of sexually transmitted infections (STIs).⁴ Monthly periodic presumptive treatment for curable STIs among sex workers started in February 2000. From the start, the importance of evaluating the impact of the project was recognized and annual surveys were included in the design of the project. The survey reported on here provides cross-sectional, baseline data for the intervention and provides the first detailed examination of the social and biomedical factors that are likely to affect the transmission of HIV in South Africa.

This survey was designed to:

- 1) assess the prevalence of HIV and selected STIs in the target populations;
- 2) explore the associations between HIV infection and a range of biological and social variables such as age, gender, socioeconomic status, knowledge of HIV transmission, condom use, sexual partners, STIs and circumcision;
- 3) provide a sound basis for evaluating the impact of the intervention on rates of STIs and HIV, as well as on behaviour, knowledge, attitudes and practices.

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Methods

The study site. The baseline survey was carried out in August 1998 on a sample of 2231 people in the Carletonville goldmining area aged 13 to 59 years, using a stratified random sample of 499 men and 712 women from the community, 899 mineworkers living in ten single-sex hostels situated near the mineshafts, and 121 women from 'hotspots' (informal areas where women sell sex to clients located in close proximity to the mine compounds). Some of the women live permanently in hotspots, others come there from Khutsong and other towns daily or at weekends.

Recruitment and training of field assistants. Forty-two local people were employed and trained to recruit the study participants or to conduct the interviews. All were fluent in English and in at least one local language.

Sampling and stratification. Sample size calculations were based on a 5% significance level with 80% power and various assumptions concerning the prevalence and incidence of HIV and STIs, giving a sample size of 2000. An additional 200 people were recruited to allow for incomplete data collection. Altogether, 173 persons refused to participate and 135 were identified but not found. Neither the sex ratio nor the age distribution of those who did not participate differed significantly from those that did.

The population of the township was stratified according to housing type (private or council houses, site-and-service schemes, council hostels and informal settlements or squatter camps) and the number of people drawn from each housing type chosen in proportion to the population, using the results of a demographic survey commissioned by the municipal authorities in 1996. In the township, 15 index houses were chosen randomly from aerial ordnance survey maps of the area and every third house to the right of the index house was included in the survey. In the hostels an index room was chosen at random and every second room to the right of the index room was included. The sample in the hotspots was a small convenience sample of women who were willing to participate.

Ethical considerations. The consent form was presented to all participants in their own language, describing the nature and purpose of the survey and the reasons for taking blood and urine samples. They were told that they could get the results of STI tests if they so wished and would be provided with free treatment if necessary. Once this had been done, all personal identifiers would be removed so that the results of the HIV tests could be linked to the other results but would remain completely anonymous. Participants were offered a free HIV test with pre- and post-test counselling to be done apart from the survey if they so wished. Ethical approval for this study was granted by the Committee for Research on Human Subjects of the University of the Witwatersrand, Johannesburg.

The interview. The questionnaire was based on the 'Multi-site Study' conducted by UNAIDS, Geneva, in two West African and two East African cities,⁵ with some changes mainly to include issues of migration. The questionnaire was translated into four African languages (Sotho, Tswana, Zulu and Xhosa) and back translated into English to ensure the integrity of the translations. Interviews were conducted one-to-one in the language of the interviewee and, whenever possible, by a same-sex interviewer.

Blood and urine collection. A qualified nursing sister drew venous blood and participants delivered approximately 10 ml of first-stream urine. Blood and urine samples were stored at the South African Institute for Medical Research, Johannesburg.

Laboratory analyses. HIV antibodies were detected in blood samples using a Capillus HIV-1/HIV-2 Latex Aggregation Test (Cambridge Diagnostics, Galeax, Ireland) and syphilis antibodies using a rapid plasma reagin (RPR) test (Immutrep-Carbon

Antigen, Omega Diagnostics, Scotland) and also a specific *Treponema* antigen test (Cellognost Syphilis H, Dade Behring, Marburg, Germany). Here, 'recently acquired syphilis' means that both tests were positive, 'previously acquired syphilis' means that only the *Treponema* antigen test (TPHA) was positive.⁶ A ligase chain reaction was used in the detection of *Neisseria gonorrhoeae* and *Chlamydia trichomatis* (Abbott Laboratories, Illinois), respectively.

Data management and statistical analysis. Laboratory results and data from the behavioural survey were entered into a database (Microsoft Access 4.0 for Windows), using double entry. The entries were compared, corrected and edited to ensure external and internal consistency. The Statistical Package for Social Sciences (SPSS 9.0 for Windows) was used for statistical analysis.

Results

HIV prevalence

The prevalence of HIV was high in all groups. Among women in hotspots, nearly 70% were HIV positive, while in the township 37% of women were HIV positive, reaching nearly 60% among those aged 20 to 29 years. Among men, 22% of those in the township and 29% of mineworkers were HIV positive. Figure 1 shows the age distribution of HIV infection among the various groups of people. The prevalence of infection was effectively zero below the age of 15 years, rose rapidly, especially among young women, peaked at 58% among 26-year-old women, and 45% among 32-year-old men, and declined with age thereafter. In comparison, the age prevalence of HIV for mineworkers was constant and for SWs declined with age.

Other sexually transmitted infections (syphilis, gonorrhoea and chlamydia)

The prevalence of STIs, particularly of syphilis, was high in all groups (Table 1). At least one current STI was found in 14% of the men and 22% of the women in the township and in 11% of the mineworkers and 36% of the women in hotspots.

At the time of the survey, about one in ten men, over half of the women in the township and two thirds of the women in hotspots reported current STI symptoms. However, the only significant correlation between reported symptoms and laboratory tests for STIs was among men. Twelve per cent who reported current discharge had a chlamydia infection, whereas 4.1% with chlamydia reported no discharge ($P = 0.01$).

HIV was correlated with some STIs. Of all men with gonorrhoea, 41% were HIV positive (35% of the township men and 44% of miners), among all men without gonorrhoea, 26% were HIV positive (21% of the township men and 28% of the miners) ($P = 0.02$). Forty-three per cent of men who reported genital sores in the previous year were HIV positive (adjusted OR 2.1, 95% CI 1.5–3.0, $P < 0.0001$). Of the women in the township with gonorrhoea, 61% were HIV positive, among those without gonorrhoea, 35% were HIV positive (adj. OR 1.9, 95% CI 1.1–3.4, $P = 0.02$). Of the women in the township with recently acquired syphilis, 54% were HIV positive, among those without recently acquired syphilis, 35% were HIV positive (adj. OR 1.9, 95% CI 1.1–3.4, $P = 0.02$). Of the women who had had genital sores in the previous year, 60% were HIV positive; of those who had not, 37% were HIV positive (adj. OR 2.4, 95% CI 1.5–4.0, $P < 0.0003$).

Migration

Ninety-seven per cent of the mineworkers were migrants. While 93% of them had a wife or regular partner, only 4.5% of

these partners lived in Carletonville; the others lived elsewhere in South Africa or in another country. More than half of the mineworkers said they had had sexual intercourse with at least one casual partner in the year before the survey and, of these, 70% never used condoms with their casual partners whereas 10% sometimes did. Eighty-three per cent of the migrant men never used condoms with their spouses.

Forty-seven percent of the women in hotspots and 21% of the women living in the township said that they were migrants. Migrant women earned more money (median income R300 per month) than non-migrant women (median income R150 per month) and migrant women were more likely to have received money for casual sex than non-migrant women (53% versus 30%, respectively).

Migrant women in the township were more likely to have had a casual partner in the last 12 months than non-migrant women (37% versus 18%). Condom use was similar for both groups of women: more than 80% never used condoms with their regular partners and 73% of non-migrant and migrant women never used condoms with their casual partners. Migrant women were more likely to be HIV positive than non-migrant women (51% versus 39%; $P < 0.002$). There was no statistically significant difference in prevalence of other STIs between migrant and non-migrant women or men.

Male circumcision

Male circumcision is practised by some but not all ethnic groups as an important ritual. Altogether, 43% of the men in the study were circumcised. Most of the Pedi and Xhosa were circumcised and almost half of the Basotho and Shangaan men. The Zulus, Tswanas and Swazi do not traditionally circumcise their men and only about 15% of men of each of these three ethnic groups were circumcised.

Circumcision was associated with lower prevalence of HIV (adj. OR 0.6, 95% CI 0.5–0.8, $P = 0.002$). Twenty-four per cent of all circumcised men were HIV positive compared to more than 28% of uncircumcised men. Of all HIV-positive men, 39% were circumcised, 61% were not. No protective effect of circumcision was found for STIs (syphilis, gonorrhoea and chlamydia).

Knowledge, perceived risk of HIV infection and behaviour

Knowledge of the most important risk factors for infection and methods of preventing transmission was high. Between 83% and 87% of participants gave correct answers in relation to the

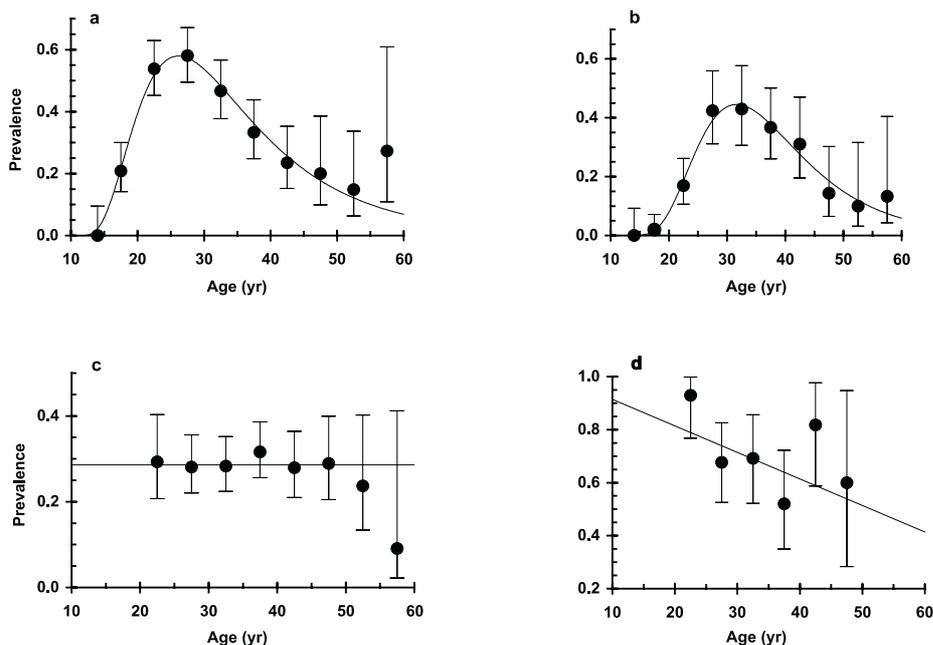


Fig. 1. The age prevalence of HIV-infection among (a) township women, (b) township men, (c) mineworkers and (d) women in hotspots.

role of faithfulness, condom use and the use of clean needles in the prevention of HIV infection. However, 35% of the men and 31% of the women expected HIV-positive people to show symptoms of infection.

Only 19% of the men in the township and 23% of the miners thought they were at high risk of HIV infection and, of these men, 27% and 30%, respectively, were infected with HIV. However, even among the 33% of township men and the 22% of mineworkers who said that they were at no risk of acquiring HIV, 15% and 28%, respectively, were already infected. Among the women in the township, 25% believed that they were not at any risk but, of these, 28% were already infected. Even among women in hotspots there were 17% who believed that they were not at risk of infection but, of these, 70% were already infected. Of the more than two thousand people who participated in the survey, no one indicated that they knew their HIV status.

There is a strong mismatch between perceived risk and actual risk. The majority of men and women knew that having multiple partners increases your chances of being infected with HIV and yet 32% of the men and 22% of the women in the township and 53% of the mineworkers said that they had had sexual intercourse with at least one casual partner in the previous year. Furthermore, 60% of the men and 74% of the women in the township and 68% of the mineworkers believed that their casual partner had had other sexual partners in the month prior to the interview.

Condom use among all groups was relatively low. The use of condoms with regular and casual partners is outlined in Table 2, with the reasons for choosing to use condoms.

Table 1. STI prevalence in township men, miners, township women and women in hotspots.

	Township men (%)	Mineworkers (%)	Township women (%)	Women in hotspots (%)
Life-time syphilis (TPHA ¹)	27.7	30.3	48.4	76.9
Syphilis (TPHA + RPR ²)	6.1	5.2	9.7	23.3
Gonorrhoea	3.4	3.0	6.9	15.7
Chlamydia	5.2	3.8	8.1	9.1
At least one current STI	13.7	11.4	21.5	36.4

¹TPHA, *Treponema pallidum* haemagglutination assay.
²RPR, rapid plasma reagin.

Table 2. Percentage of men and women who used condoms with regular and casual partners and for those who used condoms the percentage giving various reasons for using them.

	Men with regular partners	Men with casual partners	Women with regular partners	Women with casual partners
Condom use				
Never	81	69	79	58
Sometimes	12	10	11	9
Always	7	21	9	34
Reasons for using				
Avoid getting disease	31	70	43	64
Avoid pregnancy	29	–	17	–
Avoid transmitting disease	14	12	22	19

Social capital

Membership of an association and the feeling of belonging to a group of people or to an organization usually involves acceptance of the ideology and value system of that association. Health promoting behaviours, such as faithfulness or condom use, are more likely to be practised when the value system of the organization promotes them and when these beliefs and behaviours are shared with peers.

There was some association between HIV prevalence and associational membership. The strongest association for both township men and women was the protective effect of membership of a sports club. Of the men who belonged to a sports club, 16% were HIV positive, of those that did not 25% were HIV positive ($P = 0.02$). For women the corresponding figures were 21% and 41%, respectively ($P = 0.0001$).

Among township women over the age of 20 years, those who belonged to burial societies were less likely to be infected with HIV than those who did not (37% vs 46%, $P = 0.04$), and among women below the age of 30 those who belonged to youth clubs were less likely to be infected with HIV than those who did not (29% vs 46%, $P = 0.003$). Among women living in hotspots, those who belonged to a church were less likely to be infected with HIV than those who did not (50% vs 77%, $P = 0.004$) those who belonged to a stokvel (rotating credit association) were more likely to be infected with HIV than those who did not (95% vs 64%, $P = 0.008$). Membership of some associations was found to be protective, whereas membership of others seemed to increase the risk of HIV infection. The latter groups were associated with either a higher number of casual partners, less condom use, increased alcohol consumption or a combination of these mediating behavioural factors.

Discussion

HIV prevalence

The more rapid increase in HIV infection among women than among men is partly due to the age differential in sexual partnerships, with male partners, on average, six years older than their female partners, and partly because male-to-female transmission is believed to be three times more effective than female to male transmission.⁷ The decline in prevalence amongst older people might be explained by the fact that people who are now middle-aged are currently less likely to engage in high-risk sex and there was little or no HIV infection at the time that they were possibly more sexually active.

Other sexually transmitted diseases (syphilis, gonorrhoea and chlamydia)

The relationship between STIs and HIV infection is confounded by their common mode of transmission and common risk factors; a significant correlation between the prevalence of

HIV and gonococcal or syphilis infections and particularly with genital sores is in agreement with other studies.^{8–14} Farber and Ballard¹⁵ estimated that genital ulcers in one partner increase heterosexual transmission of HIV eight times, whereas non-ulcerative STIs increase transmission five times. They suggest that the combined effect is multiplicative.

In this study, STI-related symptoms at the time of the survey were not significantly associated with HIV status, probably because the latter almost certainly predated the former. However, HIV status was significantly associated with STI symptoms experienced during the 12 months before the survey, which may have enhanced the risk of HIV infection. Torian *et al.*¹³ reported that although overall HIV sero-prevalence and genital ulcer diseases declined in New York City between 1990 and 1992, sero-prevalence in patients with genital ulcer diseases increased from 10% to almost 16%. Chesson *et al.*¹⁶ estimated that almost 50% of HIV cases in the heterosexual population in the U.S.A. were attributable to increased infectivity due to syphilis. Various prospective studies have recruited HIV-negative people to assess the possible role of STIs in HIV sero-conversion. Among Kenyan truck company workers, univariate analysis showed that HIV acquisition was correlated with the presence of STIs that are associated with genital ulcers.¹¹ The HIV sero-conversion of commercial sex workers in Thailand was found to be significantly associated with *Chlamydia trachomatis*.¹⁰

Migrancy

A link between migrancy and the spread of HIV has been frequently suggested.^{3,11,17,18} Migrants may be more involved in sexual activities with multiple, casual partners, particularly when away from their home environment.¹⁹ The highest regional HIV prevalence in South Africa is found in KwaZulu-Natal, followed by Mpumalanga, the Free State and Gauteng. The lowest prevalence is found in the Cape provinces, suggesting that the epidemic started in KwaZulu-Natal and spread eastwards from there. The main highway from Malawi³ runs through northern South Africa to KwaZulu-Natal and Durban. HIV acquisition by truck company employees in Kenya was associated with occupation as a driver and with occupational travel for more than two weeks per month.¹¹ These men were also among the highest paid among the truck company employees and therefore perhaps better able to pay for commercial sexual encounters. Similarly, the living space of a mine worker is confined to a bed in a dormitory and a space to keep a few belongings; recreational activity often seems centred on drinking beer and meeting women in hotspots. These activities are facilitated by the relatively high monthly income of mine-workers, which is approximately 3–10 times greater than the average income of a man in the township.

Nonetheless, this is not the only possible explanation for the course of the HIV epidemic in our study area. Researchers

following the movements of migrant workers and their regular partners, from rural areas to this mining area, reported that in 60% of discordant couples, it was the migrating husband who was infected, whereas in 40% it was the wife who remained at home who was infected (M. Lurie, 1999, pers. comm.). In Uganda, 17 men (3.6%) and eight women (1.5%) with an HIV-negative spouse sero-converted during a seven-year follow-up, whereas 12 men (5.2%) and 22 women (11%) who had an HIV-positive spouse sero-converted.⁷ Men were therefore twice as likely as women to bring HIV into a marriage and, within sero-discordant marriages, women become infected twice as fast as men.

After adjustment for age, HIV prevalence was very similar between migrant mineworkers and men resident in the township. It is not possible to accurately reconstruct the early stages of the HIV epidemic in this mining area. However, it seems unlikely that migrant men were driving the epidemic at the time of the baseline survey, in August 1998.

Male circumcision

Urassa *et al.*²⁰ observed that HIV prevalence in Africa appears to be higher among non-circumcising ethnic groups. Studies in northwestern Tanzania,²⁰ the Rakai district in Uganda,²¹ the Masaka district in Uganda⁷ and in Kisumu in Kenya also reported a protective effect of circumcision.

The protective effect of circumcision might be attributable to the age at the time of the operation. The largest difference between circumcised and uncircumcised men was found in ethnic groups who circumcised their men before the onset of sexual debut. This protective effect may be due to the decreased risk of preputial lesions. Circumcision may also be associated with better penile hygiene, which may reduce the risk of HIV and penile cancer.²⁰ However, the reduced risk of HIV infection may be less pronounced when circumcision is partial or is performed after the onset of sexual activity. Even allowing for ethnic group and age differences, there was a protective effect of male circumcision in our study, with circumcised mineworkers being about 30% less likely to be infected.

Knowledge, perceived risk of HIV infection and behaviour

Despite the high and rapidly rising prevalence of HIV in South Africa, HIV is still heavily stigmatized in the country with the result that the epidemic remains hidden and people are reluctant to believe that AIDS is real.²² Of all men and women interviewed in August 1998, only 8.7% said they knew someone with HIV/AIDS in a population where one in four men and more than one in three women are HIV positive. Feelings of personal vulnerability in this community were low. For example, mineworkers believe that high blood pressure is likely to develop in individuals who do not engage in sexual intercourse.²³ In mining communities, sexually inactive people of both genders are often labelled as abnormal, weird and childish, and abstinence was considered unhealthy.²⁴

Social capital

Sexual behaviour such as condom use is not only determined by knowledge of the importance of safer sex practices but also by a range of psycho-social and social factors such as collectively negotiated and accepted social norms.²⁵ People are more likely to change their behaviour if they see that liked peers and trusted role models change theirs. Another factor promoting safer sexual behaviour is the degree to which people feel in control of their lives and supported by their social environment.²⁶

Mine work is dangerous and physically and psychologically

demanding. At 3.6 km, the mineshafts in our study area are the deepest in the world, with an atmosphere of intense heat, humidity and noise where miners work for 8 hours without food and often without water. Based on the average fatality and reported injury rates published by the South African Chamber of Mines, an underground worker has a 2.9% chance of being killed in a work-related accident and a 42% chance of suffering a reportable injury in a 20-year working life.²⁷ New mineworkers are often encouraged by their older colleagues, urging them to remember they were men. A man is regarded as someone with the responsibility of supporting his family, who is brave and able to withstand the rigours of the job. Linked with this ethos of masculinity, bravery, fearlessness and persistence in facing the demands underground is the notion of a macho sexuality, insatiable manly desire for multiple sexual partners and flesh-to-flesh sexual contact.²⁸ Off-duty life is difficult in regimented, company-owned, single-sex hostels away from home and families. The only way miners are able to experience some comfort and intimacy is in their relations with women in the hotspots and shebeens around their hostels. Although knowledge of HIV transmission was high among the mineworkers, they were more concerned with the dangers and stresses at work, which seemed to them much more real than an invisible disease which might affect them in a few years' time.²⁸ Mineworkers know that HIV/AIDS exists but they have yet to see its impact. Unless the impact is visible, people are often unable to alter their life styles.²⁹

Sex workers in the hotspots were aware of the dangers of unprotected sex but the principle of selling sex was that 'the customer is always right'. If a woman insisted on condom use, the client may either take business elsewhere or demand a reduced price. In addition, in taking on the identity of a sex worker, the women were separated from many of the markers of conventional dignity and respectability, which are associated with the roles of wife, mother and home maker, and which form the cornerstone of African social relations.³⁰

Conclusion

While the gold mines in South Africa have responded to the HIV crisis, in particular through setting up compulsory health education programmes as part of induction training and recurrent training for mineworkers returning from leave each year, these programmes have not always been as successful as hoped in terms of widespread sexual behaviour change.³¹ Health education programmes have achieved an improvement in people's knowledge, but the results of the baseline survey show that mineworkers had a higher number of sexual partners and were using condoms less consistently with their casual sexual partners than men in the township, who were not exposed to repeated health education programmes. In addition, these education programmes did not involve the community members living in the areas surrounding the mines. For mineworkers, who are largely migrants, much of their social and sexual lives are played out in the surrounding communities, therefore a lack of coordination of effort not only has a negative impact on the community but on the mineworkers as well.

The high prevalence of asymptomatic infections means that syndromic management by itself is insufficient to deal with established STIs, as the syndromic approach is based on signs and symptoms. In an attempt to remedy this predicament, periodic presumptive treatment of STIs among SWs has been implemented since February 2000. Among the general population and the mineworkers, partner notification slips and partner treatment are being aggressively pursued in an attempt to break cycles of infection already well established. Private doctors,

doctors at local hospitals and nurses in community clinics and in the mine clinics received training in diagnosis and treatment of STIs.

The incorporation of peer education into the more traditional approaches of the intervention aims to address the problematic notion of limited feelings of personal vulnerability to HIV infection. Community-based peer education programmes are designed to do more than simply provide information and promote condoms. They provide opportunities for discussion, debates and arguments with liked and respected peers. Through this they seek to provide the context in which people can question and challenge existing norms and can perhaps collectively work towards new norms of sexual attitudes and behaviours. The close collaboration with community and other stakeholders in the area aims to make HIV/AIDS 'our problem' rather than 'theirs' and to ensure that the project receives maximum support, is well coordinated and ultimately sustainable.

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- Department of Health (1999). Summary Report, 1998 National HIV sero-prevalence survey of women attending public antenatal clinics in South Africa. Pretoria.
- Williams B.G., Gouws E., Wilkinson D. and Abdoel Karim S.S. (2000). Where are we now? Where are we going? The demographic impact of HIV/AIDS in South Africa. *S. Afr. J. Sci.* **96**, 297–304.
- Webb D. (1997). *HIV and AIDS in Africa*. David Philip, Cape Town, and University of Natal Press, Pietermaritzburg.
- Williams B.G., MacPhail C., Campbell C., Taljaard D., Gouws E., Moema S., Mzaidume Y. and Rasego B. (2000). The Carletonville-Mothusimpilo Project: limiting transmission of HIV through community-based interventions. *S. Afr. J. Sci.* **96**, 351–359.
- UNAIDS (1998). Looking deeper into the HIV epidemic: a questionnaire for tracing sexual networks. UNAIDS Best Practice Collection, Key Material. UNAIDS, Geneva.
- Ballard R.C. and Fehler H.G. (1996). Syphilis — an underestimated public health problem in southern Africa: the disease and its diagnosis. *Spec. Med.* July 1996.
- Carpenter L.M., Kamali A., Ruberantwari A., Malamba S.S. and Whitworth A.G. (1999). Rates of HIV-1 transmission within marriage in rural Uganda in relation to the HIV sero-status of the partners. *AIDS* **13**, 1083–1089.
- Baganizi E., Alary M., Guèdèmè A., Padonou F., Davo N., Adjovi C., van Dyck E., Germain E., Joly R. and Mahony J.B. (1997). HIV infection in female prostitutes from Benin: association with symptomatic but not asymptomatic gonococcal or chlamydial infections. *AIDS* **11**, 685–704.
- Ghys P.D., Fransen K., Diallo M.O., Ettiègne-Traoré V., Coulibaly I-M., Yeboué K.M., Kalish M.L., Maurice C., Whitaker J.P., Greenberg A.E. and Laga M. (1997). The association between cervicovaginal HIV shedding, sexually transmitted diseases and immunosuppression in female sex workers in Abidjan, Côte d'Ivoire. *AIDS* **11**, F85–F93.
- Kilmarx P.H., Limpakarnjanarat K., Mastro T.D., Saisorn S., Kaewkungwal J., Korattana S., Uthairavavit W., Young N.L., Weniger B.G. and St Louis M.E. (1998). HIV-1 seroconversion in a prospective study of female sex workers in northern Thailand: continued high incidence among brothel-based women. *AIDS* **12**, 1889–1898.
- Rakwar J., Lavreys L., Thompson M.L., Jackson D., Bwayo J., Hassanali S., Mandaliya K., Ndinya-Achola J. and Kreiss J. (1999). Cofactors for the acquisition of HIV-1 among heterosexual men: prospective cohort study of trucking company workers in Kenya. *AIDS* **13**, 607–614.
- Taha T.E., Hoover D.R., Dallabetta G.A., Kumwenda N.I., Mtiamvalye L.A.R., Yang L-P., Liomba G.N., Broadhead R.L., Chipangw, J.D. and Miotti P.G. (1998). Bacterial vaginosis and disturbances of vaginal flora: association with increased acquisition of HIV. *AIDS* **12**, 1699–1706.
- Torian L.V., Isaac B., Weisfuse B., Makki H.A., Benson D.A., DiCamillo L.M. and Toribio F.E. (1995). Increasing HIV-1 seroprevalence associated with genital ulcer disease, New York City, 1990–1992. *AIDS* **9**, 177–181.
- De Vincenzi I. (1994). A longitudinal study of human immunodeficiency virus transmission by heterosexual partners. *New Engl. J. Med.* **331**, 341–346.
- Farber S.A. and Ballard R.C. (1996). *Sexually Transmitted Diseases: Know your risk*. KYR Pocket-book Publishers, Randburg.
- Chesson H.W., Pinkerton S.D., Irwin K.L., Rein D. and Kassler W.J. (1999). New HIV cases attributable to syphilis in the USA: estimates from a simplified transmission model. *AIDS* **13**, 1387–1396.
- Brewer T.H., Hasbun J., Ryan C.A., Hawes S.E., Martinez S., Sanches J., Butler de Lister M., Constanzo J., Lopez J. and Holmes K.K. (1989). Migration, ethnicity and environment: HIV risk factors for women on the sugar cane plantations of the Dominican Republic. *AIDS* **12**, 1879–1887.
- Nunn A.J., Wagner H-U., Kamali A., Kengeya-Kayondo J.F. and Mulder D. (1995). Migration and HIV-1 seroprevalence in a rural Ugandan population. *AIDS* **9**, 503–506.
- Lydié N. and Robinson N.J. (1998). West and Central Africa. *International Migration*, Vol. 35 (4). Special issues: Migration and HIV/AIDS, eds R. Appleyard and A. Wilsh. The Joint United Nations Programme on HIV/AIDS (UNAIDS) and International Organisation of Migration (IOM), Geneva.
- Urassa M., Todd J., Boerma J.T., Hayes R. and Isingo R. (1997). Male circumcision and susceptibility to HIV infection among men in Tanzania. *AIDS* **11**, 73–80.
- Kelly R., Kiwanuka N., Wawer M.J., Serwadda D., Sewankambo N.K., Wabwire-Mangen F., Chuanjun Li., Konde-Lule J.K., Lutalo T., Makumbi F. and Gray R.H. (1999). Age of male circumcision and risk of prevalent HIV infection in rural Uganda. *AIDS* **13**, 399–405.
- Taylor V. (1998). *HIV/AIDS and human development in South Africa*. South African Human Development Report, UNAIDS, Geneva.
- Molapo M.P. (1995). Job stress, health and perceptions of migrant mineworkers. In *Crossing Boundaries, Mine Migrancy in Democratic South Africa*, eds J. Crush and W. James. Creda Press, Cape Town.
- Nielsen A.C. (1999). *Management report on Project Youth*. Market Research Africa for The Society for Family Health, Johannesburg.
- Campbell C. (1998). The psychological context of HIV transmission on the gold mines: implications for HIV education programmes. In *HIV/AIDS Management in South Africa*, eds B. Williams and C. Campbell. Epidemiological Research Unit, Johannesburg.
- Campbell C. with Wood R. and Kelly M. (1999). *Social Capital and Health*. Health Education Authority, London.
- Chamber of Mines (1993). *Statistical Tables 1993*. Chamber of Mines, Johannesburg.
- Campbell C. (1997). Migrancy, masculine identities and AIDS: The psychosocial context of HIV transmission on the South African gold mines. *Soc. Sci. Med.* **45**, 273–281.
- Plimmer F. (1998). Employee perspectives on HIV/AIDS in the mining industry. In *HIV/AIDS Management in South Africa*, eds B. Williams and C. Campbell. Epidemiological Research Unit, Johannesburg.
- Campbell C. (2000). Selling sex in the time of AIDS. *Soc. Sci. Med.* **50**, 479–494.
- Campbell C. and Williams B. (1999). Beyond the biomedical and behavioural. In *Managing HIV/AIDS in South Africa: Lessons from Industrial Settings*, eds B. Williams, C. Campbell and C. MacPhail. Council for Scientific and Industrial Research, Johannesburg.