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The epidemiology of migration and AIDS in South Africa

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Abstract

Southern Africa has both a rapidly growing HIV epidemic and high levels of population mobility. The common assumption about the role of migration in the spread of HIV is that migrant men become infected while away and return home to infect their rural partners. However, I argue that at least at this late stage of South Africa's epidemic, the role of migration is more complex, and there is evidence for the bi-directionality of HIV transmission within couples.

KEYWORDS: HIV/AIDS; MIGRATION; SOUTH AFRICA

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Introduction

South Africa is experiencing one of the most rapidly growing HIV epidemics in the world. Among women attending antenatal clinics nation-wide, the prevalence of HIV infection increased from 0.76 per cent in 1990 to 26.5 per cent in 2002 (DOH South Africa 2003). Among the nine South African provinces, KwaZulu/Natal has consistently had the highest antenatal HIV prevalence, which in 2002 was 36.5 per cent. As in the rest of sub-Saharan Africa, the predominant mode of transmission is heterosexual intercourse.

Over the last century, migration became common among rural men seeking employment in urban and mining centres, and this persists today. In the Hlabisa district of rural KwaZulu/Natal South Africa, the site of this study, for example, 62 per cent of adult men spent the majority of nights away from their rural homes (Lurie et al. 1997). Men also migrate to South Africa from neighbouring countries, and there are an estimated 2.5 million legal and many more undocumented migrants in South Africa today (Zwi and Bachmayer 1990). Twenty years ago the gold mines employed approximately 500,000 people, about half of whom were South African, the rest coming from neighbouring countries including Botswana, Lesotho, Mozambique and Malawi (Crush 1995). While the number of men employed on the gold mines has fallen to about 300,000, the southern Africa region is still linked by extraordinarily high levels of migration (McDonald 2000).

Although there are many different types of migration, the predominant mode in southern Africa is 'circular' or 'oscillating' migration, in which young men leave their rural partners to work in urban areas and return home periodically depending on the distances involved.

The roots of migrant labour in South Africa run deep and can be traced to the discovery of gold on the Witwatersrand in 1886, and the associated demand for labour. The system of migrant labour was a cornerstone of apartheid policy in which the movement of South Africa's black population was strictly controlled so as to maintain a separation of the races while ensuring a steady supply of labour that was prohibited from settling permanently in 'whites-only' areas. Patterns of migration have, however, changed dramatically in the last decade. With the lifting of apartheid laws, the emergence of strong trade unions able to negotiate

more flexible work contracts, and the rapid development of an extensive, informal but efficient transport infrastructure, people are able to move more freely than before, and HIV, like other infectious diseases that spread from person to person, follows the movement of people (Quinn 1985).

Migration is one of many social factors that have contributed to the AIDS epidemic (Decosas and Adrien 1997; Mabey and Mayaud 1997). Several studies have shown that people who are more mobile, or who have recently changed residence, tend to be at higher risk for HIV and other sexually transmitted diseases (STDs) than people in more stable living arrangements (Brewer et al. 1998; Legarde et al. 1996; Mbizvo et al. 1996; Pison et al. 1993). In Uganda, people who had moved within the last five years were three times more likely to be infected with HIV than those who had lived in the same place for more than ten years (Nunn et al. 1995), and in South Africa, people who had recently changed their residence were three times more likely to be infected with HIV than those who had not (Abdool Karim et al. 1992). Decosas and others have argued that it is not so much the movement itself, but rather the 'conditions and structure of the migration process' that puts people at risk of HIV and other sexually transmitted diseases (Decosas and Adrien 1997).

The role of migration in the spread of HIV has been described primarily as a result of men becoming infected while they are away from home, and infecting their wives or regular partners when they return. This assumption of directionality has been central in research on the impact of migration for the spread of HIV (Lurie 2000, Decosas and Adrien 1997). In a study of seasonal migration in Senegal, Pison argued that the virus was 'mainly transmitted first to adult men through sexual contacts met during their seasonal migration and second to their wives or regular partners once they are back home' (Pison et al. 1993). Other studies have shown that men who live away from their wives or regular partners are more likely than those who live with their wives or regular partners to have additional sexual partners and are therefore more likely to become infected with HIV (Mbizvo et al. 1996) or other STDs (Mabey and Mayaud 1997).

However, the precise way in which migration contributes to the spread of sexually transmitted diseases is complex and not well understood. Previous studies have focused on the destinations of migrants, or, less often, on the areas from which migrants come (Lurie 2000); few studies have considered both ends

of the migration process – those who leave home as well as those who remain behind. These studies therefore tend to give a static view of what is essentially a complex and dynamic process. Studying both ends of migration routes is essential if targeted interventions are to be successfully implemented.

With that in mind, this study set out to understand the extent to which the HIV-1 epidemic in rural South Africa has been driven by urban migrants returning to their rural homes – as opposed to the spread of infection within rural communities. We also sought to understand the social and behavioural factors that shape and determine the spread of infection from migrant men to their female partners and vice versa. Understanding these questions has important implications for the development and implementation of intervention programmes, especially if it is possible to establish the relative risk of infection among different groups of men and women.

In this article I investigate the rates of HIV-1 infection among migrant and non-migrant couples in order to understand the risk factors and transmission dynamics of the epidemic in South Africa. We present first the data analysed by individuals and then by couples. Next we present the results of a mathematical model developed to estimate the probability of transmission from within versus from outside primary relationships. Finally, we discuss the implications of the study findings, and present a framework for understanding different levels of causation of the HIV epidemic and interventions aimed at each level.

Methods

This study tested the hypothesis that migrants and their partners are at increased risk of HIV compared with non-migrants and their partners, and investigated potential risk factors for HIV infection. We measured the prevalence of HIV-1, syphilis, chlamydia and gonorrhoea (although in this article I report only on HIV-1) among migrant men and their rural partners, and among non-migrant men and their rural partners. We also conducted a behavioural survey with the same study participants to identify social, behavioural and biomedical risk factors associated with HIV infection.

Between October 1998 and November 2000, male migrants from two adjacent rural districts (Hlabisa and Nongoma) were recruited at two migration destinations, Carletonville and Richards Bay (Figure 1), respectively 700 and 100

kilometres away from their rural homes. These sites were chosen because they are common destinations for migrant men from rural KwaZulu/Natal (Lurie et al. 1997) and because they represent the two common types of migration prevalent in the area: long-distance migration with infrequent trips home (Carletonville), and short-distance migration with more frequent trips home (Richards Bay). Carletonville is a gold mining town southwest of Johannesburg with a population of roughly 220,000 people, of whom 80,000 are migrant men living in single-sex hostels and working on the gold mines. Because of the distances involved, these men tend to return home only three to four times a year. Richards Bay, an industrial town on the north coast of KwaZulu/Natal, is also a common migration destination for these rural men, but because of the proximity to their rural homes, they are able to return home more frequently, on average at least once a month.

Three gold mines in Carletonville and three factories in Richards Bay were selected because they employ large numbers of people from Hlabisa and Nongoma districts. Lists of workers' origins were generated, through a census in Richards Bay, and through a list provided by *The Employment Bureau of Africa*, the agency responsible for recruiting men to work on the gold mines. Men from Hlabisa and Nongoma Districts were invited to the project offices where the purpose of the study was explained and they were invited to participate. Men were only included if they were from Hlabisa/Nongoma Districts, if they had been a migrant for at least six months, and if they had at least one 'regular' partner living in Hlabisa/Nongoma. A regular partner was defined through prior focus group discussions (Dladla et al. 2000) as a stable sexual partner with whom one envisions a future (*maqondana* in Zulu). Those who were eligible and who agreed to participate were administered a detailed questionnaire and offered voluntary counselling and testing for HIV and STDs.

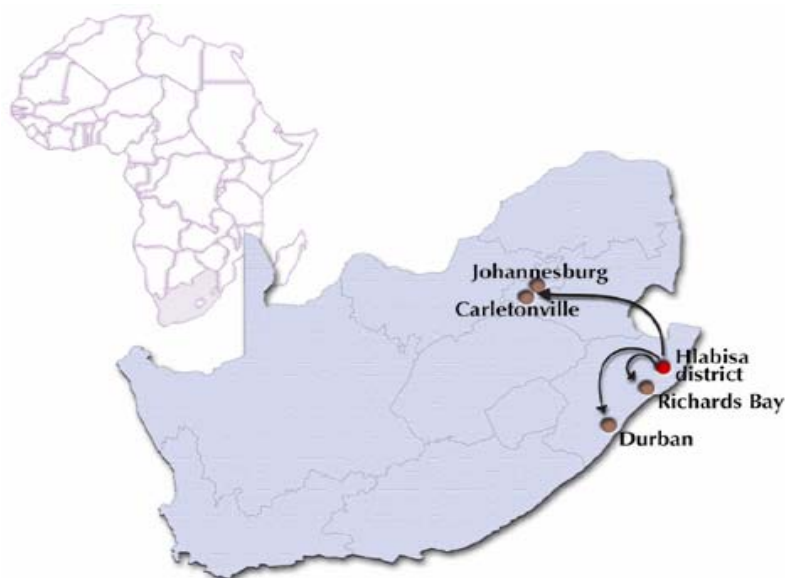


Figure 1. *Map of Migration Project Study Sites*

In addition, migrant men were asked a series of questions in order to locate and identify their rural partners. These included questions about the name of the head of the rural household, the nearest clinic and school, and specific directions to the household of the migrant man's rural partner. This information was sent to the project field office where fieldworkers visited these women and invited them to participate in the study. Once a participating partner of a migrant man was identified, a non-migrant couple living within a radius of one kilometre of each migrant household was identified and invited to participate in the study. A non-migrant man was defined as a person who spends most nights at home and who had not been a migrant for a total of more than six months over the last five years. All women were resident in Hlabisa/Nongoma districts and none were migrants. Refusal to participate in the study and the inability to trace some partners explains why the number of men and women are not equal.

Structured, face-to-face interviews were held with each participant and included socio-economic and demographic questions, migration histories, details of stable ('regular') and casual sexual partnerships, condom use, age at sexual debut, as well as a history of, and health seeking behaviour for, current or previous urogenital disease symptoms.

All participants were offered pre- and post-test HIV counselling, free condoms at each visit, and free treatment for symptomatic or laboratory-diagnosed STDs. Participants were encouraged to receive their HIV test results, but were also

given the option of not receiving them should they so desire (Mkaya-Mwamburi et al. 2000). Trained nurses treated symptomatic STDs at the time of enrolment using the KwaZulu/Natal provincial syndromic management guidelines (KwaZulu/Natal DOH 1995). Laboratory-diagnosed syphilis, chlamydia and gonorrhoea were treated at ten-day follow-up visits. The presence of symptomatic STDs is a major risk factor for HIV transmission (Grosskurth et al. 1995) and treatment therefore is likely to confer some protection against HIV infection. Those who agreed to participate were followed up every four months. The human subjects committees of Johns Hopkins University School of Hygiene and Public Health and the University of Natal, Durban approved the study.

Data analysis and development of mathematical model

Data were double entered and analysed using SAS version 6.12 (SAS Institute, Cary NC). The primary outcome was HIV-1 infection. The analysis was done separately by gender. Differences in quantitative variables were assessed using Student's t-test. Tests of significance for categorical variables were based on the chi-square test or Fisher exact test as appropriate. Logistic regression was used to estimate the adjusted odds ratios for HIV-seropositivity. Confidence intervals are given as 95 per cent. All p values were derived from two sided tests. A p value of 0.05 or less was considered statistically significant.

In order to estimate the relative risk of infection for migrant and non-migrant men and women from their spouse and from partners outside the relationship, we constructed the following model:

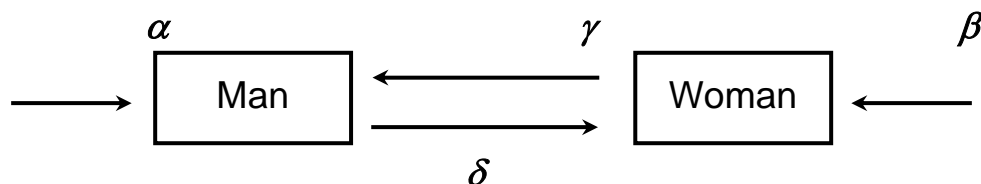


Figure 2

For a man and a woman in a partnership the man may be infected from outside the relationship with probability, the woman from outside the relationship with probability. The man may also be infected by his wife with probability (if she is already infected) and the women may be infected by her husband with

probability (if he is already infected).

If the probabilities of infection are known, then the probabilities of each of the four concordance possibilities can be calculated. The details of the mathematical model have been published elsewhere (Lurie et al. 2003a).

Results

Between October 1998 and November 2000, 260 men and 228 women were recruited into the study. Some 196 migrant men from Hlabisa/Nongoma districts were recruited at their workplaces, and 64 non-migrant men were recruited in Hlabisa/Nongoma. Some 130 female partners of migrants and 98 female partners of non-migrants were recruited in Hlabisa/Nongoma districts. Not all study participants were matched to a partner because some partners refused to participate, and in some cases it was not possible to find the partner. The overall prevalence of HIV-1 infection was 20.1 per cent. Prevalence among men was not significantly different from that among women (22.7 per cent v. 19.1 per cent, respectively, $p=0.34$; OR=1.2; 95 per cent; CI=0.80–1.93). The prevalence of HIV-1 among migrants and their partners was, however, significantly higher than among non-migrants and their partners (24.0 per cent versus 15.0 per cent, respectively, $p=0.02$; OR=1.8 95 per cent CI=1.1–3.0). Results are presented first by gender and then by couple. More detailed results and data tables can be found elsewhere (Lurie et al. 2003a; Lurie et al. 2003b).

Males

The median age was 39.1 years (mean=37.4; SD=8.4) and migrants were, on average, six years younger than non-migrants ($p<0.001$). Most men had some education, and migrants tended to be better educated than non-migrants. Almost 40 per cent of non-migrants, but only 20 per cent of migrants, had never attended school, while less than 20 per cent of non-migrants, and nearly 30 per cent of migrants, had attended secondary school. Nearly all men were either married or living as married, with similar proportions among migrants and non-migrants. Migrant men were significantly more likely than non-migrant men to derive an income from formal employment; all the migrant men, but only 43 per cent of non-migrant men had a formal income. Almost all the non-migrant men lived with their wives or regular partners most of the time while very few of the

migrant men did. In Carletonville, all but three of the men lived in single-sex hostels provided by employers, while in Richards Bay only three men lived in employer-provided accommodation and the majority lived either alone (36 per cent), with other workers (17 per cent), or with relatives (22 per cent).

Most men reported only one current regular sexual partner, but about 30 per cent of both migrant and non-migrant men said that they had two or more regular partners. Non-migrant men were more likely to have regular partners in Hlabisa/Nongoma, while migrant men were more likely to have regular partners outside Hlabisa/Nongoma, mostly at their migration destination. Migrant men were significantly more likely ($p=0.02$) than non-migrant men to have at least one current casual partner, but only 20 per cent of migrant men, and 6 per cent of non-migrant men reported having one or more casual partners. Most of the men who had casual partners were migrants below the age of thirty-five years. The median reported age of sexual debut for migrant men was 18 years and for non-migrant men 19 years. Non-migrant men reported a significantly higher number of lifetime partners than did migrant men although this may be partly confounded by age.

Condom use was low with less than 20 per cent of men in both groups reporting that they had ever used a condom. Men who were under 35 years old were significantly more likely than older men to have ever used a condom (OR = 2.4; 95 per cent CI=1.2–4.6), and men who reported having many casual partners were more likely than men who reported few casual partners to have ever used condoms. Compared with men who had no casual partners, the odds of ever having used a condom was 1.7 (95 per cent CI 1.1–2.7) among those who had one casual partner compared with 8.4 (95 per cent CI 1.5–49.0) among those who had four casual partners. Non-migrant men were more likely than migrant men to have used condoms in regular relationships (10.9 per cent versus 23.7 per cent; $p=0.04$).

Approximately one-quarter of men claimed to have had a genital ulcer at some point in their lives and 35 per cent said they had experienced genital discharge. Approximately 7 per cent of men said they were experiencing ulcers, discharges, swollen testes or swollen lymph nodes at the time of the survey. These symptoms were equally common to migrant and non-migrant men.

The prevalence of HIV among migrant men was significantly higher than among

non-migrant men (25.9 per cent versus 12.7 per cent; $p = 0.03$; OR = 2.4; 95 per cent CI 1.1–5.3), and the prevalence was higher among migrant men than among non-migrant men when stratified according to age, although individuals within age group differences were not statistically significant because of the limited sample size.

The most important univariate risk factors for HIV among men were being a migrant, being under 35 years old, having one or more casual partners, having symptoms of STDs in the previous four months, and ever having used a condom. Those with current STD symptoms, with symptoms in the previous four months, or with a history of STD symptoms were more likely to be HIV-infected than those who had never had STD symptoms. Those who had ever used condoms were more likely to be HIV positive than those who had not. The probability of being infected with HIV was not significantly associated with income, education, lifetime number of partners, age at sexual debut and the number of places lived over the course of a lifetime.

A multivariate, forward-stepwise logistic regression was carried out including all those variables that were found to be significant in the univariate analysis, as well as other variables of potential importance. In the multivariate analysis the risk of HIV infection remains higher among migrants than among non-migrant men (OR=2.65; $p=0.026$), among those who report recently having STD symptoms (OR=2.09; $p=0.029$) and among those who have lived in more than four places (OR=3.56; $p=0.001$) compared with only one place. Having lived in four or more places was not significant on bivariate analysis, but became significant in the multivariate model. Those who said that they had ever used condoms were also at increased risk of HIV infection compared with those who said that they had not (OR=2.18; $p=0.045$) but this is confounded by the fact that those who report having used condoms are also likely to have had more casual partners than those who say that they have never used condoms.

Females

Of the 228 women recruited into the study, 130 were partners of migrants and 98 were partners of non-migrants. Because of the study design, none of the women were migrants. The women were, on average, about four years younger

than their male partners. The level of education among women was similar to that of their male partners with a quarter of women having had no formal education and 23.5 per cent having had at least some secondary education; partners of migrants were significantly more educated than the partners of non-migrants ($p=0.05$). Few women in either group were formally employed. The partners of migrants were significantly more likely than partners of non-migrants to receive financial support from their partners, which is to be expected since men still migrate largely for economic reasons. Nevertheless, only half the partners of migrant men said that they received financial support from their partner.

As with the men, most of the women were married or living as married. Some 19 per cent of the regular partners of migrants and 7 per cent of the regular partners of non-migrants said that they were 'single' ($p=0.01$). Only one woman said that she had more than one regular partner and only three women said that they had any casual partners. The median age at sexual debut, 17 years, was one year younger for women than for men. Women reported having, on average, only two lifetime partners, fewer than reported by the men, suggesting that they had only ever had one partner apart from their current regular partner.

Reported use of the male condom was lower among women than it was among men ($p=0.07$) with almost 90 per cent of women saying that they had never used a condom. Women who reported ever having used a condom had slightly more lifetime partners than women who had never used a condom (1.9 versus 2.0; $p=0.096$).

STD symptoms were also common among women, with 24 per cent saying they had at some time had a genital ulcer and 44 per cent that they had experienced a discharge. Two-thirds of all women said that they had experienced discharges, ulcers and/or swollen lymph nodes, and partners of migrants were more likely to have experienced these symptoms than partners of non-migrants ($p=0.03$).

HIV infection was more frequent in partners of migrants than partners of non-migrants (21.1 per cent and 16.5 per cent respectively), although these differences were not statistically significant ($p = 0.39$). Among the youngest group of women HIV prevalence was higher among partners of non-migrants (34.5 per cent) than among partners of migrants (25.7 per cent); again this difference was not significant ($p=0.39$). In the two older age groups, partners of

migrants had a higher prevalence of HIV than partners of non-migrants; these differences were not significant.

For women, the most important risk factor for HIV was with the number of lifetime partners: women who reported having had more than one lifetime sexual partner were five times more likely to be infected with HIV than women who said that they had only had one lifetime partner (OR=5.1, 95 per cent CI=2.2–11.5). Age was also a significant risk factor for HIV, with younger women more likely to be infected than older women (OR=2.3, 95 per cent CI=1.2–4.5). Women who reported having sexual intercourse for the first time at or before the age of 17 years were more likely to be HIV positive (24.5 per cent) than those who reported a later age at sexual debut (14.3 per cent), although this was only marginally significant ($p=0.07$; OR=2.0; 95 per cent CI=1.0–4.1).

The prevalence of HIV among women was not significantly associated with being the partner of a migrant, receiving financial support from the husband or regular partner, level of education, STD symptoms or ever having used a condom. Women who had used a condom were as likely to be HIV-infected as those who had not.

Couples

A total of 168 couples were recruited into the study of which 98 (58.3 per cent) were couples in which the male partner was a migrant, and 70 (41.7 per cent) in which the male partner was not a migrant. Among 69.6 per cent of couples neither partner was infected with HIV-1; migrant couples were as likely as non-migrant couples to have neither partner HIV-1 infected (65.3 per cent versus 75.7 per cent; $p = 0.148$) (Lurie et al. 2003a). In 9.5 per cent of the couples, both partners were infected with HIV-1, and this did not differ significantly by the migration status of the male partner. In 20.8 per cent of the couples one of the partners was infected with HIV-1 (HIV-1 discordant), and migrant couples were 2.5 times more likely than non-migrant couples to be discordant for HIV (26.5 per cent versus 12.8 per cent; OR = 2.5; 95 per cent CI = 1.1 – 5.6; $p = 0.031$). Of the 35 discordant couples the man was HIV-positive in 25 (71 per cent) of the cases and the woman in the remaining 10 (29 per cent) cases. The proportion of men who were infected in the migrant discordant couples was essentially the same as in non-migrant discordant couples ($p = 0.95$).

Migrant and non-migrant couples in infected and in uninfected partnerships are similar in their demographic and behavioural characteristics. There were no significant differences among migrant versus non-migrant couples in the age of difference between partners, the proportion who were formally married, the duration of the relationship or the number of regular or casual partners. However, among infected couples non-migrant men were more likely to have had more than ten partners and non-migrant women were more likely to have had more than two partners. In those partnerships in which men reported having more than one casual partner, there was more likely to be an infection in either or both of the partners than in those partnerships for which men reported having one or no casual partners (OR = 7.06; $p = 0.032$; 95 per cent CI = 1.18 – 42.13). Women who reported having two or more lifetime partners were more likely to be in relationships in which one or both members were HIV-1 infected. Neither the number of regular partners nor the number of lifetime partners that men had were significantly associated with the chances of one or both members of a couple being HIV-1 infected.

We constructed univariate and multivariate discrete conditional logistic regression models for the risk of one or both partners in a couple being HIV-1 infected. For the model, we created new, composite variables by combining the response of the male partner with that of the female partner. Therefore a 'yes' response to the variable 'STD symptom in the last four months' meant that at least one of the partners in a couple had experienced an STD symptom during that time period. Variables considered in the univariate analysis were investigated in the multivariate model.

The most important factors predicting the presence of at least one HIV-1 infected individual in a couple were: age at first sexual intercourse, the number of current sexual partners, and having experienced STD symptoms in the last four months. Migration was not statistically significant but was retained in the model. The relative risk of HIV infection was 2.4 times higher among those whose first sexual experience was at 16 years old or younger compared with those whose sexual debut was over the age of 16; the relative risk of HIV infection increased by 1.5 for each additional current sexual partner. Those who had STD symptoms in the previous four months were more than twice as likely to have one or both partners HIV-1 infected compared with those who did not have STD symptoms in

the previous four months, keeping age at first intercourse, migration status and the number of current sexual partners fixed.

Mathematical Model

Fitting the model to the data as previously discussed shows that men and women are both more likely to be infected from outside the relationship than to be infected by their spouse, whether or not the man is a migrant. Migrant men are 26 times more likely to be infected from outside the relationship than from inside the relationship; women whose partners are migrants are 2.1 times more likely to be infected from outside the relationship than from inside. The same is true for non-migrant couples but with smaller odds ratios: 10.5 for non-migrant men and 0.8 for their partners. We also compared the relative risk of infection for migrants as against non-migrants from outside versus inside their primary relationships. Both men and women are more likely to be infected from outside the relationship and less likely to be infected by their spouse if they are part of a migrant couple but none of these risk ratios is statistically significant.

The model assumes that within a spousal relationship, male to female HIV transmission is twice as likely as female to male transmission. For comparison, we also modelled the likelihood of infection from inside versus outside a relationship using transmission probabilities of 3:1 and 1:1 and found that these changes had very little impact on the outcome of interest. Changing the relative transmissibility from men to women in either direction changes the relative risk estimates by less than 1.5 per cent in all cases.

Discussion

The exceptionally high prevalence of HIV in most southern African countries has raised important and complex questions about the factors that have contributed to the rapid spread of HIV in the region, and about the eventual prevalence the epidemic might reach. This cross-sectional, community-based study of migrant and non-migrant men, and their rural partners, has revealed a very high prevalence of HIV among both men and women. The study provides evidence of the importance of migration in the spread of HIV in southern Africa, and shows that migration is a significant risk factor for HIV-1 for men.

For men, being a migrant, and having lived in four or more places, were

independent and significant risk factors for HIV-1 infection. Thus, not only is labour migration – with its associated separation of families – an important risk factor for HIV-1 transmission, but so too is the social disruption caused by repeated relocation, in some cases forced relocation as a result of apartheid policies and political violence.

These findings are particularly interesting, given the mature stage of the southern African HIV/AIDS epidemic. It is likely, for example, that the role of migration in the spread of HIV was more important – and more easily measured – in the early stages of the epidemic than in the later stages (Coffee et al. 2000). Indeed, isolating a single causal factor in a mature epidemic, when prevalence is already very high, was likely to be difficult. The fact that the odds of a migrant man being infected was 2.4 times the odds of a non-migrant man being infected, even at this advanced stage of the epidemic, highlights the importance of migration as one explanation of the size and rapidity of spread of the southern African epidemic.

The patterns of HIV discordance in this study were unexpected and shed light on the role of migration in the spread of HIV-1 to rural areas. It has long been assumed that the primary direction of spread of the epidemic has been from returning migrant men, who become infected while away at work, to their rural partners when they return home. If this were the case, the male would be the HIV-1 infected partner in most of the discordant couples; however, in nearly one-third of the discordant couples the female was the infected partner. While this confirms the importance of migration as a risk factor for infection in both men and women, it changes our understanding of the way in which migration enhances this risk. We have found that migration is a risk factor not simply because men return home to infect their rural partners, but also because their rural female partners – both those who are partners of migrants and those who are partners of non-migrants – are likely to become infected from outside their primary relationships.

One might expect that with their partners absent, women would be more likely to have additional sexual partners, and as a result to increase their risk of becoming infected with HIV-1. The fact that the patterns of HIV-1 discordance are similar among migrant and non-migrant couples indicates that even some partners of non-migrant men become infected prior to their husbands. Serwadda

et al. (1995) found a similar proportion of women in HIV-1 discordant couples to be the infected partner in rural Uganda.

The specific circumstances in which rural women take on additional relationships needs further investigation, as well as the ways in which these relationships increase risk for HIV infection. We have found in key informant interviews (Dladla et al. 2000) that women talk about the need for social, sexual, financial and emotional support, all of which are frequently lacking in long-term 'stable' relationships, particularly when the partner spends the vast majority of his time far away from home. Research is needed to understand better the complex social and sexual lives of women who are living in rural areas, especially in relation to the migration status of their partners. Understanding these dynamics could help to promote the development of new approaches for HIV-1 prevention among rural women.

The mathematical model presented here makes it possible to estimate the probability that either his or her spouse or someone outside the relationship infects a person. We found that for everyone the risk of becoming infected from outside is greater than the risk of becoming infected from inside the spousal relationship. While we expected that migrant men would be more likely to be infected from outside their spousal relationships, we did not expect that to be true for the other groups, including women whose partners were and were not migrants. Interestingly, the model shows that migration reduces the risk of infection from inside the relationship and increases the risk from outside the relationship, both for men and for women. Since men who migrate to Carletonville, for example, spend relatively little time at home each year, the likelihood of them infecting their rural partners is correspondingly low, presumably as a result of the infrequent exposure.

Since most research on migration and AIDS has taken place only at male migration destinations and excluded the rural end of the migratory routes, there has been a suggestion that interventions for migrants should be targeted at male migration destinations. Indeed, operational issues including the ease of finding and following people make this an attractive option. Our findings, however, demonstrate the complexity of HIV transmission in the presence of large-scale male migration and the need to address the spread of disease among, especially, young rural women, not just women living in migrant relationships. What has not

been acknowledged to date is the role of local, rural transmission in this complex epidemic. The findings of this study show that it is important to include rural areas if HIV treatment and prevention programmes are to succeed in reducing the spread of HIV. In addition, further work is necessary to explore more fully the complex patterns of sexual networking, particularly among women in rural areas. Some of this work is underway within the context of the current project (Dladla et al. 2000).

By design, this study included only women who were not migrants. This was partly for operational reasons, since tracing women to many different rural districts would have been logistically challenging. Nevertheless it raises important questions about whether or not female migrants are at increased risk of HIV infection, and the extent to which non-migrant rural women who are infected became infected as a result of contact with returning migrants as opposed to contact with men who were resident in the rural communities. The latter question cannot be answered with the available data, but in a study carried out in a township near Carletonville, women who self-identified as being migrants were 1.6 times more likely (95 per cent CI 1.1–2.3) to be HIV-positive than women who self-identified as not being migrants (Zuma et al. 2003).

This study also shows that migrant men were significantly more likely than non-migrant men to have casual sexual partners and to be HIV-positive. That more men than expected reported currently having no casual partners may indicate underreporting, or that casual relationships are of short duration. For women, there was a marked reluctance – for obvious social reasons, including the fear of violence – to admit to having additional sexual partners. It is likely that, in keeping with the findings of other behavioural surveys (Cleland and Ferry 1995), women in this study underreported the extent of their own sexual networks. The reluctance of women to speak openly about whether or not they had casual relationships – even in qualitative interviews – has already been documented in this setting (Dladla et al. 2000; Lurie et al. 1997). For example, Dladla found that women spoke of *others* taking on additional sex partners, although few would acknowledge having done so themselves. It is likely that this reluctance would be further exacerbated in the more formal setting of a survey. Further research, and perhaps the development of additional methods for the study of female sexual behaviour in rural areas are urgently needed to shed more light on

social arrangements that underlie the complex epidemiological patterns identified in this study.

Interventions

The high rates of self-reported sexually transmitted disease symptoms may highlight a possible target for intervention strategies. Successful syndromic management of symptomatic STDs can significantly reduce the incidence of HIV (Grosskurth et al. 1995) and should be a central component of HIV prevention programmes in this setting (Harrison et al. 2000). In addition, presumptive STD treatment among sex workers on some South African gold mines has been reported to reduce the prevalence of STDs among miners (Steen et al. 2000).

Although this study focused only on male circular migration within South Africa, and from the perspective of two rural health districts, circular migration is in fact extremely common throughout southern Africa. It is important to recognise, however, that other types of migration do exist, and may play an important role in facilitating the dissemination of HIV throughout the southern African region. Further studies that focus on other types of migration – particularly female migration – are urgently needed.

The high prevalence of HIV among migrant men indicates that this group is an appropriate target for focused intervention strategies. At the same time, migrant interventions that concentrate exclusively at the workplace are likely to have only limited success, given that a significant amount of HIV transmission among rural women occurs irrespective of the migration status of a woman's partner. Interventions are most likely to be effective if they include both men at the workplace and women in rural communities.

Where possible, interventions should deal with migrant couples as a social unit and not just with one or the other partner. HIV prevention interventions have often been aimed at individuals, encouraging people to use condoms and reduce the number of partners. Interventions designed specifically to address the situation in which one partner is already infected are needed to protect the uninfected partner who is likely to be at high risk of infection. These interventions could include couple counselling, more aggressive treatment of STDs, antiretroviral therapy for HIV-infected partners, and education messages aimed at couples rather than individuals. Van der Straten and colleagues (Craiel et al.

1998; van der Straten et al. 1998; van der Straten et al. 2000) found that including seronegative partners in counselling interventions may decrease sexual risk-taking among serodiscordant couples, and Padian et al. (1993) found that social support resulting from couples counselling is an effective way of promoting behaviour change. More generally, interventions aimed at couples could help improve communication within relationships, focusing on protecting those who are at high risk (Painter 2001).

Levels of causation of the HIV/AIDS epidemic

Most social and health problems cannot be attributed to single causal factors; they are instead a product of the complex interaction between many factors. Sweat and Denison (1995) identified a typology of four different levels of causation of the HIV epidemic: superstructural, structural, environmental and individual levels.

Starting at the highest level of causation, the superstructural level addresses the macrosocial and political environments that create advantages and disadvantages for members of society. These would include dominant societal attitudes like racism and sexism that serve to disadvantage portions of the population. In South Africa, for example, attitudes about the role of cheap black labour in the economy have dominated policies that for more than a century have served to make labour abundant to industry and other economic sectors, and to underdevelop rural sectors of the economy.

Structural factors include policies and laws that serve to exacerbate the epidemic. Examples of these laws in twentieth-century South Africa were abundant. These would include laws that prohibited black South Africans from living permanently in 'whites only' areas, or a 1913 law that sought to force black South Africans to become migrants by imposing a tax on people who at that point in time were largely removed from the monetary economy. The whole system of apartheid, with its 'separate development' set the stage for the patterns of migration that predominate in the region today.

Environmental factors that contribute to the epidemic would include the living conditions, social pressures and opportunities available to individuals. Here the single-sex hostel system, easy access to commercial sex workers and alcohol would all play a part in exacerbating the epidemic. So too would the fact that

truck drivers, for example, are routinely assigned to travel schedules that necessitate their being away from home for extended periods of time.

Finally, individual levels of causation of the epidemic are defined as the ways in which individuals experience and act on their environment. Levels of knowledge, risk perception, loneliness, boredom and perceived self-efficacy would contribute towards individual behaviour conducive to the spread of HIV.

Sweat and Denison (1995), who developed the model, argue that HIV interventions should occur at all levels of causation, but in reality prevention efforts have been dominated by interventions aimed almost exclusively at the individual (Sweat and Denison 1995). Since there are multiple causal factors that help to explain the role of migration in the spread of HIV and other STDs, successful strategies are likely to be those that address as many levels at which the epidemic occurs as possible. In general, public health specialists have shied away from the higher-level interventions, concentrating instead on individual-level programmes. Ironically, it is the structural and environmental interventions, difficult though they are to implement, that are likely to have the most far-reaching and sustained impact.

At least two structural interventions should be considered. Employers should be encouraged to provide, instead of single-sex hostels, more family-friendly housing arrangements. The mining industry, for example, has moved at a painfully slow pace in this direction: in 1993, only 2.1 per cent of miners employed by the Anglo-American Mines lived in married quarters; the vast majority, 89 per cent, lived in single-sex hostels (Crush 1995). Using mathematical models, we have found that replacing the single-sex hostels with family-style accommodation could reduce the HIV incidence by as much as 40 per cent (Gebrekristos and Lurie 2002).

A second, and perhaps more significant structural intervention is that of encouraging rural development. This has the potential to alter the conditions that force large numbers of young men to seek temporary employment in urban areas and may well be as effective an intervention as we have. Indeed, these kinds of interventions need to be discussed not only for this particular rural health district but also for all sub-Saharan Africa, where large-scale population movement is the norm, not the exception.

Conclusions

Despite migrancy being acknowledged as a major determining factor in the social conditions in the region (Packard 1989), few studies have explicitly considered the impact of migrancy on the health of people, even though the health consequences of migration may be critical to health outcomes. This study highlights the importance of migrancy as a risk factor for HIV and probably other diseases also, and the need fully to incorporate a good understanding of public health in studies on migration.

It is ironic that lifting the apartheid laws has led to increased mobility throughout southern Africa and has contributed to the spread of HIV in the region. However, while migration spreads disease, it can also be used to spread messages and interventions that can positively impact on the epidemic. Unless ways are found to deal with the combined effects of HIV and migration it is unlikely that HIV-transmission in southern Africa will be substantially reduced.

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