Centre for Actuarial Research (CARE)

A Research Unit of the University of Cape Town

HIV Risk Factors: A Review of the Demographic, Socio-economic, Biomedical and Behavioural Determinants of HIV Prevalence in South Africa

CARE Monograph No. 8

Prepared by Leigh Johnson and Debbie Budlender

January 2002.

ISBN 0-7992-2118-X

Centre for Actuarial Research

University of Cape Town
Private Bag
Rondebosch
7701 SOUTH AFRICA

Telephone: +27 (21) 650-2475
Fax: +27 (21) 689-7580
E-mail: care@commerce.uct.ac.za

Synopsis

The purpose of this report is to identify the most significant demographic, socio-economic, biomedical and behavioural determinants of HIV risk in South Africa. The report also aims to determine the relationships between these factors, and to show how these factors apply in workforce populations.

The investigation presented in this report combines a literature review of studies conducted in South Africa into the effects of various factors on rates of HIV infection, and a statistical analysis of four major South African data sets. The first two data sets are drawn from information on HIV prevalence levels among pregnant women attending public antenatal clinics. The first records HIV status at an individual level, and the second records HIV prevalence at a municipal district level. The third data set is based on a national workforce prevalence survey conducted by a large South African employer. The last data set provides HIV and STD prevalence information collected as part of the Mothusimpilo-Carletonville project, which was conducted in a mining town near Johannesburg. All four data sets were analysed using multivariate logistic regression. The results of these analyses are interpreted in the light of research done elsewhere.

The first major risk factor identified is sexually transmitted diseases (STDs) and treatment seeking behaviours in respect of these infections. STDs increase the risk of HIV transmission. Rates of STDs are particularly high among women, and women also appear to be more likely to delay or avoid seeking treatment. Asymptomatic STDs are particularly common among women, and this is a further reason for women not receiving treatment. These factors may partially explain why HIV prevalence levels in South Africa tend to be higher among women, in aggregate, than among men. It is also apparent that individuals that are employed are at a lower risk of infection with STDs.

A second risk factor is knowledge and beliefs about HIV/AIDS. Most South Africans know of HIV/AIDS, and know that it is spread sexually. However, there are many misconceptions regarding other forms of transmission and cures for HIV/AIDS. These misconceptions are most common in rural areas and outside of employed populations. Evidence suggests, though, that knowledge by itself does not provide much protection against HIV infection.

A number of sexual behaviour factors affect the risk of HIV infection. Women are particularly vulnerable to rape and violence in sexual relationships, and in many cases they have limited control over their sexual relationships. It is also clear that many women depend on sex as a source of income or support, and these women are vulnerable because they have limited power in negotiating safe sex practices. Alcohol consumption increases the likelihood of interaction with sex workers and other unsafe sex behaviours, and the link between HIV infection and alcohol consumption is particularly significant in migrant populations. While promiscuity is also a risk factor, it is clear that many individuals are at risk because of whom they have sex with, rather than how many people they have sex with.

Certain forms of sexual intercourse are also associated with higher risks of HIV transmission. Sex without a condom is the most common form of high-risk sexual intercourse. Failure to use a condom is most common at older ages and among less educated individuals. It also appears that rates of condom usage are substantially lower in rural areas than in urban areas, although it is not clear to what extent this is due to difficulties in accessing condoms. Anal sex also significantly increases the risk of transmission, and has been one of the reasons for the high levels of HIV prevalence among men who have sex with men. The extent to which anal sex is practised among heterosexuals is unclear, but there is evidence to suggest that it is common among sex workers and their clients. Dry sex and sex during menses are suspected to increase the risk of HIV transmission, although much of the evidence suggests that their effect is not significant, and there is little to suggest that their practice is common.

Migration and migrant labour have also been identified as key factors influencing HIV risk. Levels of migrant labour are particularly high among men. Many are accommodated in single sex hostels, and many engage in casual sexual relationships as a result of being separated from their regular partners. Their regular partners are also not necessarily faithful to them in their absence, often for economic reasons. The system of migrant labour thus facilitates the rapid geographical spread of the epidemic.

HIV risk is also influenced by socio-economic factors such as income, education and employment status. The relationship between HIV risk and these socio-economic markers is highly complex, and is likely to be obscured by a variety of other demographic factors. The individual's risk of HIV infection is determined by both his/her socio-economic status, and the socio-economic profile of the community in which he/she is situated. The individual's socio-economic status determines their ability to attract sexual partners (particularly in the case of men), as well as their access to STD treatment and their ability to protect themselves from HIV infection. The socio-economic profile of the community, on the other hand, is closely related to its extent of urbanization, and to the level of migration it experiences.

HIV prevalence levels vary substantially between occupational and industry groups. Levels are particularly high among mine workers, truck drivers, male security forces, and other occupations involving long separations from regular partners. HIV prevalence levels appear also to be high among teachers and agricultural workers, but the reason for this is not clear. Little data was available on HIV prevalence levels in other occupational groups, but HIV prevalence appears to be low among white-collar workers.

Race was found to be a very significant determinant of HIV risk, even when socio-economic factors were adjusted for. HIV risk is highest among black Africans, substantially lower among coloureds and Asians, and lowest among whites. It is suggested that HIV prevalence in the black African population is high because of the social effects of forced removals, the migrant labour system, and the gradual breakdown of traditional value systems. Cultural differences in sexual practices may also explain the differences. In the white population, the pattern of transmission appears to be predominantly homosexual, but this may change.

It was further found that within the black African population, there are substantial differences between language groups in terms of levels of circumcision. Circumcision has been shown to lower the risk of female-to-male transmission of HIV. Differences in levels of circumcision suggest differences in HIV prevalence levels between language groups, and these can explain part of the geographical differences in HIV prevalence.

For biological and socio-economic reasons, women are in general at a higher risk of HIV infection than men. Male and female prevalence patterns also differ substantially with respect to age. Women tend to become infected in their teens and early twenties. Men attract more sexual partners as they enter employment and acquire socio-economic status, and hence get infected at older ages on average. Large age differences between male and female partners may be a factor contributing to the rapid spread of the epidemic, although there is little research to confirm this. Marital status does not appear to be a significant determinant of HIV risk, but women that have large families tend to be at a lower risk of infection than women that have few children.

Geographical differences in HIV prevalence levels are also apparent. Differences between provinces can be explained partly by differences in demographic mix and cultural factors, and partly by differences in the level of maturity of the epidemic in different parts of the country. The epidemic appears to be most mature in KwaZulu-Natal, while Western Cape and Northern Cape are still in the relatively early stages of their epidemics. It seems likely that HIV prevalence will peak at relatively low levels in these latter two provinces and in the Northern Province. The prevalence in KwaZulu-Natal, however, seems set to peak at a level substantially higher than any of the other provinces. Prevalence levels can be expected to be lower in rural communities, because of the limited opportunities for sexual networking and the higher levels of social cohesion in these communities. However, this is not uniformly the case, particularly if a rural area is a source of migrant labour to the mines, or is located on a major road.

Religion is also a potential determinant of HIV risk. It is not clear whether church members in general are less likely to be HIV positive than non-members. There is evidence, however, to suggest that members of Pentecostal and independent churches are less likely to engage in extra- and pre-marital sex, and are less likely to be HIV positive, than members of other Christian churches. No evidence was found regarding other religions such as Islam and Judaism.

A variety of other factors have been identified, but have not been discussed in much detail due to a lack of information on these factors. These factors include the use of hormonal contraceptives; the role of armed conflict and the military; modes of transmission other than heterosexual intercourse; and psychological factors.

The most important conclusion to be drawn from this study is the importance of distinguishing between risk factors that determine the individual's own sexual behaviour patterns, and risk factors that determine the level of infection in the group of people from which the individual is likely to choose a sexual partner. Into the first group can be placed factors such as age, gender, religion, knowledge of HIV, and STD treatment seeking behaviour. The second group includes community risk factors such as the extent of urbanization, the presence of armed conflict or military forces, and STD prevalence. Some factors, such as income and migration, can be grouped under both headings. It is vital that interventions focus on both individual and community risk factors.

The second conclusion is that HIV risk factors are highly interlinked. In order to identify the factors that are the most direct determinants of HIV risk, and determine the relationships between these factors, it is necessary to use statistical tools such as multivariate logistic regression. Gender, in particular, is fundamentally linked to most of the other risk factors.

Table of contents

1. Introduction

The purpose of this report is to identify the most significant demographic, socio-economic, biomedical and behavioural determinants of HIV risk in South Africa. The report also aims to identify relationships between these factors, and to show how these factors apply in workforce populations in particular.

The investigation presented in this report combines a literature review of studies conducted in South Africa into the effects of various factors on rates of HIV infection, and a statistical analysis of four major South African data sets. The literature review and the statistical analysis are reported on together in relation to each factor. Section 2 contains a brief description of the data sets and the methodology used to analyse them. In section 3 each risk factor is discussed. The major biomedical risk factors - sexually transmitted diseases, circumcision and use of injectable contraceptives - are discussed in sections 3.1, 3.7.2 and 3.11.1 respectively. Behavioural factors are discussed in 3.3, and socio-economic factors are described in sections 3.5 and 3.6. A variety of demographic and other factors are analysed in the remaining sections. Often a particular factor can be classified under more than one heading, and the division between behavioural, biomedical, socio-economic and demographic risk factors is therefore not discussed in any detail.

A limitation on the investigation has been the lack of available workforce prevalence data. Detailed HIV prevalence data was obtained for only one workforce (described in 2.3), and although the data is of a high quality, it is not clear to what extent it can be regarded as representative of the general workforce population. Other HIV prevalence information was obtained for a variety of occupational and industry groups, but it was not disaggregated according to age, gender or skill level. It was therefore only possible to use the data for simple comparisons between industry and occupational groups.

Acknowledgements

The authors would like to thank Rob Dorrington, Michel Garenne and Brian Williams for reviewing this paper and their helpful and positive comments. This research was funded by the European Union (Project 99/73200/23), through the Centre for Health Policy, University of Witwatersrand, and forms part of broader project to develop non-discriminatory responses to HIV/AIDS in the workplace.

2. Overview of the major HIV prevalence data sets analysed

In assessing HIV risk factors, it is necessary to review HIV prevalence data from a variety of different sources. Although there have been many HIV prevalence studies conducted in South Africa, few studies manage to capture detailed demographic data on subjects. Consequently, most studies are of limited use in analysing the relationships between HIV risk factors. However, four data sets have been identified as being sufficiently large and detailed to enable a thorough analysis of HIV risk factors to be conducted. The findings of these surveys are discussed in part 3, but a brief description of each data set is given below.

2.1 Public antenatal clinic data: results for individuals

In October of every year, a national HIV prevalence survey is conducted among pregnant women attending public antenatal clinics. It is estimated that 80% of all pregnant women attend these public sector antenatal clinics (DOH, 1999(b)). These surveys thus provide a valuable source of information regarding likely HIV prevalence in the general female population. In the 2000 survey, 400 clinics were sampled, and 16 607 blood specimens were taken (DOH, 2001). First time attendees of the participating clinics were informed of the survey and were requested to participate. Although the rate of non-participation among these attendees is not reported, it is expected to be small. (In Swaziland, using a similar protocol, the rate of refusal was below 0.2%).

Results for each individual tested are available for 1997 to 1999 (detailed results from the 2000 antenatal clinic survey have not yet been provided by the Department of Health). Results from the 1997 survey, however, are not adequately detailed, and the analysis presented here is thus restricted to 1998 and 1999 data. For each individual tested, the following demographic information was recorded: age, province, race, gravidity and highest educational grade achieved. In this data set, the details of the clinic attended were not provided for any of the women tested, although the province in which the clinic was situated was recorded. A multivariate logistic regression was performed on this data to determine the relative significance of each of the factors.

2.2 Public antenatal clinic data: results for districts

Antenatal clinic results are available at a magisterial district level for certain provinces in certain years. The provinces for which we currently possess results at a district level are KwaZulu-Natal (1995 – 1999), Free State (1998 – 2000) and Western Cape (1998 and 1999, although only usable for 1999). It is possible that this data set may be augmented by data from other provinces in future.

Kirk (2001) has regressed these district prevalence levels on geographical variables (such as the density of national roads in a district) and demographic variables (such as the population density, average income and unemployment rate in a district) obtained from the 1996 Census. This makes it possible to analyse the factors affecting HIV prevalence at a community or district level, rather than at an individual level. There is, however, the potential for significant confounding in such an analysis, as the general demographic profile of a particular district will not necessarily correspond to that of pregnant women attending public antenatal clinics in that district.

Kirk presents three analyses: the first two consider only the results for 1999 (thus removing the need to analyse a 'year effect'), and the third considers the data for all years. The first two models are referred to as Model A and Model B. Model B differs from A in that it allows for the inclusion of interaction terms between variables. The third model is referred to as Model C. Although the results from the different models are more or less consistent, it will at times be necessary to distinguish between the models.

2.3 Company data

HIV prevalence data from a large company have been obtained. The company in question conducted an HIV prevalence survey among its employees, using an anonymous, cross-sectional design. Participating employees filled in questionnaires in which they provided demographic information as well as information about their sexual behaviour and knowledge of HIV/AIDS. Employees were sampled in a random manner, and employees invited to participate were free to choose whether or not to participate. The participation rate was in excess of 80%.

Although details of the company and the industry in which it operates cannot be given, this data set is extremely valuable. It provides insights into how the demographic risk factors that have been identified in the general population apply to workforce populations. It also provides information on sexual behaviour patterns and knowledge about HIV/AIDS in employed groups.

The relationships between the HIV prevalence levels and the questionnaire data were analysed using multivariate logistic regression.

2.4 The Mothusimpilo-Carletonville study

Between July and August of 1998, roughly 2 230 individuals participated in an HIV and STD prevalence study in and around Carletonville, a mining town near Johannesburg (Williams *et al*, 2000). This provided the baseline data for the Mothusimpilo-Carletonville project, a project aimed at assessing the dynamics of the epidemic and developing interventions such as STD treatment and condom distribution. Three groups were sampled separately in the baseline study:

1. Mine workers living in mine hostels situated to the south of Carletonville. Rates of non-participation on different shafts varied between 0% and 70%, depending largely on the extent to which mine management and trade union involvement had been sought.
2. Women living in informal settlements close to the mines. Many (but not all) of these women were commercial sex workers. Williams *et al* refer to them as 'women living in hotspots', and, for convenience, the same terminology shall be applied here. The rate of participation in this group was not reported.

3. The general population of Khutsong, a large township to the north-west of Carletonville. Rates of participation in Khutsong were very variable between housing types, with a 10% participation rate among individuals living in private houses, and an 80% participation rate among inhabitants of council houses.

Anonymous testing for HIV, syphilis, gonorrhoea and chlamydia was conducted for each individual participating in the survey.

This study provides information on associations between HIV prevalence and demographic variables, as well as the effect of sexual behaviour and knowledge of HIV/AIDS. It also provides information on STD prevalence and treatment seeking behaviours.

Two sets of statistical analyses were performed by Williams *et al* on these data. The first was a series of univariate logistic regressions, which was used to identify which risk factors to include in a multivariate analysis. The second analysis was a multivariate logistic regression, used to determine which of the risk factors identified in the univariate analyses remained significant determinants of HIV risk when other risk factors were adjusted for. (The shortcoming of this methodology is that factors that do not appear to be significant in the univariate analysis may nevertheless be significant in the multivariate analysis, and certain risk factors may thus fail to be recognized). This second analysis was performed only on individuals who reported being sexually experienced.

2.5 Methodology

For each of the four data sets described above, the major statistical tool used to identify risk factors was multivariate logistic regression. A brief description of logistic regression is included in Appendix A. It is important to emphasize the need for a multivariate analysis when assessing HIV risk factors; the weakness of univariate analyses is that they fail to allow for interactions with other risk factors, and can thus produce misleading results. Some studies have shown, for example, that higher levels of education are correlated with higher levels of HIV infection. However, these studies fail to adjust for the fact that the young tend to be better educated than the old. HIV is most prevalent among the youth, and it is thus not clear whether the correlation between level of education and HIV prevalence is independent of the correlation between age and HIV prevalence, unless a multivariate analysis is used. The use of multivariate analyses is thus crucial. All odds ratios quoted in section 3 should be assumed to be odds ratios produced from a multivariate analysis, unless stated otherwise.

3. Analysis of risk factors

A large number of factors affect the risk of HIV infection, and interactions between these factors can be complex. Although the major factors are analysed separately below, and attempts have been made to control for variations in other factors as far as possible, it needs to be emphasized that these risk factors are highly inter-linked. The purpose of the discussion that follows is both to identify the effects that the various factors have on HIV risk (independently of associations with other risk factors) and to describe how each factor relates to other risk factors.

3.1 STDs and treatment-seeking behaviour

One of the most significant bio-medical factors driving the epidemic in South Africa is the high prevalence of sexually transmitted diseases (STDs). In the Carletonville study (Williams *et al*, 2000), it was estimated that the lifetime risk of contracting syphilis was roughly 60% for both men and women living in the Khutsong township. It is estimated that there are between 5 000 and 15 000 cases per 100 000 of syphilis in South Africa – this compares with a rate of about 15 per 100 000 in the United States of America and the United Kingdom (Pham-Kanter *et al*, 1996). STDs greatly increase the risk of HIV transmission, and there is thus a significant correlation between STD and HIV prevalence.

As Table 1 shows, the prevalence of STD symptoms is high in most populations, but certain groups experience a higher prevalence than others. The Carletonville data suggests that STD prevalence is substantially higher among men than among women, but the data from the workforce described in 2.3 suggests that this gender differential is not significant in workforce populations. It is also clear that the STD prevalence in the employed population is lower than that in the general population, although this is not the case for mineworkers. Both observations suggest that STD prevalence is strongly correlated with economic status, those with higher economic status having better access to effective treatment and greater control over their reproductive health. Those employed in the formal sector have especially good access to treatment, as many are either members of medical schemes or have access to workplace STD clinics.

	Population	Reference	Sample size	% reporting	
				Painful urination or discharge	Genital sores
12 month prevalence levels	Men in Khutsong	Williams et al (2000)	475	22%	12%
	Women in Khutsong		712	46%	14%
	Mine workers		899	28%	12%
	Women in "hotspots"		121	49%	16%
3 month prevalence levels	Men	DOH (1999(b))	5671	10%	5%
	Male employees	-	-	6%	4%
	Female employees	-	-	-	4%

Table1: Prevalence of STD symptoms

Levels of STD treatment are low for a number of reasons. Firstly, many STDs (particularly those affecting women) are asymptomatic, and even when symptoms occur, they may not be recognized as being due to infection. A study of pregnant women in KwaZulu-Natal, for example, found that although more than 50% had at least one infection of the reproductive tract, none volunteered symptoms of an STD (Sturm *et al*, 1998).

A second problem is that even when symptoms occur, individuals will often not seek treatment, either because treatment is inaccessible or because the infection is not regarded as being serious. Wilkinson *et al* (1997) estimate the average time before treatment for STD symptoms is sought to be 10 days for men and 18 days for women. As Table 2 shows, women are less likely to seek treatment for their STDs than men, both in the workforce described in 2.3 and in the population of Khutsong. Among individuals who do seek treatment, treatment-seeking patterns are very variable. Table 2 shows that in employed groups, individuals are most likely to seek treatment from a general practitioner (GP), occasionally seek treatment at a public STD clinic or workplace clinic, and only rarely seek treatment from a traditional healer. In the general population, however, treatment at a public STD clinic is most common, treatment from a GP is also often obtained, and treatment from traditional healers is also occasionally sought. Results from Hlabisa, a rural district, showed higher reliance on public STD clinics in rural areas, but the sample was in this case biased because respondents were attendees of public STD clinics and GPs, who were questioned as to where they had received treatment for their previous STD.

	Population	Reference	Place / form of treatment				
			STD clinics	GP	Traditional healer	Self-treatment	No treatment
Males	Men in Khutsong	Williams et al (2000)	47%	25%	17%	22%	17%
	Mine workers		40%	45%	16%	9%	8%
	Male employees	-	14%	51%	3%	8%	22%
Females	Women in Khutsong	Williams et al (2000)	48%	24%	9%	14%	23%
	Women in "hotspots"		50%	31%	14%	19%	14%
	Female employees	-	12%	39%	2%	15%	24%
M + F	Attending STD clinics and GPs in Hlabisa	Wilkinson et al (1997)	59%	28%	9%	4%	-

Table 2: Treatment seeking behaviours among subjects with STD symptoms

The differences in treatment seeking behaviours are only relevant to the extent that different providers of treatment do not provide the same quality of treatment, and to the extent that certain providers of treatment may be accessed more easily and promptly than others. Relatively little research is available on this issue. Wilkinson *et al* (1997) report that diagnosis of multiple syndromes is much more common among those attending GPs than among those attending public STD clinics, and this suggests that general practitioners may be providing better treatment of STDs than public clinics. However, there is also evidence to suggest that private practitioners may be providing a lower quality of STD care than public clinics (Schneider *et al* (2001) and Nphlovu *et al* (2000)). In addition, Colvin *et al* (2000) found that 90% of workplace clinics in KwaZulu-Natal gave unsuitable or partial treatment for STDs. Treatment seeking behaviour may thus be an important determinant of an individual's risk of HIV infection.

The increased risk of transmission of HIV when one sexual partner is infected with an STD has been reported in numerous studies. Rehle *et al* (1999), for example, estimate the probability of HIV transmission per sexual contact to be 6% if either partner is experiencing genital sores or ulcers. This compares with HIV transmission rates in the absence of STD infection of 0.2% (for the probability of an infected male infecting an uninfected female) and 0.1% (for the probability of an infected female infecting an uninfected male). Many individuals do not cease to have sex when experiencing STD symptoms. O'Farrell *et al* (1992), for example, report that 36% of Zulu men and women continue to have sex despite experiencing genital ulcers, and Williams *et al* (2000) have found that only 24% of men and 19% of women seek to protect their partner by abstaining from sex or using a condom if they have an STD.

Individuals who frequently experience STDs and who do not receive prompt treatment for their STDs are thus more likely to be HIV positive. In the Carletonville study (Williams *et al*, 2000), it was found that there was a strong positive correlation between HIV prevalence, syphilis prevalence and prevalence of gonorrhoea. The correlation between STD prevalence and HIV prevalence is also evident from a comparison of STD and HIV prevalence data at a provincial level. Figure 1[1] shows HIV prevalence levels among pregnant women, estimated from the 1998 antenatal clinic survey (DOH, 1999(a)), compared with percentages of men reporting having experienced STD symptoms in the last three months (DOH, 1999(b)), in each of the nine provinces. With the exception of Gauteng and Northwest, there is a pattern of high HIV prevalence in provinces with high STD prevalence, and lower HIV prevalence in provinces with low STD prevalence. The low STD prevalence in Gauteng can be explained in terms of better access to STD treatment in this heavily urbanized province, but it is not clear why there is a poor correspondence in the levels of STD prevalence and HIV prevalence in Northwest.

[1] The abbreviations used in Figure 1, and in subsequent diagrams, for the nine provinces are as follows: KZN (KwaZulu-Natal), M (Mpumalanga), FS (Free State), NW (Northwest), G (Gauteng), EC (Eastern Cape), NP (Northern Province), NC (Northern Cape), WC (Western Cape)

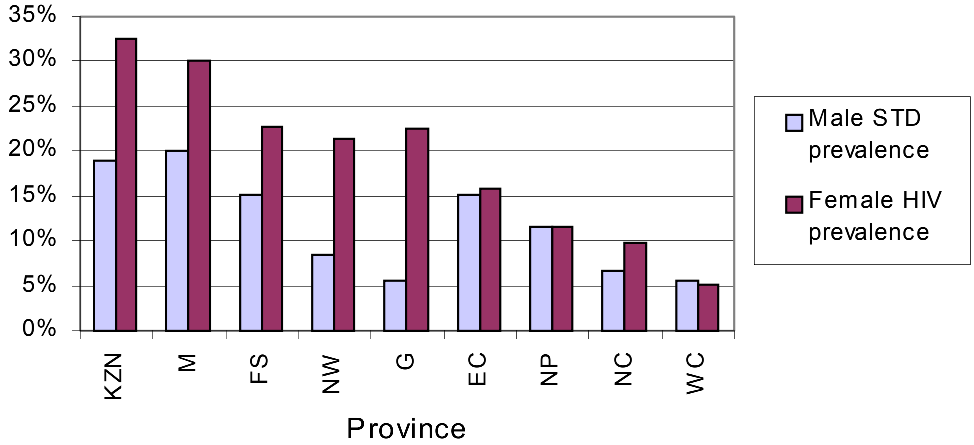

Figure 1: Comparison of STD and HIV prevalence levels
Source: DOH (1999(a) and 1999(b))

In summary, STD prevalence levels in South Africa are alarmingly high. Rates are particularly high among women, and women also appear to be more likely to delay or avoid seeking treatment. Asymptomatic STDs are particularly common among women, and this is a further reason for women not receiving treatment. These factors may partially explain why HIV prevalence levels in South Africa tend to be higher among women than among men. It is also apparent that individuals who are employed are at a lower risk of infection with STDs, and this suggests that in workforce populations the HIV infection rate may be lower than in the general population.

3.2 Knowledge and belief about HIV/AIDS

A number of studies show that there is good knowledge of the basic facts surrounding HIV/AIDS: that it is spread sexually, and that the risk of infection can be reduced by using condoms (Van der Ryst *et al* (2001), KFF (2001), Williams *et al* (2000), DOH (1999(b))). However, there are many misconceptions about other forms of transmission. An extremely common belief, for example, is that HIV can be spread by blood-sucking insects, and there are also substantial numbers who believe that sharing food with an HIV positive person, using public toilets, and touching HIV positive people can lead to transmission (Williams *et al* (2000), DOH (1999(b)). There are also many misconceptions about cures for HIV/AIDS. A national survey of teenagers (KFF, 2001) suggested that 7% of teenagers believed that a person could be cured of AIDS by having sex with a virgin, 13% believed that traditional African medicine had a cure for AIDS, and 15% believed that Western medicine had a cure. Equally concerning is the belief that HIV positive individuals can always be identified by their symptoms; over 30% of those sampled in the Carletonville study expressed this view (Williams *et al*, 2000).

Beliefs such as these can give individuals a very false sense of their risk of infection. It may therefore be hypothesized that higher HIV prevalence is associated with poor knowledge of HIV, if this false sense of risk results in risk-taking behaviour. Williams *et al* (2000), however, found no such association, although it was found that substantial proportions of those who did not regard themselves as being at risk of infection were in fact HIV positive. High levels of awareness are not necessarily indicative of a low risk of infection. Some individuals may have actively sought knowledge because of their high-risk status, and others may not act on the knowledge they have.

Levels of knowledge and awareness of HIV/AIDS are typically substantially lower in rural areas than in urban areas (KFF (2001), DOH (1999(b))). Levels of knowledge and awareness also tend to be higher in employed groups, as many of the larger employers run HIV/AIDS awareness programmes.

3.3 Sexual behaviour patterns

A number of sexual behaviour factors and patterns affect the risk of HIV infection. Each of these factors is described below.

3.3.1 Violence in sexual relationships

South Africa remains a fairly patriarchal society, in which women are vulnerable to sexual abuse. In 1998 South Africa had the highest per capita rate of reported rape in the world (115.6 cases per year for every 100 000 of the population), and if we accept the common but highly debatable assumption that only one in every twenty rape cases are reported, close to one million acts of rape occur in South Africa every year (RCCT, 2001). Marital rape is particularly under-reported, with many relationships being characterized by violence and sexual abuse. Rape is also commonly reported among women at very young ages. Vundule *et al* (2001) found, in a study of black teenagers attending antenatal clinics in Cape Town, that 72% of girls reported having been forced to have sex at some stage, and 11% reported having been raped. The South African National Youth Survey (KFF, 2001) also found that 39% of sexually experienced girls had been forced to have sex, and 33% reported being afraid of refusing a partner sex. Sexually experienced girls surveyed in the former Transkei (Buga *et al*, 1996) also reported being forced to have sex on their first sexual contact in 28% of cases. In many relationships, therefore, it would appear that women have limited control over their sexual activity, and are thus more vulnerable to HIV infection.

Maman *et al* (2000) draw on 29 studies from the United States of America and sub-Saharan Africa to study the links between HIV and gender-based violence. (Two of the studies (Wood *et al* (1998) and Abdool Karim *et al* (1995)) were conducted in South Africa, although both involved small samples). They argue that there are four mechanisms linking HIV and violence. Firstly, violence can increase the risk of HIV infection where a woman is forced to have sexual intercourse. Secondly, violence may mean that a woman is less able to negotiate the use of preventive measures such as a condom. Thirdly, links have been found between physical and sexual abuse during childhood and high levels of risk-taking behaviour in adolescence and adulthood. Lastly, women who are infected and disclose their HIV status may be at increased risks of violence. Violence is thus both a determinant and a potential consequence of HIV infection.

3.3.2 Sex and alcohol consumption

Alcohol consumption has been identified as an important determinant of HIV risk in South Africa. This occurs because much sex work is done in shebeens, and because alcohol consumption is likely to result in inconsistent condom usage and other unsafe sex behaviours (Williams *et al*, 2000). The Carletonville study confirms this relationship: in a multivariate analysis it was found that for both mine workers and women living in hotspots, individuals who did not consume alcohol were at a significantly lower risk of HIV infection. The difference was not significant, however, for men and women living in the Khutsong township. This suggests that alcohol consumption is more likely to be a risk factor if it is associated with an unsettled lifestyle and migrancy (since 97% of the mine workers and 47% of the women living in the hotspots described themselves as migrants). Alcohol consumption may be a more important determinant of HIV risk for migrants because migrants are less likely to have a regular partner living with them, and are thus more likely to rely on visits to shebeens to acquire sexual partners.

3.3.3 Commercial sex and sex for support

Commercial sex workers are particularly at risk of infection. The first reason for this is the high number of sexual partners that they have (Rees *et al* (2000), for example, estimate that the average sex worker has 25 clients a week). The second reason is that sex workers are frequently forced to engage in high-risk forms of sexual intercourse, such as anal sex and sex without condoms. It should also be recognized that many women 'sell sex' without regarding themselves as prostitutes, relying on regular financial support in return for sexual favours (Jochelson *et al* (1991), Heywood (1998)). Other forms of sexual bartering are also common. The South African National Youth Survey (KFF, 2001) found, for example, that 16% of sexually experienced girls indicated having had sex for money, drink, food or gifts, and 20% of sexually experienced boys reported having given a girlfriend pocket money, food or drink in exchange for sex. This widespread dependence on sex as a source of income or other benefits creates an environment conducive to the rapid spread of HIV.

3.3.4 High-risk forms of sexual intercourse

A number of forms of sexual intercourse are associated with a high risk of transmission of HIV. The effect of having sex while experiencing STD symptoms, for example, has already been described. Further forms of high-risk sexual behaviour are discussed below.

Anal intercourse

A large number of studies demonstrate a significantly increased risk of male-to-female transmission from anal intercourse relative to vaginal intercourse (Douglas, 2001). This association may be due to the higher trauma associated with anal sex relative to vaginal sex. The extent to which anal sex is practised in the heterosexual population is not clear, though Rees *et al* (2000) found that 7% of sex workers reported practising anal sex at least once a week, and Ramjee *et al* (2000) found that 42% of male clients of sex workers reported having practised anal sex. There is thus evidence to suggest that anal sex may be contributing to the heterosexual epidemic to some extent.

Dry sex

Women practising dry sex use drying agents (including cloth, soap, detergents and traditional medicines) to tighten or dry their vaginas, in order to enhance the sexual experience of their male partners. Although it is commonly hypothesized that the risk of HIV transmission is much greater when women use these drying agents, most African studies do not show any significant relationship between use of drying agents and HIV prevalence (Sandala *et al* (1995) and Dallabetta *et al* (1995)). In a univariate analysis, Williams *et al* (2000) also did not find any significant relationship between dry sex and HIV prevalence, either for women in Khutsong or women living in hotspots. Furthermore, only 3.2% of the women sampled were using drying agents, which suggests that the practice may not be as widespread as previously thought.

Sex during menses

It is hypothesized that the bleeding that occurs during menstruation may allow a more direct route of transmission of HIV, and that women who have sex during menses are thus more likely to pass the virus on to their partners. However, studies have yielded conflicting findings in this regard. Some studies find that sex during menses results in a significantly increased risk of female-to-male transmission and others have found that sex during menses has no significant effect on the risk of transmission (Douglas, 2001). Williams *et al* (2000) found that roughly one in four women reported having had sex during menses in the last 12 months.

Lack of condom usage

Although knowledge of HIV/AIDS is often good, many people do not act on this knowledge, and many continue to engage in high-risk forms of sexual behaviour. This is particularly the case in respect of condom usage. Several studies (Van der Ryst *et al* (2001), KFF (2001), Williams *et al* (2000), Rees *et al* (2000), DOH (1999(b)), Buga *et al* (1996), Sekeitto *et al* (1993)) show that rates of condom usage in South Africa are low, particularly in the light of the extent of the epidemic in the country. Comparing the condom usage rates reported in these studies is unfortunately not feasible, as there is little consistency between the studies in terms of how questions about condom usage were phrased. However, it is clear that condom usage rates are higher with casual partners than with regular partners (Van der Ryst *et al* (2001), Williams *et al* (2000)). Commercial sex workers (Williams *et al* (2000), Rees *et al* (2000)) and individuals with histories of STD infection (Sekeitto *et al* (1993)) appear to have relatively high rates of condom usage, presumably because they are aware of their high risk of infection. Levels of education are also strongly associated with condom usage, with higher rates of condom usage likely among those with higher levels of education (DOH (1999(b)), Sekeitto *et al* (1993)). It would also appear that among women rates of condom usage are significantly higher at younger ages, both in spousal and non-spousal relationships (DOH, 1999(b)).

A question that is often not addressed in these surveys relates to ease of access to condoms. In the 1998 Demographic and Health Survey (DOH, 1999(b)) it was found that the rate of condom usage among women in urban areas was almost double that in non-rural areas. Although this to some extent reflects differences between urban and rural populations in terms of education and age profile, it does suggest that difficulty in accessing condoms may be a significant barrier to condom usage in rural areas.

3.3.5 Levels of sexual activity

It is widely held that promiscuity is a key determinant of an individual's risk of HIV infection. The Carletonville study (Williams *et al*, 2000), however, presents a number of findings that challenge the conventional views in this regard. Figure 2 shows the HIV prevalence for each of three groups plotted against the reported number of lifetime sexual partners. It would appear that the risk of infection is high even for individuals who report only ever having had sex with one other person – particularly in the case of women and mineworkers. For women this can probably be explained in terms of unfaithful partners, and for mineworkers it can be explained in terms of the high HIV prevalence of their partners (mostly sex workers). Men in Khutsong who are in monogamous relationships appear to be at a much lower risk of infection than women in monogamous relationships, presumably because their partners are much less likely to be unfaithful to them. In the multivariate analysis, which applied only to those individuals who reported being sexually experienced, the number of lifetime sexual partners was not a significant determinant of the risk of HIV infection in *any* of the groups. This suggests that being sexually active, rather than being promiscuous, is the major determinant of HIV risk.

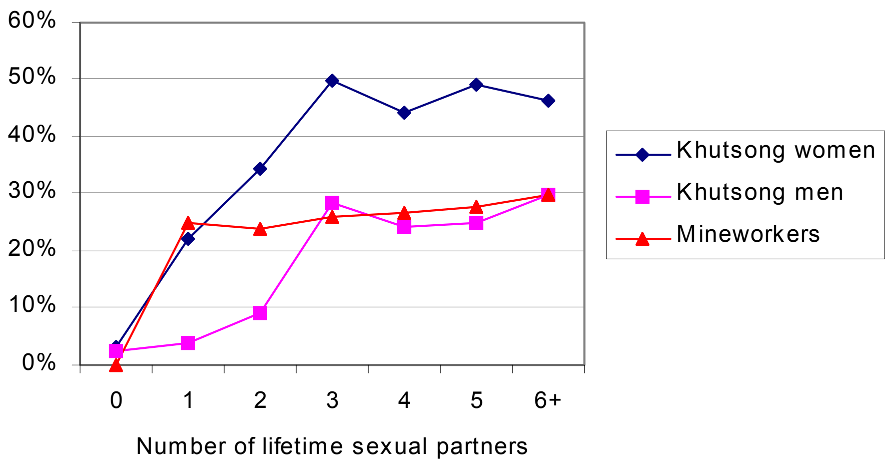

Figure 2: HIV prevalence as a function of the number of lifetime partners
Source: Williams *et al* (2000)

It can also be observed in Figure 2 that for individuals with three or more partners, HIV prevalence appears to be stable with respect to the number of lifetime partners. This is perplexing, as one would expect the HIV prevalence to continue to rise with the increasing number of partners. It has been suggested that it is possible for certain individuals to develop a resistance to infection with HIV (O'Farrell, 2001), and this is one possible explanation for the prevalence patterns observed. However, it should also be recognized that significant confounding with age is likely in this analysis.

Those who report a high number of lifetime sexual partners are likely to be older, and if the majority of their reported partnerships occurred prior to the epidemic entering the Carletonville community, these would not contribute to their risk of HIV infection. It should also be acknowledged that data on sexual behaviour is often unreliable. In this study, certain subjects reported having never had sex, and subsequently tested HIV positive. Although the possibility of other forms of transmission cannot be ruled out, this suggests that the questions on sexual behaviour may not have been answered truthfully in all cases.

It was further found, in the multivariate analysis applied only to those individuals who were sexually experienced, that having had a casual sexual partner in the last 12 months was not a significant determinant of an individual's HIV status in any of the four groups. This adds further weight to the hypothesis that promiscuity by itself is a relatively minor determinant of HIV risk. These findings should not be interpreted as indicating that promiscuity does not increase an individual's risk of infection; they indicate rather that individuals who are not promiscuous can be just as much at risk of infection if their partners are promiscuous. Much of the stigma attached to HIV/AIDS rests on the assumption that HIV positive individuals have become infected as a result of promiscuous behaviour, but clearly this is not generally true.

3.4 Migration

South Africa has experienced high levels of political and economic migration in recent decades, both between its provinces, and between itself and its neighbouring countries. Migration increases the extent of sexual networking, and thus facilitates the swift spread of the HIV/AIDS epidemic. Williams *et al* (2000) found that among male migrant workers in Carletonville, only 5.4% reported having regular partners living in Carletonville, and more than half reported having had at least one casual partner in the last year. It was further found that among women who were migrants, 53% had accepted money for sex. Migrant labour is thus strongly associated with high-risk sexual behaviour.

As a result of this, migrants and migrant workers are at a significantly higher risk of HIV infection. This is demonstrated in a number of studies. In a study of a rural community in KwaZulu-Natal, people who had recently changed place of residence were three times more likely to be HIV positive than those that had not (Abdool Karim *et al*, 1992). Male migrants in Carletonville were found to have an HIV prevalence significantly higher than that of non-migrants (29% versus 19%) and female migrants were at a similarly high risk of infection (51% versus 39% among non-migrants). Areas of high in- and out-migration tend to be associated with unusually high or low male to female ratios (Jochelson *et al*, 1991), and these gender imbalances increase the level of HIV risk. This is demonstrated by Kirk (2001), who shows that the extent to which the male to female ratio varies from 1 in a particular district is a strong determinant of the level of antenatal clinic prevalence in the district.

Levels of migrant labour are particularly high among men. In some rural areas, rates of migrant employment are as high as 60% of males, compared with a third of females (Lurie *et al*, 1997). Many of these men spend their working lives accommodated in barracks and single-sex hostels, and the mining industry in particular has been associated with this form of accommodation. Crush (1995), for example, reports that 90% of all black employees in the gold mining industry are migrants, and that 89% of these miners are accommodated in single-sex hostels. Having to live separately from their spouses and regular sexual partners (many of whom are situated in rural areas), those living in single-sex hostels often engage in casual sexual relationships and interact with commercial sex workers in the surrounding community (Jochelson *et al*, 1991). In a workforce HIV prevalence survey (see 2.3) it was found that the odds ratio of HIV infection among non-hostel dwellers, relative to hostel dwellers, was 0.76 ($p = 0.05$).

Migrant workers who become infected in urban areas then pass the virus on to their partners when they return to the rural areas. Evidence suggests that transmission in the opposite direction may also occur. Lurie *et al* (2000) have found that for nearly 40% of discordant migrant couples, it is the female partner who is infected with HIV, not the male. This may indicate that women are forced to rely on sex to supplement their incomes while their partners are away for long periods. Jochelson *et al* (1991) also suggest that some women may feel financially insecure if they are relying on only one partner for an income. Inequality in the economic status of men and women is thus a factor that is closely related to the role of migration in the spread of the epidemic.

3.5 Income, education and employment status

Income, education and employment status are important determinants of HIV risk, and are clearly closely related insofar as they determine an individual's socio-economic status. Each of these factors is discussed separately below.

It should be noted that there are considerable complications in measuring factors such as income and employment status. Income can be defined in terms of individual income or household income. In the analysis that follows, there is no attempt to distinguish between the two, although clearly a high household income does not necessarily imply a high individual income. Different definitions of unemployment are possible, and these are briefly discussed. The effect of income and employment status on HIV risk can also be examined at both individual and community levels.

3.5.1 Income

The relationship between income and risk of HIV infection is a highly complex one. There are a number of arguments explaining why higher rates of infection might be expected among the poor, but there are also several to explain why patterns of infection may be the other way around. To a large extent the appropriateness of these arguments depends on the gender and the extent of urbanization of the risk group to which the arguments are being applied.

The relatively poor members of society are vulnerable to HIV infection, as most of the risk factors described above are linked to low socio-economic status. Heywood (1998) observes that the poor tend to be exposed to greater dangers in the course of their everyday life than the relatively wealthy. To many the threat of AIDS may seem remote relative to the stresses of their day-to-day lives, and as a result, they may not take the necessary steps to avoid infection. Being relatively uneducated, they are also less likely to know what AIDS is and how HIV is transmitted. Many do not have access to proper treatment for STDs, or cannot afford treatment. Of HIV/AIDS admissions to Somerset and Groote Schuur Hospitals between 1988 and 1993, only 48% of heterosexual males had ever been employed, and of those who had been employed, 74% had been employed in unskilled or semi-skilled labour (Maartens *et al*, 1997). This suggests a concentration of HIV infection in the unemployed and unskilled or semi-skilled groups. A workforce prevalence study (described in 2.3) also found that HIV prevalence levels were significantly lower at higher skill levels, in a multivariate analysis (results are shown in Table 3). To the extent that skill levels are likely to be highly correlated with income levels, low HIV prevalence may thus be expected at high income levels.

Job grade	Odds ratio	p value
Semi-skilled	1.00	-
Skilled	0.69	0.02
Lower mngt	0.40	0.001
Senior mngt	0.45	0.19

Table 3: Odds ratios for HIV prevalence at different skill levels

It is not clear, however, that wealthier individuals are necessarily at a lower risk of infection. It can be argued that as men earn more and their socio-economic status rises, they are able to attract greater numbers of sexual partners, which places them at greater risk of infection (Kinghorn and Steinberg, 1998). A study conducted in KwaZulu-Natal suggested that prevalence levels among pregnant women attending obstetricians in the private sector were not dissimilar from those of women attending public antenatal clinics, when race was controlled for (Wilkinson, 1999). Kirk (2001) shows that the level of poverty in a magisterial district is *negatively* related to the HIV prevalence among antenatal clinic attendees in the district. The relatively low level of prevalence in the Northern Province, a very poor and rural region, confirms that the poorest of the poor – particularly the rural poor – are less affected than those with slightly higher levels of income. There is thus considerable evidence to suggest that the poor are in some situations at a lower risk of HIV infection.

The complexity of the relationship between HIV prevalence and income is demonstrated by Kirk (2001). His findings show that the relationship between the average annual income in a district and the HIV prevalence among antenatal clinic attendees in the district is non-linear. The odds of infection among antenatal clinic attendees are lowest in districts with an average annual income of between R15 000 and R30 000, and higher both in wealthier and poorer districts.

Substantial caution must be applied in interpreting Kirk's findings. Antenatal clinic attendees are – even in relatively wealthy communities – economically vulnerable, and their HIV prevalence may thus not be representative of that for the community as a whole. Nevertheless, it is likely that communities in which the average income is high are communities in urban areas, and communities in which there are more men than women – precisely the sort of environment in which commercial sex work and 'sex-for-support' relationships are common. Economically vulnerable women are in these circumstances more likely to become infected, and this may explain the relatively high level of prevalence among antenatal clinic attendees in communities with higher aggregate income levels.

It should also be noted that when the odds ratios of HIV infection were calculated using Kirk's results, these were found not to be substantially different from one. Furthermore, it was only in Model C (see explanation in 2.2) that Kirk found a significant relationship between income and HIV prevalence. This suggests that at a community level, income may not be a significant determinant of HIV risk. Alternatively, income may be a significant factor, but its relationship with HIV prevalence may not be the same in different types of communities. In particular, the effect of income may differ between urban and rural communities. This is discussed further in 3.5.3.

It is also quite plausible that the effect of income on HIV risk may be different for men and women. Men may be more likely to use their higher socio-economic status to acquire sexual partners than women, and this suggests that male prevalence may peak at higher income levels than for women. However, many women have an income that is strongly correlated with that of their male partners, and male and female income prevalence patterns are thus not independent. In the absence of empirical data, no firm conclusions can be drawn.

3.5.2 Education

Education is to a large extent correlated with income, and much of the complexity that is evident in the relationship between income and HIV prevalence is thus also evident in the relationship between education and HIV prevalence. Analysis of levels of education reported by women attending public antenatal clinics in 1998 and 1999 shows that women with no education are in fact at a lower risk of HIV infection than women who have received high school education – but women who have received tertiary education have the lowest risk of all (Figure 3). It is likely that many of the relatively uneducated women are living in rural areas, leading traditional lifestyles in socially cohesive communities, and thus experiencing a slightly lower prevalence than women who – although more educated – are located in urban communities that are less bound by traditional values. However, highly educated women who attend public antenatal clinics are probably not representative of equally educated women attending private antenatal clinics, and the relationship between HIV prevalence and level of education is thus slightly unclear at higher education levels.

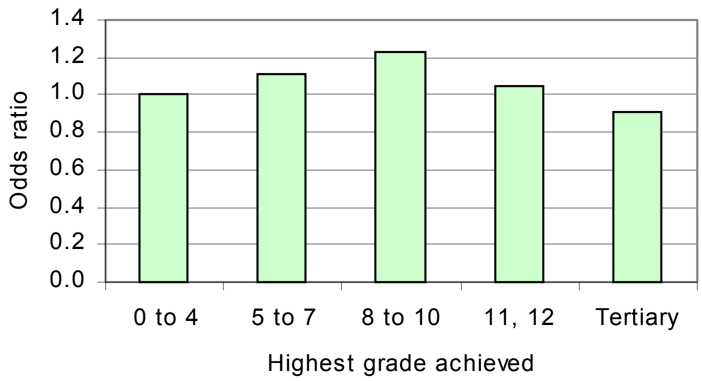

Figure 3: Odds ratio for HIV infection at different education levels

Although education was a significant determinant of HIV risk in the multivariate analysis, it can be seen from Figure 3 that the odds ratios are not substantially different from one. This again suggests that socio-economic factors are less significant determinants of HIV risk than other factors, and that they can be confounded with a variety of other factors. Williams *et al* (2000) have found similar relationships between levels of education and HIV prevalence among women in a univariate analysis, but did not find that education was a significant determinant of HIV status in a multivariate analysis. This further suggests that education is not a simple determinant of HIV risk.

3.5.3 Employment status

There is little reliable data on the relationship between employment status and HIV prevalence. Williams *et al* (2000) found that employment status was not a significant determinant of HIV status in any of the four groups sampled as part of the Carletonville study, but this was based only on a univariate analysis. One would expect HIV prevalence levels to be higher among the unemployed than among the employed. This is particularly so for women, since women who are unemployed are more likely to rely on sex as a means of supporting themselves.

However, Kirk (2001) shows that in densely populated areas (i.e. in urban communities) low rates of unemployment tend to be associated with *high* levels of HIV prevalence among antenatal clinic attendees. This can be explained using the same argument that has been used to explain the link between high aggregate income levels and high antenatal clinic prevalence (see 3.5.1). Again, it must be emphasized that antenatal clinic attendees are an economically vulnerable subset of the general community, and their HIV prevalence might not reflect that of the general community. Kirk's findings do not suggest that individuals who are unemployed are at a lower risk of infection. They indicate rather that in urban communities with high levels of economic activity, poor women are more at risk of infection than they would be if levels of economic activity were lower.

Strangely, the relationship between unemployment rates and antenatal clinic prevalence appears to be different in sparsely populated areas. Figure 4, based on

Kirk's Model B, shows that in sparsely populated rural areas, antenatal clinic attendees are more likely to be HIV positive if the overall rates of unemployment are high. It also demonstrates the clear difference in prevalence patterns between sparsely and densely populated areas.

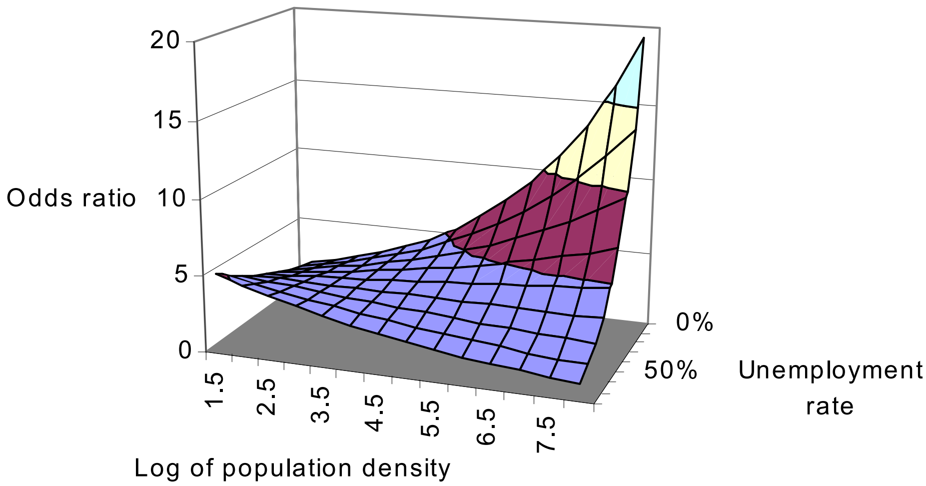

Figure 4: Odds ratio for HIV infection at different rates of unemployment

There are two possible explanations for the difference in the effect of unemployment in urban and rural areas. The first is that the definition of unemployment used by Kirk[2] may be less applicable in rural areas. Because there are fewer jobs available, fewer individuals are likely to be looking for work. A low rate of unemployment therefore does not necessarily imply a high rate of (paid) employment. In many cases, a low rate of unemployment in a district may be associated with a substantial proportion of the population living by subsistence agriculture (the Census considers such people to be employed). Although they may be relatively poor, they are likely to be leading settled lives, and their behaviour is likely to be in accordance with traditional value systems to a large extent. A high rate of unemployment in a rural area, on the other hand, suggests a less settled population, since being unemployed may be associated with seeking work in urban areas on a regular basis. Urban areas with low levels of unemployment are likely to be attracting high levels of migration, and rural areas with high rates of unemployment are likely to be experiencing high levels of movement to and from urban areas. The role of employment status is thus closely linked to the role of migration. This is a second possible explanation for the differences in the role of unemployment in urban and rural areas.

[2] The definition of the unemployment rate used by Kirk (2001) is the rate of unemployment among individuals who are either employed or unemployed and looking for work. This definition, based on 1996 Census data, falls somewhere between the official definition of unemployment (unemployed and *actively* seeking work) and the expanded definition (unemployed, but not necessarily actively looking for work).

Within the employed population, distinction also needs to be drawn between individuals employed in the informal and formal sectors. However, it is not clear whether the HIV prevalence in the informal sector is closer to that in the formal sector or that among the unemployed.

3.5.4 Conclusion

The relationship between HIV prevalence and socio-economic markers such as income, education and employment status, is highly complex, and is likely to be obscured by a variety of other demographic factors. The crucial point is that the individual's risk of HIV infection is determined by both his/her socio-economic status, and the socio-economic profile of the community in which he/she is situated. Both factors are 'non-linear' in terms of the effect they have on HIV risk. At a community level, low socio-economic profile is associated with a slightly lower HIV risk than is apparent in communities with a 'medium' socio-economic profile, but communities with high socio-economic status appear also to have low levels of HIV prevalence. (This latter point is not apparent from Kirk's analysis because the analysis was based only on prevalence levels in public antenatal clinics, and these would not have been situated in affluent areas). A similar pattern is observed at an individual level. Individuals who have some income are often at a greater level of risk than individuals without any income (particularly in the case of men), but at higher income levels individuals are likely to find it easier to avoid infection, and are more likely to be in stable relationships. The interaction between these factors is demonstrated in Table 4.

	Individual socio-economic status	High	Medium	Low
Community socio-economic profile	Description	Completed high school/tertiary education, employed in skilled/managerial	High school or primary education, semi-skilled or unskilled employment, receiving an income	Uneducated or primary school, unemployed, not receiving a regular income
High	Established, wealthy urban communities	Very low	Medium	-
Medium	Townships, rural areas with high levels of economic in- and out-migration	Low	Very high	High
Low	Rural agricultural communities, tribal villages	-	Medium	Low

Table 4: Socio-economic determinants of HIV risk at individual and community levels

Clearly socio-economic status – at both an individual and a community level – is strongly related to factors such as age, degree of urbanization, migration and the status of women. All of these factors are significant determinants of HIV risk in their own right, and because of difficulties in controlling for these factors, the relationship between HIV risk and socio-economic markers is often obscure.

3.6 Occupation and industry

Data on HIV prevalence levels in employed groups is scarce. Although many companies have conducted HIV testing among their employees, most are reluctant to release the findings, and there has been no effort to collect and collate these data on a national basis. Some companies have commissioned actuarial assessments into the likely extent of HIV infection in their workforces, and report on these estimated HIV prevalence levels. However, these actuarial assessments can only provide a rough indication of HIV prevalence, and need to be distinguished from those based on voluntary testing of employees. For this reason we consider only the results known to be based on voluntary testing.

A problem common to HIV prevalence studies in employed groups is the absence of 'control' groups. In many of the studies that have been conducted in employed groups, no attempt is made to measure the level of HIV prevalence relative to that in individuals with similar demographic characteristics, who are not members of the group considered. This makes it difficult to determine the extent to which membership of a particular workforce or occupation increases or reduces the risk of HIV infection.

In an attempt to overcome this problem, we have compared the levels of HIV prevalence reported in various studies with the levels of prevalence estimated by the ASSA2000 model for the period, geographical region and gender profile concerned[3] (age information, however, was generally not available from the studies considered). The ratio of the former prevalence to the latter prevalence provides a crude measure of the effect of membership of the particular occupation or industry on HIV risk. The results of this analysis are displayed in Table 5.

[3] The ASSA2000 model (ASSA, 2001) was used where samples were taken at a national level. Where samples were taken at a provincial level, the provincial versions of the ASSA2000 model were used. These provincial versions have not been updated since 2000, and are not publicly available. Their results have, however, been presented (Dorrington, 2000). In all cases, the prevalence levels in the 'adult' population are the prevalence levels in the 20 – 65 age group. There may thus be some distortion in the analysis presented, to the extent that the age profile of the 20 – 65 population differs from the age profile of the samples taken.

Sample population / comparison population	Reference	Prevalence	Date	Sample prevalence: Comparison prevalence
All teachers SA adults	Van Niftrik (1995) ASSA (2001)	2.8% 2.8%	Nov 93 - Apr 94	1.00
Male security forces SA male adults	Van Niftrik (1995) ASSA (2001)	2.3% 2.7%	Nov 93 - Apr 94	0.86
Female nurses SA female adults	Van Niftrik (1995) ASSA (2001)	2.1% 2.9%	Nov 93 - Apr 94	0.72
Other insurance applicants SA adults	Van Niftrik (1995) ASSA (2001)	1.5% 2.8%	Nov 93 - Apr 94	0.54
Miners in Carletonville Gauteng adult males	Williams *et al* (2000) -	28.5% 17.1%	July - Aug 98	1.66
Sugar mill workers in KZN KZN adults	Caelers (1999) -	26.0% 26.3%	1999	0.99
Agricultural workers in KZN KZN adults	Rosen (2001) -	22.9% 26.3%	1999	0.87
Retail employees in KZN KZN adults	Rosen (2001) -	7.9% 29.6%	2001	0.27
Heavy/light industry SA adults	Rosen (2001) ASSA (2001)	8.8% 17.4%	1999	0.50
Freight & trucking in Gauteng (a) Drivers and operators (b) Management & admin Gauteng adults	 Evian (2000) Evian (2000) -	 20.6% 4.1% 21.8%	Aug 2000	 0.95 0.19

Table 5: HIV prevalence levels in employed groups

Table 5 shows that the ratio of HIV prevalence in particular occupational groups to general prevalence levels in individuals with similar demographic characteristics. This ratio tends to be high for occupations associated with accommodation away from home, but low for other occupations (with the exception of teachers and agricultural workers).

The first four prevalence estimates are based on HIV prevalence levels among life assurance applicants (Van Niftrik, 1995). These suggest that teachers are at a particularly high risk of HIV infection, and it is often argued that this occurs because of teachers having sexual relationships with their pupils. It is also clear that HIV prevalence levels are relatively high in the male security forces. These men are at risk (a) because many are accommodated in barracks, away from their regular partners; and (b) because many confront violence and danger in their day-to-day lives, and see the risk of HIV infection as less immediate and significant. Among other life assurance applicants HIV prevalence levels are substantially lower. However, HIV prevalence levels among life assurance applicants are generally lower than among similar individuals without cover, and the life assurance applicant data presented here may thus understate the effect of occupation on HIV risk.

Mineworkers are also at a particularly high risk of infection. At a recent Business-to-Business conference on the impact of HIV/AIDS, the HIV prevalence among Gold Fields employees was estimated at 26% for employees, and Clem Sunter of Anglo

American Group quoted an estimate of 20% HIV prevalence in the group. (In neither case, however, was it clear whether the estimate was based on voluntary testing, nor was it clear whether the estimate applied to the whole workforce or only the mineworkers). Lonmin also reported earlier this year that their HIV prevalence in 2000 was estimated to be 26%. Although unreliable, these estimates are roughly consistent with the 28.5% prevalence observed among mineworkers by Williams *et al* (2000).

Other studies show that truck drivers are at a particularly high risk of HIV infection (Evian (2000) and Ramjee *et al* (2000)). As with mineworkers, their high prevalence levels can be explained in terms of the long separations from their regular partners, and the relatively easy access they have to commercial sex workers. The study of Ramjee *et al*, however, is biased in that it based on a sample of truck drivers that were clients of sex workers, and is therefore not included in Table 5. Agricultural workers also appear to have a significant risk of infection (Caelers (1999) and Rosen (2001)), although it is not clear to what extent this can be explained by migrant labour.

Among white-collar workers, HIV prevalence levels appear to be substantially lower. This is shown in the difference in HIV prevalence levels between drivers/operators and management in the freight and trucking company studied by Evian (2000). It is also clearly shown in Table 3. Arguably, therefore, it is the individual's *occupation* that determines their HIV risk, rather than the industry they are located in.

Research is currently being conducted by Rob Dorrington and David Acott into the effect of industry on HIV risk, as part of a study on the economic impact of the epidemic. This work has not yet been published, but preliminary estimates of industry effects are included here. These are based on some of the data presented above, and on attempts to model the insurance claims experience of certain companies. Table 6 gives the ratios of sector prevalence levels to those of the ASSA2000 model, allowing for race and sex, as in 1999. It must be stressed that at this stage these are very tentative estimates. The authors feel that they are probably on the low side for the employed (particularly Government, TMT and possibly the financial services sector), and on the high side for the unemployed.

	Ratio
Unemployed	1.25
Financial	0.13
Government	0.55
Industrial (light manufacturing)	0.55
Industrial (heavy manufacturing)	0.70
Industrial (wholesale)	0.33
Industrial (retail)	0.23
Industrial (land and water transport)	0.98
Industrial (other)	0.73
Resources (forestry and coal)	0.75
Resources (gold and metal ore)	1.03
Resources (petroleum and metal manufacturing)	0.60
TMT (post and telecom)	0.26
TMT (IT and research)	0.05

Table 6. Ratio of sector to national prevalence levels in initial modelling attempts: 1999

3.7 Race, cultural group and circumcision

3.7.1 Race

Data from a number of sources show that HIV prevalence levels are highest in the black African population, slightly lower in the coloured population, and lowest in the Asian and white populations. Table 7, for example, shows odds ratios for HIV infection in each race group, relative to the black African group. (These statistics are based on a multivariate logistic regression performed on 1998 and 1999 antenatal clinic data). Although the sample size for Asians was small, and the difference between Asian and black prevalence levels was thus only of borderline significance, the results for coloureds and whites are clearly substantially lower than those for black Africans.

Race	Odds ratio	p value
Black African	1.00	-
Asian	0.23	0.05
Coloured	0.17	< 0.001
White	0.13	< 0.001

Table 7: Odds ratios for HIV infection in different race groups

A number of explanations for these prevalence differentials can be given. Currently income is distributed unevenly between the four race groups. HIV prevalence differentials between the race groups can thus be explained to some extent by the correlation between income and HIV prevalence. However, it has been demonstrated in 3.5 that the relationship between HIV prevalence and socio-economic markers is fairly complex, and socio-economic markers by themselves cannot fully explain the prevalence differentials between the race groups.

Studies show that race is in fact a significant determinant of HIV risk even when socio-economic risk factors have been adjusted for. Table 7, for example, presents the results of a multivariate analysis in which the level of education has been controlled for. The fact that the antenatal clinic surveys apply only to women attending antenatal clinics in the public sector is further evidence that these results are unlikely to be significantly distorted by socio-economic differences. A workforce HIV prevalence study (see 2.3) has also shown that significant differences between black and white prevalence levels exist among workers at the same skill level. This is demonstrated in Figure 5, where odds ratios are all expressed relative to black semi-skilled workers. It appears that at higher skill levels the prevalence differentials between race groups become small, although the sample taken in the senior management job grade was too small to yield reliable estimates, either for white or black employees. None of the black senior managers tested HIV positive.

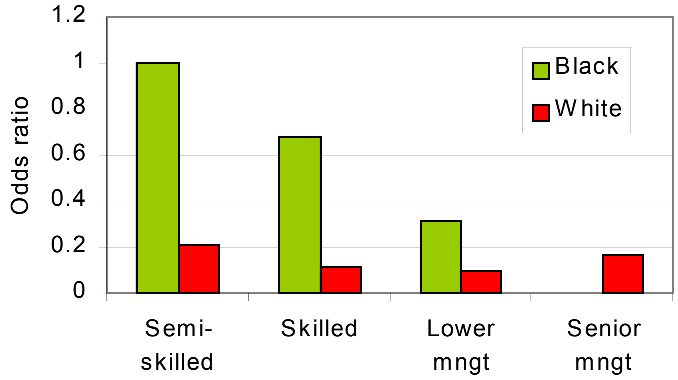

Figure 5: Odds ratios at different skill levels, for black and white employees

Differences in income and education level therefore cannot completely explain race differentials in HIV prevalence at an individual level. Several other factors explain the high prevalence in the black population: the social effects of forced removals, the nature of township lifestyle, the migrant labour system, and the gradual breakdown of traditional society, for example, may also be responsible. Race is thus in many respects a marker of former social disadvantage. In addition, disruptions caused by the struggle against apartheid, both from inside and outside the country, could well have led to a disintegration of sexual mores and traditional values. Cultural differences in sexual relationships may also be the cause of the higher prevalence in the black population. Polygamy, for example, is practised among some black Africans, but there is little empirical evidence to suggest whether or not this increases the risk of HIV infection. Demographic and Health Survey data also suggest that differences in partner ages tend to be greater and more variable in the black African population than in other population groups, and it will be shown in 3.7.2 that this may have some effect on HIV prevalence.

That prevalence differentials exist between race groups even when socio-economic markers are controlled for is perhaps not surprising. As explained in 3.5, an individual's risk of infection is determined by both the individual's own behavioural and demographic characteristics, and by the general risk profile of the community in which the individual is situated. To the extent that the HIV risk profile of the black African community is high *in aggregate*, a black African of high socio-economic status, for example, may be at a higher risk of infection than a white with the same level of socio-economic status simply because black Africans are more likely to interact sexually with other black Africans than are whites.

The epidemic in the coloured community is substantially less severe than in the African black community. Figure 6 shows national antenatal clinic prevalence levels for coloureds between 1990 and 1999 (data was not available for 1996). It suggests that HIV prevalence levels in the coloured population have already stabilized at roughly 3%.

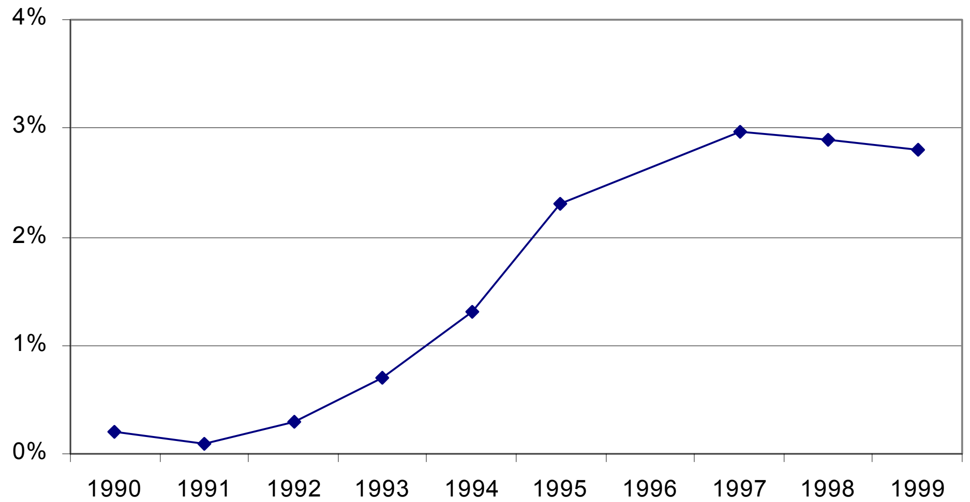

Figure 6: Coloured antenatal clinic prevalence
Source: ASSA (2001)

The epidemic is least severe in the Asian and white population groups. Samples of these groups, taken in the antenatal clinic surveys, are too small to allow for reliable prevalence estimates, but they do nevertheless show that prevalence levels for Asian and white antenatal clinic attendees are significantly lower than those for black African antenatal clinic attendees. The epidemic in the white population was marked initially by mostly homosexual transmission, and by November of 1995, 404 of the 485 reported AIDS cases among whites were male homosexuals or bisexuals (DNHPD, 1995(a)). The extent to which the heterosexual epidemic will develop in the Asian and white populations is still very much a matter of conjecture.

3.7.2 Circumcision and cultural group

It is frequently suggested that differences in levels of male circumcision may also, to some extent, explain HIV prevalence differentials between various cultural groups. It is hypothesized that men who are uncircumcised are more susceptible to HIV infection, as the foreskin of the penis provides a vulnerable portal of entry for the virus. Evidence from elsewhere in Africa suggests that societies in which male circumcision is common tend to experience lower HIV prevalence levels (Moses *et al*, 1990). Studies of HIV transmission, however, produce varying results. Some show significant associations between lack of circumcision and susceptibility to HIV transmission, while others do not find any significant relationship (Douglas, 2001). Although the majority of studies suggest that there is some relationship between circumcision and HIV transmission, it is unclear how strong the relationship is. Garenne and Lydié (2001) state that the risk of transmission from an infected female to an uninfected, uncircumcised male is roughly double that if the male is circumcised. In addition, circumcision reduces the incidence of ulcerative STDs, such as syphilis and chancroid, and this confers further benefit. They caution, however, that the protective effect of circumcision may vary according to the age at which circumcision occurs and the completeness of circumcision.

In South Africa rates of circumcision are very variable between cultural groups. In the Carletonville study (Williams *et al*, 2000), rates of circumcision in adult males were found to vary from roughly three quarters among the Pedi, to roughly two thirds among the Xhosa, and to less than a half for the Sotho and Shangaan. The Tswana, Zulu and Swazi do not traditionally circumcise, but roughly 15% of adult men in both groups were circumcised. It was also found that circumcision was significantly protective in mineworkers, but this was not found among men living in Khutsong (possibly because the latter sample was substantially smaller than the sample of mineworkers). To the extent that circumcision is protective, it could explain the high prevalence of HIV in KwaZulu-Natal (inhabited mostly by Zulus) relative to that in the Eastern Cape (inhabited mostly by Xhosas) and the Northern Province (inhabited largely by the Pedi). It may to some extent also explain the high prevalence in the urbanized black population, in which the practice of circumcision is becoming less common.

No information was found on rates of circumcision in the Asian, coloured and white populations.

3.8 Gender, age, marital status and number of children

3.8.1 Gender differentials

HIV prevalence levels are higher among women than men in a purely heterosexual epidemic. Women are biologically more susceptible to infection. With the income share of women being only 30.5% of national income (MWPD, 1998), and with lower employment levels among women (Budlender, 1998), they are also more susceptible because of their lower socio-economic position. Many women are, as a result of their financial dependence on their partners, unable to insist on safer sexual practices, and the role of violence in sexual relationships has already been discussed in 3.3.1.

In the early stages of the epidemic, estimates of the ratio of male prevalence to female prevalence were usually close to 0.7. Data from blood donors (Crookes and Heyns, 1992) suggested a ratio of 0.68, and data from TB clinic attendees suggested a ratio of 0.71 (McAnerney, 1994). The differential between male and female prevalence levels is, however, likely to change over time (Garenne and Lydié, 2001). When the course of the epidemic was simulated using the ASSA2000 model (ASSA, 2001), it was found that the ratio rose from 76% in 1990, to 82% in 1995 and 88% in 2000, but then dropped to 84% in 2005 and 82% in 2010. Thus, while it may have been acceptable to assume a ratio of 0.75 in the early stages of the epidemic, it is probably inappropriate to be using this ratio at the current time.

It should also be recognized that although these ratios are fairly representative of the population as a whole, they do not apply in all sub-populations. McIntyre (1996) states that male:female prevalence ratios are likely to be closer to parity in urban areas. (This may be because the epidemic tends to be more advanced in urban areas than in rural areas). In addition, blood transfusion data shows that while the above ratios typically apply to the black and coloured populations, the ratios in the Asian and white population groups are usually significantly greater than one (Abdool Karim *et al* (1998) and Crookes and Heyns (1992)). This may be due to differences in the level of homosexual infection relative to heterosexual infection.

3.8.2 Age differentials

Gender affects not only the general level of HIV prevalence, but also the shape of the prevalence curve as a function of age. The effect of age on HIV prevalence therefore needs to be discussed separately for men and women.

Among women, prevalence tends to peak between the ages of 25 and 29, with social and economic pressures encouraging high-risk sexual behaviour at early ages, particularly with men who are significantly older. There is also evidence to suggest that for *biological* reasons women may be at a higher risk of infection at younger ages (Garenne and Lydié, 2001). Table 8 shows the odds ratio of infection among women attending antenatal clinics at various ages, relative to the odds of infection in the 15 – 19 age group. In the teenage age group, antenatal clinic data are biased, as they represent only those girls who are sexually active, many of whom have not take precautions against falling pregnant. At the older ages, levels of prevalence at antenatal clinics decline, owing to the drop in fertility of women infected with the virus, and the lower levels of sexual activity at older ages. However, the numbers in the sample at these ages are too small to show this result with any degree of significance.

Age	Odds ratio	p value
15 - 19	1.00	-
20 - 24	1.59	< 0.001
25 - 29	1.80	< 0.001
30 - 34	1.44	< 0.001
35 - 39	1.08	0.36
40 - 44	0.87	0.37
45 - 49	0.60	0.28

Table 8: Odds ratios for HIV infection in different age groups, 1998 and 1999

It is important to emphasize that this pattern of prevalence is evolving over time. In the early stages of the epidemic, female prevalence tended to be at its highest in the 20 – 24 age band. Figure 7 shows that prevalence levels in other age groups have since risen relative to the prevalence level in the 20 – 24 age group. This suggests that incidence drops off quite rapidly after the late teens and early twenties, with the high proportions surviving to later ages showing up significantly as the epidemic matures.

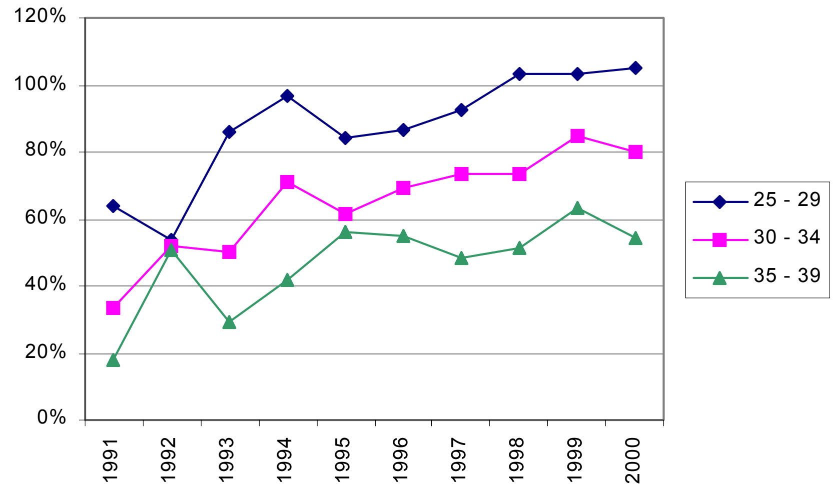

Figure 7: Female antenatal clinic prevalence in different age groups, as a percentage of prevalence in the 20 – 24 age group
Source: DNHPD (1995(b), 1996, 1997), DOH (1999, 2001)

In men, HIV prevalence tends to peak at slightly older ages (usually between the ages of 30 and 35), and at lower levels. Figure 8 shows the age prevalence levels observed among inhabitants of Khutsong, sampled as part of the Carletonville study (Williams *et al*, 2000). Among teenage males HIV prevalence is substantially lower than that among teenage females, and this suggests that teenage girls are becoming infected predominantly by older men. Sexual 'buying power' of men is low at young ages, but increases as men enter employment and acquire greater socio-economic status. Most of this 'buying power' is directed at women who are economically vulnerable and most of these women are relatively young. At older ages HIV prevalence tends to be higher among males than among females (the results shown in Figure 8 are unreliable over the age of 45 because of small sample sizes at these ages).

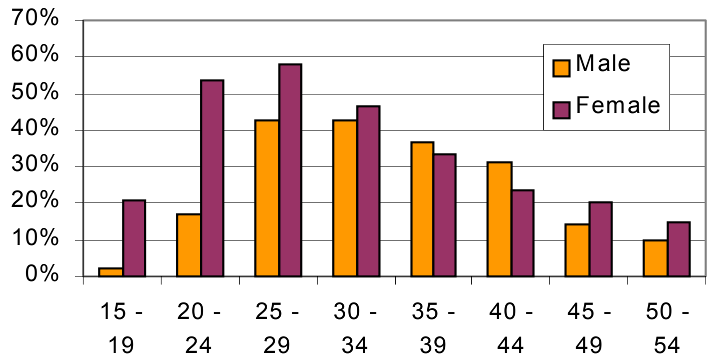

Figure 8: HIV prevalence by age and gender in Khutsong
Source: Williams *et al* (2000)

Large differences between male and female partner ages are often regarded as being conducive to the rapid and pervasive spread of the epidemic. Large age differentials tend to be associated with disparities in status and difficulties on the part of female partners in negotiating safer sexual practices. Large age differences between partners also allow for the rapid spread of the epidemic between different age groups. Auvert *et al* (2001) found that in a univariate analysis, differences of more than 5 years between male and female partner ages were associated with a significantly increased risk of HIV infection for both male and female partners (the difference was not significant, however, in a multivariate analysis).

In workforce populations, patterns of HIV infection with respect to age are similar to those observed in the general population, but differentials between male and female prevalence levels are not as great. Figure 9 shows the odds of infection for men and women in different age bands, relative to men under the age of 30, in the workforce described in 2.3. As in the general population, prevalence peaks below the age of 30 for females and above the age of 30 for males. The drop in prevalence at older ages is, however, much more substantial for females than for males. It would also appear that in this workforce the overall level of prevalence is *lower* among females than among males. Both the level and pattern of prevalence suggests that many of the factors that result in women having a higher HIV prevalence in the general population are largely socio-economic.

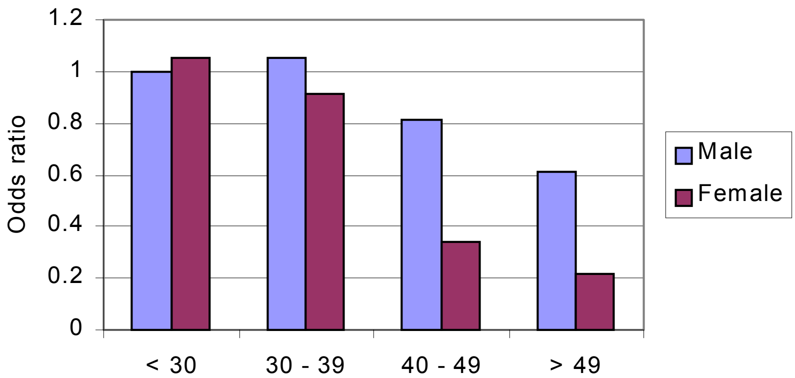

Figure 9: Odds ratios in different age groups, for males and females

The effect of age on HIV risk is thus influenced to a large extent by gender, and to a lesser extent by employment status.

3.8.3 Marital status and number of children

Relatively little data is available on the relationship between marital status and HIV prevalence. It might be expected that individuals who are married are less at risk of HIV infection because they are less likely to have multiple sexual partners. However, Williams *et al* (2000) found that in a multivariate analysis there was no significant relationship between marital status and HIV prevalence in any of the four groups sampled as part of the Carletonville study. Garenne and Lydié (2001) argue that marriage is no longer protective against HIV infection, since partners often become infected before they marry. Marriage is also not protective in couples that experience long separations due to migrant employment.

There is also little data available on the relationship between an individual's HIV status and the number of children they have given birth to or fathered. Table 9 shows the odds of HIV infection among women at different levels of gravidity[4], relative to women in their first pregnancy, determined from antenatal clinic data collected during 1998 and 1999. HIV infection is most common among women who are in their second pregnancy, and significantly less common among women in their third and subsequent pregnancies. Women who have large numbers of children are likely to be in more stable, long-term relationships, than women with relatively low fertility. It has also been shown that HIV infection tends to *cause* lower fertility rates (Zaba and Gregson, 1998), and this may also partially explain the high HIV prevalence observed among women with low levels of gravidity.

Gravidity	Odds ratio	p value
1	1	-
2	1.135	0.002
3	0.946	0.29
4 or more	0.722	< 0.001

Table 9: Odds ratios for HIV infection at different levels of gravidity

3.9 Geographical risk factors

Levels of HIV infection are very different between South Africa's provinces, and also between South Africa's urban and rural communities. The reasons for this are explained below.

3.9.1 Provincial variations

Provincial variations in antenatal clinic data have been analysed extensively in univariate analyses. As Figure 10 shows, antenatal clinic prevalence levels vary substantially between South Africa's nine provinces. Prevalence levels are highest in KwaZulu-Natal, and slightly lower in Mpumalanga, Free State and Gauteng. Northwest and Eastern Cape follow at slightly lower levels, while levels of infection are lowest in the Western Cape, Northern Cape and Northern Province. The overall trend is one of increasing HIV prevalence, although slightly anomalous results are apparent in a few cases (for example, the 1997 prevalence for the Western Cape, the 1998 prevalence for Mpumalanga, and the 2000 prevalence for Gauteng).

[4] A women's gravidity is the number of children she has given birth to, including any child(ren) she is currently pregnant with.

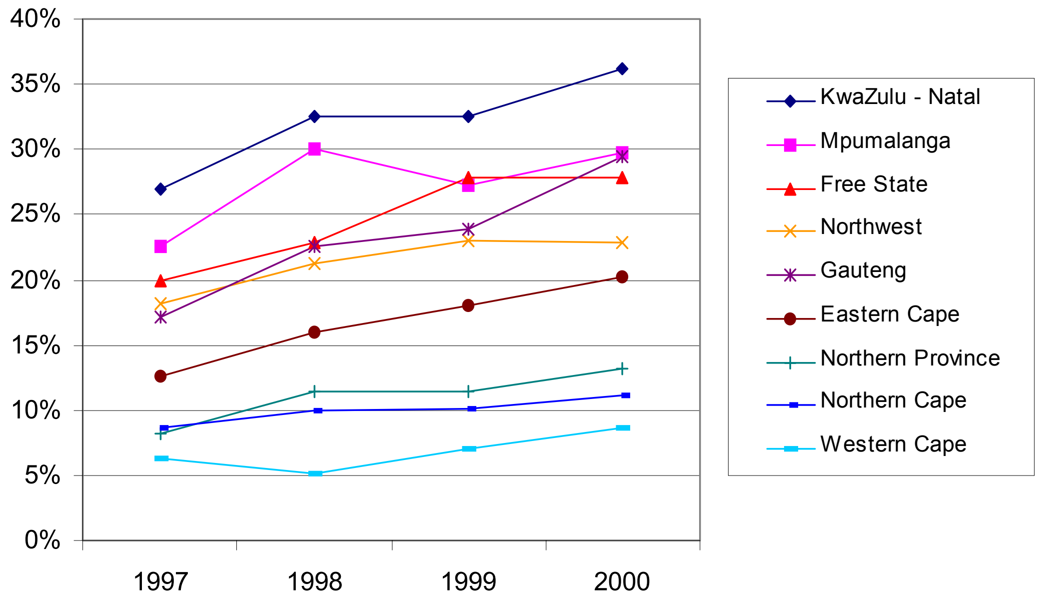

Figure 10: Provincial antenatal clinic prevalence rates, 1997 – 2000
Source: DOH (1999, 2001)

To some extent these differences reflect the fact that the various provincial epidemics are at different levels of maturity. A substantial amount of the variation, however, can also be explained in terms of demographic differences between the provinces. For example:

- As Wawer *et al* (1997) show in Uganda, the epidemic spreads most quickly to, and is most pervasive in, areas surrounding heavily-travelled roads. The fact that most of the trucking routes from the north terminate in Durban may explain why the epidemic has been slow to spread to the western half of the country (Webb, 1994(b)).
- As observed in 3.6, rates of HIV infection are highest in the black population. The proportion of the population that is black is relatively low in the Western Cape and the Northern Cape, and this partially explains why prevalence levels are so low in these provinces.
- The Eastern Cape and the Northern Province are the two poorest provinces - 77% of households in the Northern Province and 72% of households in the Eastern Cape are below the poverty line (MWPD, 1998). Levels of urbanization in these provinces are also relatively low, and this pattern of low urbanization and low income could partly explain the relatively low prevalence levels in these two provinces (see 3.5).
- Levels of male circumcision are high among the Xhosa (who inhabit mostly the Eastern Cape) and the Pedi (who inhabit parts of the Northern Province). This also partly explains the low prevalence levels in the Eastern Cape and the Northern Province.
- Low levels of circumcision among Zulu men and high levels of political turmoil in KwaZulu-Natal are partly responsible for the high levels of HIV prevalence in this province.

Once socio-economic and demographic differences are controlled for in a multivariate analysis, different patterns in infection levels between provinces become apparent.

Table 10 shows the odds of HIV infection among antenatal clinic attendees in each province, relative to the odds of infection in the Western Cape. This analysis, based on antenatal clinic data collected in 1998 and 1999, controlled for age, gravidity, level of education, race and year (Mpumalanga was not included in the analysis because demographic data for women attending antenatal clinics in this province was inadequate).

Province	Odds ratio	p value
Western Cape	1.00	-
Northern Cape	1.37	0.016
Eastern Cape	1.64	< 0.001
KwaZulu-Natal	3.51	< 0.002
Northern Province	0.96	0.72
Northwest	2.16	< 0.001
Free State	2.42	< 0.001
Gauteng	2.28	< 0.001

Table 10: Odds ratios for HIV infection in different provinces

The most startling result from this multivariate analysis is that the epidemic in KwaZulu-Natal is much more severe than is suggested by a simple univariate analysis, with the odds ratio for KwaZulu-Natal far exceeding the odds ratios for any of the other provinces. It is also remarkable that once demographic differences are controlled for, the epidemic in the Northern Province is of roughly the same severity as the epidemic in the Western Cape. Northwest, Free State and Gauteng all appear to have roughly equal levels of HIV risk. The differences that emerge in the multivariate analysis are attributable largely to differences in the level of maturity of the different provincial epidemics, but may to some extent also reflect the effect of residual demographic differences that could not be controlled for in this analysis (such as levels of male circumcision, and the degree of urbanization).

Assessing the levels of maturity of the different provincial epidemics is a complex process. A simplistic explanation of the process is that it requires the estimation of the level at which HIV prevalence in each province will ‘plateau’, and then an assessment of how close each province is to reaching that plateau. Differences between provinces in terms of closeness to reaching plateau prevalence are measured in terms of time leads or lags. Williams and Campbell (1998) attempted to estimate these plateau prevalence levels and time lags by fitting logistic functions to historical antenatal clinic data, and we have repeated their analysis using more recent data. Although these analyses do provide interesting insights, there are problems inherent in the use of logistic functions, and for some provinces (notably Northwest and Mpumalanga), historic antenatal clinic prevalence levels are too unstable to permit the fitting of logistic functions.

Nevertheless, findings based on the fitting of logistic functions to antenatal clinic data (included in detail in Appendix B) do confirm that there are substantial differences in the extent to which the different provincial epidemics have matured. It is estimated that the epidemic in KwaZulu-Natal leads the national epidemic by about 8 months, while the epidemics in both Gauteng and Free State lag the national epidemic by about 4 months. The epidemic in Northern Province lags the national epidemic by only 8 months. This, although longer than for some other provinces, is curiously inconsistent with the very low odds ratio reported for the Northern Province in Table 10, and does suggest that factors other than a relatively immature epidemic are the explanation for the low prevalence levels in this province. The lag for the Eastern Cape is roughly 13 months, while the lags for the Northern Cape and the Western Cape are 27 months and 32 months respectively. The epidemics in the Northern Cape and the Western Cape are therefore still in their relatively early stages.

Differences in prevalence levels between provinces are thus determined to some extent by differences in the levels of maturity of the various provincial epidemics. They are also, however, largely attributable to differences in the socio-demographic factors described in previous sections.

3.9.2 Differences between urban and rural areas

Little investigation has been conducted in South Africa into the difference between urban and rural levels of HIV prevalence. In the early stages of the epidemic, the Johannesburg City Health Department suggested an urban prevalence roughly 2.7 times higher than the rural prevalence (Webb, 1994(a)). McAnerney (1994) reported an antenatal clinic prevalence in rural areas of 2.5% and a prevalence in urban areas of 9.4% (about 3.8 times higher than for rural areas). Undoubtedly this gap has narrowed as the epidemic has matured.

In some respects rural communities may be regarded as being more at risk than urban communities. Levels of STD prevalence tend to be higher in rural areas because of poorer access to STD treatment (for example, 9.1% of men in urban areas report having had STD symptoms in the last three months, while the corresponding proportion for non-urban areas is 16.6% (DOH, 1999(b))). Levels of knowledge about HIV/AIDS are also lower in these regions, as mentioned in 3.2. The explanation for the low prevalence levels in rural areas may lie in the limited scope for sexual networking in isolated communities, and the greater influence of traditional values. Further, the Jaipur paradigm, presented by Barnett *et al* (2000), is based on the hypothesis that it is the degree of social cohesion in a community or society, as well as the level of wealth of the community, that determines the severity of its epidemic. It is further suggested that the degree of social cohesion is a more significant determinant of levels of HIV prevalence than income, and to the extent that rural communities are more socially cohesive, they may be expected to experience lower prevalence levels.

The urban-rural differential may also be due to temporal factors. In many sub-Saharan countries the AIDS epidemic has been slow to spread to rural communities because of their relative immobility and geographic isolation. Once the epidemic is imported into the rural community, the incidence pattern may follow that in urban areas – that is to say, the observed urban-rural differential may be due to a time lag. Chin and Sato (1994) suggest that as the epidemic spreads and as prevalence levels in urban areas begin to level off, the difference between urban and rural prevalence levels is likely to diminish.

If this is indeed a valid explanation of urban-rural differentials in sub-Saharan Africa, it should not be assumed that the same factors will work to produce an urban-rural differential in South Africa. South African rural communities are not as static or as geographically isolated as those in the rest of Africa. The migrant labour system has caused a steady flow of HIV-infected men through the rural communities in which their wives and families are situated, and the urban areas in which they work. The superior transport system in South Africa may also have ensured a more rapid spread of the epidemic to rural areas. Piot *et al* (1994) have noted that in the Ivory Coast (a country which, like South Africa, has good road and transport systems) the HIV/AIDS epidemic has spread equally into urban and rural areas.

That the differential could be relatively small in South Africa is suggested by one of the country's few sentinel surveys: Wilkinson *et al* (1999) show that the prevalence levels in Hlabisa, a rural district in KwaZulu-Natal, are roughly the same as those for the province as a whole. However, it needs to be emphasized that Hlabisa is not a 'typical' rural district. A major national road crosses the district, and rates of migrant labour are very high, with approximately 60% of households having a male who is a migrant (Wilkinson *et al*, 1997). Kirk (2001) shows in both models A and C (see 2.2 for further explanation) that high levels of population density are significantly associated with high levels of HIV prevalence, and this suggests that levels of HIV infection are indeed higher in urban communities.

3.10 Religion

There is very little literature on the links between religion and HIV/AIDS. There has, however, been some work on how religious affiliation affects sexual attitudes and, possibly, behaviour. Garner (2000) refers, in particular, to literature on the impact of the upsurge in Pentecostalism and other 'dynamic' types of church on attitudes and behaviour. A Zimbabwean study (Gregson *et al*, 1999) focuses more specifically on how affiliation to different Christian denominations might influence vulnerability to HIV infection.

Garner's (2000) research in Edenvale township of Pietermaritzburg in KwaZulu-Natal finds significantly lower levels of extra- and pre-marital sex among members of Pentecostal churches than among those affiliated to 'mainline' churches. The latter refers to established or mission churches such as Anglican, Methodist, Presbyterian and Roman Catholic. The lower levels of extra- and pre-marital sex among Pentecostal members are, in turn, hypothesised to result in lower levels of HIV infection. The study also highlights the fact that condom usage is particularly frowned upon by the Pentecostal churches, and low levels of sex outside marriage are thus particularly important among its members in lowering vulnerability to HIV infection.

Garner suggests that the different levels of extra- and pre-marital sex among different religious groups are a result of four inter-related variables, which he refers to as indoctrination, religious experience, exclusion and socialization. Indoctrination refers to the nature of the religious group's educational programme and, in particular, its teaching and use of the Bible. Religious experience refers to the subjective experience of the individual in terms of participation and emotional involvement. Exclusion refers to the strength of the boundaries of the group. Socialization refers to the manner in which the group creates its boundaries and monitors activities of members. High levels on each of these variables are found among the Pentecostal churches and are argued to lead to lower levels of sex outside of marriage.

Gregson *et al* (1999) focus on two rural areas of Zimbabwe. Using a range of data sources – from missions, ethnography and demography - they find significant differences in recent demographic trends between members of mission and independent or 'spirit-type' churches. In particular, until recently, birth rates and infant mortality were higher among members of independent churches while, more recently, there has been an increase in mortality among members of mission churches. The authors postulate that differences in religious teaching on use of healthcare and sexual behaviour, differences in church 'regulation', and different norms about consumption of alcohol can explain the patterns. For example, resistance to using modern medicines accounts for the higher birth rates and infant mortality among independent church members in the past, while greater controls over sexual behaviour, and thus lesser exposure to HIV/AIDS, explain the current lower mortality rates. In terms of church regulation, the study describes controls over the virginity of unmarried women within the spirit-type churches.

The authors explicitly discard the idea that the observed differences in fertility and mortality rates can be accounted for on socio-economic grounds, noting that the socio-economic indicators for members of the different churches are similar in both areas except, to some extent, for education. However, they argue that the educational difference is a consequence, rather than determinant, of religious affiliation.

Finally, the authors note that the patterns found in the two rural areas are not found, or not to the same extent, in urban areas. They suggest that this is due to higher levels of education, greater exposure to western influences, and thus greater secularization.

The extent to which church membership generally is protective against HIV infection is unclear. Williams *et al* (2000) found that church membership was not significantly associated with HIV prevalence in a univariate analysis, except among women living in 'hotspots' (see 2.4). In the latter group the odds ratio for HIV infection among church members, relative to non-members, was 0.2 ($p = 0.002$) in a multivariate analysis. Because of the limitations associated with univariate analyses, it is not clear whether or not church membership was protective against HIV infection in the other three groups sampled.

In summary, it is not clear whether church members in general are less likely to be HIV positive than non-members. There is evidence, however, to suggest that members of Pentecostal and independent churches are less likely to engage in extra- and pre-marital sex, and are less likely to be HIV positive, than members of other Christian churches. No evidence was found regarding other religions such as Islam and Judaism.

3.11 Other factors

3.11.1 Hormonal contraception

There is some evidence to suggest that the use of hormonal contraception increases a woman's biological susceptibility to HIV infection. It is suggested that this occurs because these contraceptives affect the immune system and the cervical and vaginal epithelium (Garenne and Lydié, 2001). Use of hormonal contraceptives can also be considered an HIV risk factor to the extent that women using this form of contraception are less likely to be using condoms.

Wang *et al* (1999) show, in a meta-analysis of 28 studies conducted throughout the world, that oral contraceptives increase the risk of HIV infection by roughly 20%. A Kenyan study (Martin *et al*, 1998) also shows that Depo-Provera, an injectable contraceptive, roughly doubles the risk of HIV transmission in women. Garenne and Lydié (2001) note that the use of Depo-Provera is particularly common in Eastern and Southern Africa, and suggest that it is one of the reasons for the particularly high HIV prevalence levels in these regions.

Injectable contraceptives (predominantly Depo-Provera) are the most common form of contraceptive in South Africa. In the South African Demographic and Health Survey (DOH, 1999(b)), 57% of women reported having ever used injectable contraceptives, and 27.3% reported using them currently. Use of injectable contraceptives appears to correlate strongly with several of the risk factors that have already been identified. For example:

- Rates of injectable contraceptive use are highest among black Africans (35.1%), lower among coloureds (27.4%) and lowest among whites and Asians (4.7% and 3.6% respectively).
- The use of injectable contraceptives is most common in teenagers (50.7%), and falls steadily with increasing age to a rate of 6.1% among women in the 45 – 49 age band. This mirrors the pattern of HIV incidence for females.
- Usage rates are highest among women whose highest educational standard is between grades 8 and 11. This corresponds to the educational risk group that is most at risk of infection (see Figure 3).
- Women who report having had one child are more likely to be using injectable contraceptives than women at any other parity level. This corresponds to the peak HIV risk among women with one child demonstrated in Table 9.

The widespread use of Depo-Provera in South Africa may therefore partly explain the observed associations between HIV risk and factors such as race, age, education and gravidity. However, the provincial variations in the use of Depo-Provera do not appear to mirror the provincial variations in HIV prevalence, and the difference in the use of the contraceptive in urban and rural areas is only marginal. The use of Depo-Provera thus cannot account for geographical variations in HIV prevalence.

The use of oral contraceptives is slightly less common. In the South African Demographic and Health Survey, 37.6% of women reported having ever used the pill, and 9.3% were currently using it. Use of the pill is particularly common among white and Asian women and among women with higher levels of education. Its use does not appear to be strongly associated with the factors that are usually associated with HIV risk, as is the case for Depo-Provera.

3.11.2 Armed conflict and the role of the military

Armed conflict has the effect of both displacing those seeking to avoid conflict, and destabilizing the traditional power structures and value systems of the society. It also creates movements of armed forces between regions. Many of the former revolutionary cadres, such as umKhonto weSizwe, fought to the north of South Africa's borders, and were incorporated into the national defence force after 1994 without any HIV testing. The return of these security forces, from areas of high HIV prevalence, to military bases throughout the country, has contributed to the rapid growth of the epidemic in South Africa (Shell, 2000). The role of the military in the spread of the epidemic is thus closely related to the role of one form of migration.

The role of the military can also be explained in terms of the culture of machismo and the relative affluence of military personnel. This is associated with sex worker interaction and the formation of casual sexual relationships in the surrounding community. Kirk (2001) suggests that HIV prevalence levels may be particularly high in areas surrounding military bases.

However, armed conflict does not always involve only the military. KwaZulu-Natal has been particularly afflicted by violence and political conflict between ANC and IFP supporters. This violence has led to a collapse of social cohesion and a disintegration of parental authority (Humbridge, 1990). This is a significant factor contributing to the high levels of HIV prevalence in the province.

3.11.3 Modes of transmission other than heterosexual intercourse

Although heterosexual intercourse is the predominant mode of transmission in the South African HIV epidemic, several other modes of transmission are common. Figure 11 shows the composition of all reported AIDS cases, by mode of transmission, as at 30 November 1995. (These statistics ceased to be published after 1995). AIDS is notoriously under-reported in developing countries such as South Africa, and these statistics cannot be regarded as representative of the true patterns of transmission. Nevertheless, they do provide a rough sense of the possible relative magnitude of the different forms of transmission.

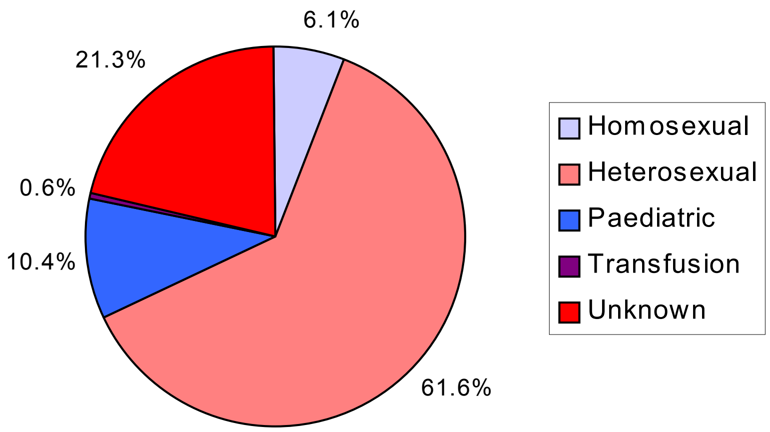

Figure 11: Modes of transmission
Source: DNHPD(1995(a))

In the early phases of South Africa's epidemic, most HIV/AIDS cases were among white homosexuals (Schoub *et al*, 1988). Since the early nineties, however, the homosexual epidemic has been eclipsed by the heterosexual epidemic. Nevertheless, men who have sex with men remain a high-risk group, as anal intercourse is associated with a high risk of transmission for penetrated partners. Homosexuality can therefore be regarded as a risk factor.

Homosexual transmission of HIV appears to be most common in the white population, with 75% of all reported homosexual AIDS cases being among whites, as at the end of 1995 (DNHPD, 1995(a)). The percentage of AIDS cases attributable to homosexual transmission was at this time 83% for whites, 36% for Asians, 21% for coloureds and 2.5% for black Africans. Homosexuality is thus predominantly a risk factor for white males, and appears to be relatively rare among black Africans. However, the heterosexual epidemic has evolved substantially since 1995, and the relative significance of homosexual transmission in the white population at the current time is thus unclear.

Intravenous drug use is not a common form of transmission in South Africa. As at 30 November 1995, only 3 of South Africa's 8 784 reported AIDS cases were attributable to intravenous drug use. The percentage of all cases that this represents is so small that it was not included in Figure 11.

Most of the infections that have occurred among blood transfusion recipients and haemophiliacs occurred in the early years of the epidemic, before measures were introduced to remove the risk of HIV contamination of blood supplies. This is therefore no longer a significant source of risk (Schoub *et al*, 1988).

Transmission of HIV from HIV positive mothers to their children is common, as Figure 11 shows. The probability of transmission is particularly high when the mother breastfeeds and when the mother does not have access to short-course antiretroviral treatment (McIntyre and Gray, 2000). This is most likely to occur among mothers who are poor and do not have access to private health services. The government is currently running two pilot sites in each of the nine provinces, and these sites provide short-course antiretroviral treatment and formula feeding to HIV positive pregnant women. However, only a small proportion of pregnant women currently have access to this service.

Very few of the children infected by their mothers survive to adulthood. In the adult population, therefore, the common forms of infection are heterosexual and homosexual intercourse. Infection through blood products and through intravenous drug use is extremely rare.

3.11.4 Psychological factors

The role of psychological factors as determinants of HIV risk should not be ignored. Studies show that individuals with low levels of self-esteem and self-efficacy tend to be more likely to engage in unsafe sex (Eaton and Flischer (2001) and Kipp *et al* (1994)). Factors such as these, however, are complex to measure, and there has been little research conducted into how these psychological factors relate to other HIV risk factors such as gender and level of education.

4. Conclusion

A number of themes have emerged from the preceding discussion. The first is that the relationships between the various risk factors are complex, and simple univariate analyses of HIV prevalence data do not provide a particularly deep understanding of the relative significance of the various risk factors. Tools such as multivariate logistic regression are needed to identify which factors most directly determine HIV risk, and to determine how risk factors interact.

A particularly important example of such an interaction is the significance of male-female differences in respect of many of the risk factors. For example, many STDs affecting women are asymptomatic, and many women do not receive treatment for these. Other biomedical risk factors, such as circumcision and hormonal contraceptive use, are directly relevant to one gender, and only indirectly relevant to the other. Income, migrancy and age also affect the risk of HIV infection, but the explanation of the relationship differs for men and women.

The most important theme, however, is the importance of distinguishing between the risk factors that determine the individual's own sexual behaviour patterns, and the risk factors that determine the level of infection in that group of people from which the individual is likely to choose a partner. Into the first group can be placed factors such as age, gender, marital status, religion, knowledge of HIV, education, STD treatment seeking behaviour, sexual orientation, and psychological factors. The second group includes community risk factors such as the extent of urbanization, the presence of armed conflict or military forces, STD prevalence and race. Many factors can be included under both headings. For example, the individual's income and level of migration (and linked to it, their occupation and employment status) affect their sexual behaviour. However, levels of migration, income and unemployment in the individual's community also determine the risk that their partner(s) will be infected. Circumcision is also an example: it is protective at an individual level, but to the extent that it is more prevalent in some communities, it can also be regarded as protective at a community level.

As Zwi and Cabral (1991) argue, much of the literature tends to focus on individual risk behaviours without focussing on the social, economic and political determinants of these behaviours. While interventions need to focus on encouraging individuals to change their behaviours, it is also necessary to address the broader societal conditions that influence these behaviours. In South Africa the most important of these factors are the low status of women, the high levels of migration, and the low rates of treatment of sexually transmitted diseases. South Africa has, in fact, had all the ingredients for an explosive epidemic (Dorrington, 1999).

However, rates of HIV infection are not uniformly high in South Africa. Several regions and groups appear to be experiencing low or almost negligible levels of prevalence. By understanding the factors that are protective of infection in these groups, policy-makers can develop programmes to reduce further infections.

5. References

The following abbreviations have been used in the text to simplify referencing:

ASSA	Actuarial Society of South Africa
DNHPD	Department of National Health and Population Development
DOH	Department of Health
KFF	Kaiser Family Foundation
MWPD	Ministry for Welfare and Population Development
RCCT	Rape Crisis Cape Town

Abdool Karim Q., Mathews C., Gutmacher S., Wilkinson D., Abdool Karim S.S. (1998) *HIV and STDs in South Africa: Epidemiology and demographics*. National STD/ HIV/AIDS Review

Abdool Karim Q., Abdool Karim S., Dipdata M., Soldan K., Zondi M. (1995) Reducing the risk of HIV infection among South African sex workers: socio-economic and gender barriers. *American Journal of Public Health*. Vol. 85(11), 1521-1525.

Abdool Karim Q., Abdool Karim S.S., Singh B., Short R. and Ngxongo S. (1992) Seroprevalence of HIV infection in rural South Africa. *AIDS*. Vol. 6, 1535 – 1539. Quoted in Lurie (2000)

Actuarial Society of South Africa. (2001) *The ASSA2000 AIDS and Demographic model*. Online. Available: www.assa.org.za/committees/aids/aids.htm

Auvert B., Ballard R., Campbell C., Carael M., Carton M., Fehler G., Gouws E., MacPhail C., Taljaard D., Van Dam J., Williams B. (2001) HIV infection in a South African mining town is associated with herpes simplex virus-2 seropositivity and sexual behaviour. AIDS. Vol. 15, 885 - 898

Barnett T., Whiteside A., Decosas J. (2000) The Jaipur paradigm – a conceptual framework for understanding social susceptibility and vulnerability to HIV. *South African Medical Journal*. Vol. 90, 1098 – 1101

Budlender D. (1998) *Women and men in South Africa*. Central Statistics. Pretoria

Buga G., Amoko D., Ncayiyana D. (1996) Sexual behaviour, contraceptive practice and reproductive health among school adolescents in rural Transkei. *South African Medical Journal*. Vol. 86, 523 – 527

Caelers D. (1999) Costs mount as 1700 test HIV positive daily. *The Argus*. 15 Nov. 1999

Chin J., Sato P.A. (1994) *AIDS in Africa* (Chapter 13). Essex M., Mboup S., Kanki P. J., Kalengayi M. R. (editors). Raven Press. New York

Colvin M. (2000) Sexually transmitted diseases in southern Africa: a public health crisis. *South African Journal of Science*. Vol. 96, pp. 335 – 339.

Colvin M., Abdool Karim Q., Hoosen A. (1997) Management of sexually transmitted diseases in workplace based clinics in KwaZulu/Natal: implications for HIV. *South African Journal of Public Health*. Vol. 87, 245 – 249. Quoted in Colvin (2000)

Crookes R., Heyns A. (1992) HIV seroprevalence – data derived from blood transfusion services. *South African Medical Journal*. Vol. 82, 484 – 485

Crush J. (1995) Mine migrancy in the contemporary era. In *Crossing boundaries: Mine migrancy in a democratic South Africa*. Crush J., James W. (editors). IDASA/ IDRC. Cape Town. Quoted in Lurie (2000)

Dallabetta G., Miotti P., Chiphangwi J., Liomba G., Canner J., Saah A. (1995) Traditional vaginal agents : use and association with HIV infection in Malawian women. *AIDS*. Vol. 9, 293 - 297

Department of Health (DOH). (2001) *National HIV and syphilis sero-prevalence survey of women attending public antenatal clinics in South Africa, 2000.*

Department of Health (DOH). (1999(a)) *1998 National HIV sero-prevalence survey among women attending public antenatal clinics in South Africa*.

Department of Health (DOH). (1999(b)) *South Africa Demographic and Health Survey 1998: Preliminary Report.*

Department of National Health and Population Development (DNHPD). (1997) Seventh national HIV survey of women attending antenatal clinics of the public health services in the Republic of South Africa, Oct /Nov 1996. *Epidemiological comments*. Vol. 23, No. 2, pp. 4 - 16

Department of National Health and Population Development (DNHPD). (1996) Sixth national HIV survey of women attending antenatal clinics of the public health services in the Republic of South Africa, Oct/Nov 1995. *Epidemiological comments*. Vol. 23, No. 1, pp. 3 - 15

Department of National Health and Population Development (DNHPD). (1995(a)) AIDS in South Africa: Reported AIDS cases as on 30 November 1995. *Epidemiological comments*. Vol. 22, No. 10, pp. 233 – 234

Department of National Health and Population Development (DNHPD). (1995(b)) Fifth national HIV survey in women attending antenatal clinics of the public health services in South Africa, Oct/Nov 1993. *Epidemiological comments*. Vol. 22, No. 4, pp. 90 – 100

Department of National Health and Population Development (DNHPD). (1994) Fourth national HIV survey in women attending antenatal clinics, South Africa, Oct / Nov 1993. *Epidemiological comments*. Vol. 21, No. 4, pp. 68 – 78

Dorrington R. E. (2000) *The ASSA2000 suite of models*. Paper presented at the Actuarial Society of South Africa Convention, 2000. Available: www.assa.org.za.

Dorrington R. E. (1999) *AIDS Then, Now and Tomorrow*. Presented at the SA Round Table on HIV/AIDS held as part of the 3rd UAPS Conference, Durban, 6-10 December 1999

Douglas G. (2001) *Literature review to investigate the assumptions of HIV-positive fertility, heterosexual transmission and HIV-positive survival in the ASSA2000 models*. Honours research project, Department of Actuarial Science, University of Cape Town

Eaton L., Flischer A. (2001) Why do young people engage in unsafe sex? *South African Journal of Psychiatry*. Vol. 7, 55 – 58

Evian C. (2000) *UNITRANS: Selected Gauteng and North West provincial operations, HIV prevalence survey*. Quoted in Kohler H. et al (2001) *The impact of HIV/AIDS on company equity*. Honours research project, Department of Finance, University of Cape Town.

Garenne M., Lydié N. (2001) *Gender and AIDS*. Paper prepared for the WHO monograph on Gender Analysis of Health

Garner S. (2000) Safe sects? Dynamic religion and AIDS in South Africa. *The Journal of Modern African Studies*. Vol. 38: 41-69

Gregson S., Zhuwau T., Anderson R., Chandiwana S. (1999) Apostles and Zionists: The influence of religion on demographic change in rural Zimbabwe. *Population Studies*. Vol. 53, 179-193

Heywood M. (1998) *How the Poor Die: HIV / AIDS and Poverty in South Africa*.

Humbridge M. (1990) AIDS / HIV and social dislocation in Natal. *AIDS Analysis Africa (Southern Africa Edition)*. Vol. 1, No. 3

Kaiser Family Foundation (KFF). (2001) *Hot prospects, cold facts: portrait of a young South Africa*. Copies of the report may be requested from Love Life, c/o Box 45 Parklands 2121, fax (011) 771 6801 or e-mail talk@lovelife.org.za.

Kipp W., Masheisha C., von Sonnenburg F., Weis P. (1994) Influence of personal experience of dying AIDS patients on attitude and sexual behaviour in Kabarole district, Uganda. *AIDS*. Vol. 8, 392 - 394

Jochelson K., Mothibeli M., Leger J. (1991) Human immunodeficiency virus and migrant labour in South Africa. *International Journal of Health Services*. Vol. 21, 157 - 173

Kinghorn K., Steinberg M. (1998) *HIV / AIDS in South Africa: The Impacts and the Priorities*. Department of Health

Kirk D. (2001) *Risk factors associated with HIV prevalence*. Honours research project, Department of Actuarial Science, University of Cape Town

Lurie M. (2000) Migration and AIDS in southern Africa: a review. *South African Journal of Science*. Vol. 96, 343 – 347

Lurie M., Williams B., Sturm A., Garnett G., Mkaya-Mwamburi D., Abdool Karim S.S. (2000) *HIV discordance among migrant and non-migrant couples in South Africa*. Paper presented at the XIII AIDS Conference, Durban. Quoted in Lurie (2000)

Lurie M., Harrison A., Wilkinson D., Abdool Karim S.S. (1997) Circular migration and sexual networking in rural KwaZulu/Natal: implications for the spread of HIV and other sexually transmitted diseases. *Health Transition Review*. Suppl. 3 to Vol. 7, pp. 15 – 24. Quoted in Lurie (2000).

Maartens G., Wood R., O'Keefe E., Byrne C. (1997) Independent epidemics of heterosexual and homosexual HIV in South Africa – survival differences. *Quarterly Journal of Medicine*. Vol. 90, 449 – 454

Manan S., Campbell J., Sweat M., Gielen A. (2000) The intersection of HIV and violence: directions for future research and interventions. *Social Science and Medicine*. Vol. 50, 459-478

Martin H., Nyange P., Richardson B., Lavreys L., Mandaliya K., Kackson D., Ndinya J., Kreiss J. (1998) Hormonal contraception, sexually transmitted diseases, and the risk of heterosexual transmission of human immunodeficiency virus type 1. *Journal of Infectious Diseases*. Vol. 178, 1053 – 1059. Quoted in Garenne and Lydié (2001)

McAnerney J. (1994) HIV seroprevalence in TB patients. *AIDS Bulletin*. Vol. 3, No. 3, pp. 14 - 15

McIntyre J., Gray G. (2000) Preventing mother-to-child transmission of HIV. *Southern African Journal of HIV Medicine*. Vol. 1, 30 - 31

McIntyre J. (1996) HIV / AIDS in South Africa – a relentless progression? *South African Medical Journal*. Vol. 86, 27 - 28

Ministry for Welfare and Population Development (MWPD). (1998) *White Paper on Population Policy*. Online. Accessed January 2000. Available: http://www.polity.org.za/govdocs/white_papers/popwp.html

Moses S., Bradley J.E., Nagelkerks N.J., Ronald A.R. (1990) Geographical patterns of male circumcision practices in Africa: association with HIV seroprevalence. *International Journal of Epidemiology*. Vol. 19, 693 – 697

Nphlovu L., Harrison A., Ntuli N., Rasego B., Van Dam J., Williams B. (2000) *The evaluation of sexually transmitted diseases (STDs) quality of care in Carletonville, South Africa*. Presented at the 13th International AIDS Conference, Durban 2000.

O'Farrell (2000) Enhanced efficiency of female-to-male HIV transmission in core groups in developing countries. *Sexually Transmitted Diseases*. Vol. 28, 2: 84 – 91. Quoted in Douglas (2001).

O'Farrell N., Hoosen A., Coetzee K., Van den Ende J. (1992) Sexual behaviour in Zulu men and women with genital ulcer disease. *Genitourinary Medicine*. Vol. 68, 245 - 248

Pham-Kanter G., Steinberg M., Ballard R. (1996) Sexually transmitted diseases in South Africa. *Genitourinary Medicine*. Vol. 72, 160 – 171. Quoted in Colvin (2000)

Piot P., Goeman J., Laga M. (1994) *AIDS in Africa* (Chapter 8). Essex M., Mboup S., Kanki P., Kalengayi M. (editors). Raven Press. New York

Ramjee G., Gouws E., Stein Z., Nyembe M. (2000) *HIV prevalence among truck drivers in KwaZulu-Natal, South Africa – implications for the explosive nature of the South African HIV epidemic*. Presented at the 13th International AIDS Conference, Durban 2000.

Rape Crisis Cape Town (RCCT). 2001. *The Rape Crisis Website: Statistics*. Online. Available: www.rapecrisis.org.za/statistics Accessed March 2001

Rees H., Beksinska M., Dickson-Tetteh K., Ballard R., Htun Y. (2000) Commercial sex workers in Johannesburg: risk behaviour and HIV status. *South African Journal of Science*. Vol. 96, 283 – 284

Rehle T., Saidel T., Hassig S., Bouey P., Gaillard E., Sokal D. (1999) *AVERT: a user-friendly model to estimate the impact of HIV/STD prevention interventions on HIV transmission*. Copies of the report may be requested from Dr Thomas Rehle, e-mail: Trehle@fhi.org

Rosen S. (2001) *The impact of HIV/AIDS on business in Southern Africa*. Centre for International Health, Boston University School of Public Health. Presentation

Sandala L., Lurie P., Sunkutu M., Chani E., Hudes E., Hearst N. (1995) 'Dry sex' and HIV infection among women attending a sexually transmitted diseases clinic in Lusaka, Zambia. *AIDS*. Vol. 9 (Suppl 1): S61 – S68

Schneider H., Blaauw D., Dartnall E., Coetzee D., Ballard R. (2001) STD care in the South African private health sector. *South African Medical Journal*. Vol. 91, 151 – 156

Schoub B., Smith A., Lyons S., Johnson S., Martin D., McGillivray G., Padayachee G., Naidoo S., Fisher E., Hurwitz H. (1988) Epidemiological considerations of the present status and future growth of the AIDS epidemic in South Africa. *South African Medical Journal*. Vol. 74, 153 – 157

Seiketto P., Padayachee G., Schoub B., Ballard R., De Beer M. (1993) Knowledge of transmission and prevention of sexually transmitted diseases and AIDS, among STD patients in Johannesburg. *CHASA Journal*. Vol. 4, 80 - 83

Shell R. (2000) *Trojan horses: HIV/AIDS and military bases in Southern Africa*. Unpublished

Sturm A., Wilkinson D., Ndovela N., Bowen S., Connolly C. (1998) Pregnant women as a reservoir of undetected sexually transmitted diseases in rural South

Africa: implications for disease control. *Am. J. Public Health*. Vol. 88, 1243 – 1245. Quoted in Colvin (2000)
Van der Ryst E., Joubert G., Steyn F., Heunis C., Le Roux J., Williamson C. (2001) HIV/AIDS-related knowledge, attitudes and practices among South African military recruits. *South African Medical Journal*. Vol. 91, 587 – 591
Van Niftrik J. (1995) HIV testing for life assurance: pragmatism vs prejudice. *AIDS Analysis Africa (Southern Africa Edition)*. Vol. 5, No. 5
Vundule C., Maforah F., Jewkes R., Jordaan E. (2001) Risk factors for teenage pregnancy among sexually active black adolescents in Cape Town. *South African Medical Journal*. Vol. 91, 73 – 80
Wang C., Reilly M., Kreiss J. (1999) Risk of HIV infection in oral contraceptive pill users: a meta-analysis. *Journal of Acquired Immune Deficiency Syndrome*. Vol. 21(1), 51 – 58. Quoted in Garenne and Lydié (2001)
Wawer M., Serwadda D., Gray R., Sewankambo N., Li C., Nalugoda F., Lutalo T., Konde-Lulu J. (1997) Trends in HIV-1 prevalence may not reflect trends in incidence in mature epidemics: data from the Rakai population-based cohort, Uganda. *AIDS*. Vol. 11, 1023 - 1030
Webb D. (1994(a)) Modelling the emerging geography of HIV. *AIDS Analysis Africa (Southern Africa Edition)*. Vol. 4, No. 4
Webb D. (1994(b)). Mapping the AIDS pandemic: geographical progression of HIV in South Africa 1990 – 93. *Nursing RSA*. Vol. 9, 20 – 21
Wilkinson D. (1999) HIV infection among pregnant women in the South African private medical sector. *AIDS*. Vol. 13, 1783
Wilkinson D., Connolly C., Rotchford K. (1999) Continued explosive rise in HIV prevalence among pregnant women in rural South Africa. *AIDS*. Vol. 13, 740
Wilkinson D., Connolly A., Harrison A., Lurie M., Abdool Karim S. (1997) Sexually transmitted disease syndromes in rural South Africa: results from health facility surveillance. Online. Available: www.mrc.ac.za. Accessed 10 March 2001.
Williams B., Gilgen D., Campbell C., Taljaard D., MacPhail C. (2000) *The natural history of HIV / AIDS in South Africa: A biomedical and social survey in Carletonville*. Council for Scientific and Industrial Research. Johannesburg.
Williams B., Campbell C. (1998) Understanding the Epidemic of HIV in South Africa. *South African Medical Journal*. Vol. 84, 247 – 251
Wood K., Maforah F., Jewkes F. (1998) 'He forced me to love him': putting violence on adolescent sexual health agenda. *Social Science and Medicine*. Vol. 47(2), 233-242
Zaba B. and Gregson S. (1998) Measuring the Impact of HIV on Fertility in Africa. *AIDS.* Vol. 12 (suppl. 1): S41 – S50
Zwi A., Cabral A. (1991) Identifying 'high risk situations' for preventing AIDS. *British Medical Journal*. Vol. 303, 1527 - 1529

Appendix A: Background on logistic regression

Logistic regression is a statistical tool that is frequently used in medical research and epidemiological studies. The following example shows how a logistic regression model is typically formulated.

Suppose that

$$\log\left(\frac{\pi_{ij}(x)}{1-\pi_{ij}(x)}\right) = \alpha + \beta_{i1} + \beta_{j2} + \beta_3 x \qquad (1)$$

where $\pi_{ij}(x)$ is the probability of HIV infection for a randomly sampled individual in age band *i*, in province *j*, with an income of *x*

α is a constant term

β_{i1} represents the effect of the i^{th} age band on HIV prevalence

β_{j2} represents the effect of the j^{th} province on HIV prevalence

β_3 represents the effect of income on HIV prevalence if a simple linear relationship between income and HIV prevalence is assumed.

This is a logistic regression equation. The left-hand side of the equation is known as the (logistic) *link function*, and the right-hand side is referred to as the *linear predictor*. The probability of infection is the *response* and age band, province and income are *explanatory variables*. In this example, age band and province are modelled as *categorical* variables, while income is modelled as a *continuous* variable (i.e. *x* can take on infinitely many values, whereas *i* and *j* correspond to categorical groupings of the age and province variables). The example is one of a *multivariate* analysis, since the effects of more than one explanatory variable are included in the model.

If we believed that age prevalence patterns differed between provinces, we could allow for an *interaction term* in the above equation. The term β_{ij12}, representing the effect of the interaction between the i^{th} age band and the j^{th} province, would be added to the linear predictor. The implication of including such an interaction effect in the model is that the effect of age on HIV prevalence is assumed to depend on the province in which one is situated – and similarly, the effect of province is assumed to depend on one's age.

The parameters included in the above model can be estimated using statistical programmes such as GENSTAT and SAS. The programme we have used in analysing antenatal clinic data for individuals, and in analysing workforce prevalence data, is GENSTAT. Kirk (2001) uses the same programme. Williams *et al* (2000) provide little information regarding the programme or method used in their logistic regression analysis of the Carletonville data.

The method that is most commonly used to quote the results from logistic regression analyses is the *odds ratio*. The *odds* of an event is defined as

$$\frac{p}{1-p}$$

where p is the probability of the event being observed. The odds ratio is thus the ratio of the odds of an event for one group of subjects to the odds of the same event for another group of subjects. In our example, the odds ratio for HIV infection among individuals in the j^{th} province, relative to individuals in the k^{th} province, is simply

$$\exp(\beta_{j2} - \beta_{k2})$$

(This can be shown by algebraic manipulation of equation 1). The odds ratio is usually assessed relative to the *baseline* level of the factor concerned. The baseline level for a given explanatory variable is chosen arbitrarily, and its coefficient is zero (this constraint is imposed to prevent the model from becoming over-parameterized). Thus, in the example above, the odds ratio if the k^{th} province is the baseline province is simply

$$\exp(\beta_{j2})$$

If the odds ratio is substantially greater than one, it indicates that the risk of HIV infection in the j^{th} province is substantially greater than that in the baseline province (province k) – and vice versa if the odds ratio is less than one. If the odds ratio is significantly different from one, it is an indication that there is a statistically significant difference in prevalence levels between provinces j and k.

In many cases odds ratios are tabulated without any explicit reference to the baseline level for the factor concerned. The baseline level can be identified, however, as that level of the factor for which the odds ratio is one (since the ratio of the odds of an event in one group of subjects to the odds of the same event in the same group of subjects is obviously one). There is also no p-value or confidence interval quoted for the baseline level of the factor.

Odds ratios are usually presented in tabular form, with 95% confidence intervals. In this report we have chosen to use p-values instead of confidence intervals. We have in some cases also presented odds ratios graphically, with neither p-values nor confidence intervals. While we acknowledge that this is not standard statistical practice, our aim has been to demonstrate in an easily understandable manner the *interactions* between variables such age and gender, and race and job grade.

The methods used to identify optimal logistic regression models are beyond the scope of this brief description. However, it is worth noting that in analysing the antenatal clinic and workforce prevalence data, we have used a 'stepwise' procedure, and have relied on the likelihood ratio test. Stepwise procedures are generally regarded as inferior to 'all subsets' procedures, because they can produce poor results in the presence of multi-collinearities (Kirk, 2001). This is a flaw in our analysis, but since the models we fitted to antenatal clinic and workforce prevalence data were very close to the full models in both cases, we do not expect there to be any bias in our results. Kirk used an 'all subsets' procedure, which requires the use of the Akaike Information Criterion (AIC). No information was provided on the model selection procedure used by Williams *et al* (2000).

Appendix B: Modelling the provincial epidemics using logistic functions

Logistic functions were fitted to HIV prevalence data from each of the nine provinces between 1990 and 2000. The analysis was also conducted for the country as a whole. This analysis was performed in order to assess, for each province

(a) the asymptotic prevalence level
(b) the intrinsic growth rate
(c) the extent to which the provincial epidemic 'lags' the national epidemic.

A logistic function is of the form

$$f(x) = \frac{a}{b + \exp(-c(x-d))}$$

The parameters can be interpreted in the following way:

- The asymptotic prevalence level is given by a / b.
- The intrinsic growth rate is represented by c. The higher c is, the more rapidly the prevalence rates are tending towards their asymptotic levels.
- d is a 'location parameter'; the higher the value of d, the greater the extent to which the provincial epidemic lags the national epidemic.

The loss function used in the least squares algorithm was of the form:

$$\left(\frac{Observed - predicted}{Observed}\right)^2$$

No attempt was made to weight by the numbers of women sampled, or by the width of the confidence intervals for each prevalence point.

The full model was initially fitted, but it was found to be over-parameterized, with the fitted values of *d* providing very little information. It was therefore decided to fit the model with *b* set at 0.1.

The following asymptotic prevalence levels and intrinsic growth rates were estimated:

Gauteng	27.5%	0.6542
Free State	27.8%	0.6951
Northwest	25.5%	0.7884
Northern Province	13.1%	0.6815
Mpumalanga	31.8%	0.7524
KwaZulu-Natal	35.4%	0.6156
Eastern Cape	23.3%	0.6142
Northern Cape	10.9%	0.9310
Western Cape	8.1%	0.7891
South Africa	25.5%	0.6349

The asymptotic prevalence levels appear to be too low. If they were indeed correct, they would suggest that the epidemic has already peaked in most provinces. Williams and Campbell (1998) experienced the same problem in fitting logistic curves using antenatal clinic data up to 1996 (for example, their fitted plateau prevalence for

KwaZulu-Natal was 23% at that time). This may indicate that the logistic function is an inappropriate function to fit. A particular feature of the logistic function that makes it undesirable is its almost symmetric first derivative; we would prefer the derivative to have a heavier right tail.

The average intrinsic growth rate, 0.725, is slightly greater than that fitted by Williams and Campbell (0.691), but is distorted by the high rates for the Northern Cape, Western Cape, Mpumalanga and Northwest, all of which exhibit unusual prevalence patterns at some point in their history. The provinces that appear to have more 'normal' prevalence histories (e.g. Eastern Cape and KwaZulu-Natal) tend to have lower intrinsic growth rates.

For the purpose of fitting time lags, it is necessary to set the intrinsic growth rate at the same level in all provinces. This would imply the same shape of prevalence curve in all provinces, with differences attributable only to scaling factors and time leads or lags.

The c parameter was therefore set at 0.65 (keeping b fixed at 0.1 as well). The following were the fitted values for d, and the differences between the fitted values for d and the fitted value for the country as a whole.

Gauteng	2.18	0.33
Free State	2.16	0.31
Northwest	3.11	1.26
Northern Province	2.45	0.6
Mpumalanga	3.07	1.22
KwaZulu-Natal	1.15	-0.70
Eastern Cape	2.92	1.07
Northern Cape	4.08	2.23
Western Cape	4.49	2.64
South Africa	1.85	

The lags estimated for Northwest and Mpumalanga appear to be unrealistic. The fit for Mpumalanga is distorted by unusual survey results in 1993 and 1996, and the fit for Northwest is distorted by unusual survey results in 1991 and 1996. However, deleting these unusual results and refitting did not produce significantly different fits (the fitted value for d was then 3.16 for Northwest and 2.88 for Mpumalanga). The reason for the unrealistic lags for Mpumalanga and Northwest is thus unclear.