HIV on the Move: Sex Differences in Patterns of Migration and HIV in South Africa

by

Carol Suzanne Camlin

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Doctoral Committee:

Associate Professor Rachel C. Snow, Chair
Professor James A. Levinsohn
Professor Yu Xie
Assistant Professor Mark B. Padilla

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Abstract

This dissertation advances knowledge of an under-investigated aspect of gender and health: what are women's unique patterns of migration, and how do they contribute to health risks such as HIV/AIDS in southern Africa? Empirical studies of women's migration are few in number, in part due to data limitations and measurement biases; existing datasets typically still reflect only a small part of female mobility. Research on migration and HIV/AIDS has almost exclusively focused on male labor migration, finding migration to be a risk factor for men and their non-migrant partners, yet often failing to measure the HIV risks of migration for women. Bodies of literature on migration in sub-Saharan Africa have largely presumed a stable female-headed household to and from which male migrants circulate. The very manner in which migration is conventionally studied is shaped by the paradigm of male labor migration, and thus it fails to capture the complexity of women's mobility, and women's increasing participation in migration in Africa today.

This dissertation pursues three sets of questions: 1) How extensive is women's participation in migration in southern Africa? Has it increased? What are its characteristics? 2) What are the major causes of migration in southern Africa, and do they differ for men and women? 3) How has migration influenced patterns of HIV/AIDS infection in southern Africa? Does migration present a higher HIV infection risk to

women than to men? If so, why? I pursue these questions with demographic, social and HIV surveillance data collected from some 45,000 adults since 2000 by the Africa Centre for Health and Population Studies, a research center based in rural KwaZulu-Natal.

Findings of this study are that the use of innovative measures erases any assumed predominance of males in migration, and reveals distinct sex differences in migration patterns. Furthermore, all of those who are more mobile are at higher risk of HIV infection relative to their more stable counterparts, not only the non-residents, disproportionately male, who would in conventional approaches be defined as the population's 'labor migrants'. Moreover, migration has a different impact on the risk of HIV for each sex: women's involvement in migration exacerbates their already disproportionate infection risk relative to men. The influence of higher risk sexual behavior on prevalent HIV infection is modified both by sex and by participation in migration, net of the effects of other covariates of infection. Aspects of the migration experience render its 'behavioral consequences' more hazardous for women. This study points to an urgent need for HIV prevention efforts in the population, and highlights the particular vulnerability of migrants, especially female migrants, to HIV/AIDS.

Chapter 4

Gender and the Consequences of Migration for HIV/AIDS in South Africa

Introduction. This chapter presents an analysis of sex differences in the HIV risks associated with migration in the adult population living in a primarily rural area in Umkhanyakude District, KZN, South Africa. This population differs from the one for which findings were presented in Chapters 2 and 3 in a key respect: the time period for eligible household membership is shifted just over two years forward, to 01 June 2003, when the population eligible for the first round of an annual HIV surveillance study of the Africa Centre for Health and Population Studies was established. The population also does not restrict, but includes, individuals who were members of more than one household, in order to maximize the available HIV data. This chapter also differs from the previous two, in that migration events preceding, rather than subsequent to, the household membership eligibility date are measured. While the first round of testing offers only a measure of HIV prevalent infection in the population (and it is impossible to know at what point in time individuals became infected with the virus), all information on the migration patterns, as well as their antecedents, temporally precede the HIV test date. Causality cannot be inferred, but the data will be informative. Further, an analysis of the association between patterns of migration and HIV incidence, using information from those who participated in both of the first two rounds of HIV surveillance, will be carried out to interrogate whether the findings of cross-sectional analyses are confirmed by longitudinal data.

Studies linking migration to HIV in sub-Saharan Africa are numerous, having accumulated since nearly the start of the epidemic in the region. Yet, remarkably few studies have measured the HIV risks associated with migration for women, and fewer still have undertaken any sex comparison in the HIV risks associated with migration. None have done so in a South African population, and none have undertaken a direct statistical comparison of such risks for men and women (involving a pooled analysis of men and women, using interaction terms of the migration event by sex), to my knowledge, in any population in the region. This study will be the first to do so, and also the first to describe patterns of prevalent HIV infection by different types of migration and mobility. Such an analysis is needed in order to more fully understand the ways in which gendered patterns of migration may be contributing the wide sex disparities in HIV prevalence in South Africa, and to consider the HIV/AIDS prevention and care implications of such findings.

Benefits of migration. To balance this analysis of a key negative consequence of migration in southern Africa— HIV/AIDS, and its risk to the migrant and to the 'sending' communities to which he or she returns— I begin with a brief review of what are known to be the benefits of migration for migrants and their families. After all, voluntary migration would not be undertaken in South Africa were it not tied to aspirations and an expectation of improved life conditions. A body of literature on the socio-economic benefits of migration is nearly as large as the literature on migration overall: it is a central theme to the discipline. Nearly every study of the impacts of migration focus on its key role in socio-economic mobility and development (e.g.)(Todaro 1976; Sabor 1979; Stark 1991; Massey, Arango et al. 1998; van der Berg, Burger et al. 2002; Kothari 2003; Zuberi and Sibanda 2004; Massey 2006; Tienda, Findley et al. 2006; Halliday 2007). Fewer studies have documented the socio-economic consequences of specifically *women's* migration in sub-Saharan Africa, but those that have are reviewed here: a highlight in the historical research is Bozzoli's documentation of the multi-generational social mobility that resulted from the migration of a generation of women from Phokeng (Bozzoli 1991). This account describes a multi-generational accumulation of socio-economic advantage for those who undertook a rural-to-urban migration: the children and grandchildren of female migrants in this community took advantage of opportunities for urban settlement, education and occupational mobility that were not available to the descendents of those 'left behind'.

Recent research from demographic surveillance sites in South Africa has also documented the benefits, to households, of sending a female migrant. Households clearly benefit from having any member who is a temporary labor migrant: these households have a higher socio-economic status than those who do not (Collinson, Tollman et al. 2003; Kahn, Collinson et al. 2003). Yet households especially benefit if the migrants is female: they remit more income to households than do male migrants, despite lower likelihood of formal employment (Posel and Casale 2003) and their lower earnings (Collinson, Tollman et al. 2003). Kahn and colleagues found a small protective effect on the health of children in households in which the mother was a migrant worker (Kahn, Collinson et al. 2003), but cautioned that "where social networks through extended family are strong enough to assume these childcare responsibilities, the net effect on children can be positive. Where not, children may experience neglect following migration of their mothers." Indeed, Case, Ardington and colleagues have documented health and education risks to children living apart from their mothers (Collinson, Tollman et al. 2003; Case and Ardington 2004; Case, Hosegood et al. 2005; Ardington, Case et al. 2007).

Kothari has explored the factors that permit people to participation in migration, positing that an individual's level of access to various forms of capital (human, social, political, economic and so on) characterizes the degree to which they are excluded from the migration process (Kothari 2003), and other research tends to confirm that a modicum of resources is required for migration: poverty is a cause of migration, but the poorest households are unable to send a migrant (Collinson, Tollman et al. 2003). At individual level, socio-economic position (measured, e.g., by education level, employment status or income) is associated with the decision to migrate: individuals move to seek employment, escape from poverty and provide financial support to the families they leave behind (Ibid.; (van der Berg, Burger et al. 2002; Posel and Casale 2003). For the most part, migration confers a distinct economic benefit to both female and male migrants and to the households in which they are members.

The HIV/AIDS-related consequences of migration in southern Africa. While the economic benefits of migration in sub-Saharan Africa are clear, the health benefits of voluntary migration in the region are more mixed. Specifically, the role of migration in the spread of infectious disease, and especially HIV/AIDS, is well-researched: urban areas, with social conditions which facilitate high sexual partner change rates and elevated probabilities of transmission, are frequently the reservoirs of HIV infection that then spreads to more remote areas via the corridors of major population movement. Since the early stages of the southern African pandemic, infections in rural areas have been traced to those who had been in urban areas (Jochelson, Mothibeli et al. 1991; Garin, Jeannel et al. 1993; Glynn, Ponnighaus et al. 2001; Coffee, Garnett et al. 2005); infection rates have been higher along roads (Wawer, Serwadda et al. 1991; Barongo, Borgdorff et al. 1992; Tanser, Lesueur et al. 2000); and truckers have been found to be at higher risk because of their greater mobility (Bwayo, Plummer et al. 1994; Mbugua, Muthami et al. 1995; Glynn, Ponnighaus et al. 2001; Ramjee and Gouws a 2002). More recent research has focused on the implications of mobility for the spread of HIV-1 genetic diversity (Perrin, Kaiser et al. 2003).

The bulk of literature on the role of migration in the spread of HIV/AIDS in southern Africa (and in the region overall) has almost exclusively focused on the strikingly high HIV risks to male labor migrants. Numerous studies in the region have found labor migration to be a risk factor for men and their non-migrant female partners (Jochelson, Mothibeli et al. 1991; Nunn, Wagner et al. 1995; Lurie, Harrison et al. 1997; Brockerhoff and Biddlecom 1999; Hope 2000; Hope 2001; Lurie, Williams et al. 2003; Coffee, Garnett et al. 2005; Desmond, Allen et al. 2005; Zuma, Lurie et al. 2005).

In his critique of the public health literature on migration and HIV/AIDS, Hunter (2007) was the first to note that few studies have interrogated the assumption that migration is predominantly circular, or examined the contribution of women's migration to HIV. This literature has presumed a stable female-headed household to and from which male migrants circulate; generally, the mobility of female partners has not been measured, and HIV risks to female partners were presumed to result purely from unprotected sexual contact with the migrant male partner (or another partner). For example, an often-cited study on HIV and migration in South Africa found that migrant men were 2.4 times more likely than non-migrant men to be HIV-infected (Lurie, Williams et al. 2003). In 71.4% of discordant couples in which the male partner was a migrant, the male was the infected partner; but in a full one-third of these couples (29%), the female- whose patterns of mobility were not measured- was the infected partner (Lurie, Williams et al. 2003).

Notable exceptions to the research measuring the HIV risks to men only include an early study by Karim and colleagues (Abdool Karim, Abdool Karim et al. 1992) finding that migration increased infection risk by almost three-fold for women and seven-fold for men in KwaZulu-Natal. Strikingly, after this study in 1990, no other South African study examined the role of migration in HIV infection in women until 2003, when Zuma and colleagues examined migration among women residing near a mining area in South Africa (Zuma, Gouws et al. 2003). This study found a 60% higher odds of HIV infection (OR 1.6) in migrant vs. non-migrant women; migrant women were older, were also more likely to report having had two or more partners in the past year, and were less likely than non-migrant women to have used condoms. This study undertook no sex comparison, but was limited to women.

These studies are joined by three others from the region, which found higher risk behavior and HIV prevalence in mobile compared to women with stable residence in Tanzania (Boerma, Urassa et al. 2002; Kishamawe, Vissers et al. 2006), Senegal (Pison, Le Guenno et al. 1993) and Cameroon (Lydie, Robinson et al. 2004). Some of these studies compared not only stable versus migrant women, but also examined the migration-related risks of HIV for men and women, respectively; migration-related HIV risk appeared to be higher for men (Pison, Le Guenno et al. 1993; Lydie, Robinson et al. 2004), although a statistical test of the sex difference in the migration-attributed HIV risk was not undertaken. In contrast, a study in Tanzania showed that men's mobility had no affect on their risk behavior or HIV status, but those whose female partner was a migrant reported higher risk behavior (Kishamawe, Vissers et al. 2006). No study to date has compared the risks of HIV to migrant men versus migrant women in South Africa.

Such a comparison is important for understanding the role that migration may have played in producing the startlingly disparate levels of HIV prevalence in South African men and women: a recent study from KZN found 27% of adult women versus 13.5% of adult men were HIV-positive (Welz, Hosegood et al. 2007). Because a sex comparison of the HIV risks related to migration has not been undertaken, the full contribution of migration to these large sex differentials in HIV risk is unknown. Further questions remain about the role of gender in the migration processes of men and women which would facilitate the levels of HIV risk to which they are exposed: given that men and women migrate to different types of places, are they therefore exposed to sexual networks with differential levels of HIV prevalence? HIV prevalence varies widely by types of geographic areas even in regions where epidemics are mature (i.e., and HIV/AIDS research has increasingly focused on HIV transmission "hot spots": environments in which levels of HIV prevalence in networks of sexual partnerships are high, increasing the probability of infection within a given sexual act for individuals exposed to those networks (Morris and Kretzschmar 1997; Garnett 2002). As described previously, women are more likely than men to migrate to informal settlements or small towns in predominantly rural areas (Lurie, Harrison et al. 1997; Collinson, Tollman et al. 2003; Hunter 2006). High levels of HIV prevalence have been documented in South African urban mining areas, ports and other large male migrant labor destinations since the early stages of the epidemic (e.g.) (Jochelson, Mothibeli et al. 1991; Williams and Campbell 1998), but more recently, population-based studies in South Africa have found rates of HIV to be almost twice as high in informal settlement areas, compared to urban and rural areas (Shisana and Simbayi 2002; Pettifor, Rees et al. 2004; Shisana, Rehle et al. 2005).[i] This finding is matched in other research in the region showing higher HIV prevalence rates in informal settlement areas, relative to rural or urban areas (Boerma, Urassa et al. 2002; Coffee, Garnett et al. 2005).

Alternatively, are men or women differentially more likely to engage in higher risk sexual behaviors because of migration? Qualitative research illuminates the social reality underlying studies of HIV prevalence in such settings, the common destinations of female migrants in southern Africa: the economic opportunities available in small towns, work sites and informal settlement areas (in contrast to the poverty of surrounding rural areas), are accessed by men primarily through at least sporadic access to formal employment, and by women through offering sex in exchange for money or gifts (Hunter 2002; Desmond, Allen et al. 2005; Hunter 2006), not only by women who identify as commercial sex workers (e.g. see (Campbell 2000)) but by a variety of women (Desmond, Allen et al. 2005). Hunter has highlighted how movement between rural and urban areas can foster a woman having more than one “main” lover; it is these men with whom condoms are the least likely to be used (Hunter 2004). Moreover, in a context of declining marital rates (Hosegood and Preston-Whyte 2002; Posel 2004; Hosegood, McGrath et al. 2008), pre-marital sexual relationships have become characterized by a sex-money exchange, particular among younger sexually-active adults (Hunter 2002; Selikow, Zulu et al. 2002; Posel 2005).[ii]

In summary, remarkably, to date no study has compared the patterns of mobility of South African men and women, nor has any study compared sexual behavior and HIV infection rates of male and female migrants and non-migrants in South Africa, despite very high rates of internal migration and of HIV prevalence in the nation. Research is needed to elucidate the ways in which the gender dynamic of migration affect patterns of HIV/AIDS in South Africa. Can South Africa's explosive HIV/AIDS epidemic be explained by the proliferation of 'high risk environments', characterized by large sexual networks in which HIV is highly prevalent, and transactional sex, which is typified by frequent changes in sexual partnerships and inconsistent condom use? What role does migration play, as a social antecedent to the growth of transmission 'hot spots' and the behavioral risks associated with them? Greater clarity needed on sex differences in the *determinants* of migration and in the *consequences* of migration related to HIV/AIDS. The role of gender in producing these sex differences has yet to be explored. It is hoped that this study will contribute to an improved understanding of the relationship between HIV/AIDS and migration in South Africa, by elucidating the risks that migration poses to men and women, using a full range of measures to ensure that those risks are measured adequately for women, and exploring what may account for those risks.

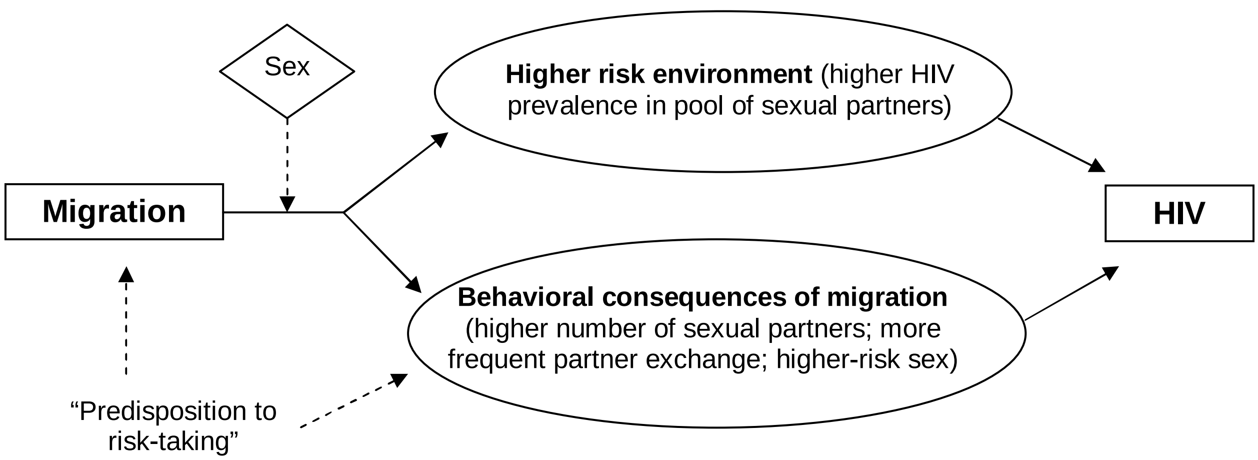
An analysis of the HIV risk associated with migration for women and men in a predominantly rural area of KwaZulu-Natal, South Africa. This study addresses a major gap in the research on HIV and migration. Its are: a) to establish whether gender differences in patterns of migration in South Africa partially account for sex differences in HIV infection rates; and b) to identify the possible causal mechanisms by which migration patterns help to explain women's disproportionately high risk of HIV infection. The analyses are carried out using a set of unique data from a demographic surveillance located in Umkhanyakude District. The setting and data source for this study have been described in the previous chapters and that description is not repeated here. A key contribution of this analysis is that, as in the previous chapters, it uses a range of measures that more thoroughly capture women's patterns of migration and mobility than those typically utilized in studies of migration and HIV/AIDS.

Research questions and hypotheses. The following questions are pursued in this analysis: Does migration increase the odds of HIV infection for men and women equally, net of the effects of other factors that influence risk? Are certain patterns of migration more sensitive than others for the prediction of HIV risk, and do these vary by sex? To what degree are the large sex differentials in HIV risk accounted for by differences in men's and women's patterns of movement? Are there sex differences in the level of HIV risk that migration confers because men and women migrate to different types of places, and are thus exposed to sexual networks with differential levels of HIV prevalence? Alternatively, are men or women differentially more likely to engage in higher risk sexual behaviors because of migration?

The key hypotheses embedded within these questions are displayed in Figure 4.A.

Figure 4.A posits, principally, that migration leads to an increased HIV risk, via two main mechanisms: 1) migrants may have a greater HIV infection risk because the places to which they migrate-- and the sexual networks to which they are exposed-- may be higher in HIV prevalence than the places from which they originated; and 2) the social context of migration, related to social instability, anonymity, and financial hardship, leads to higher risk sexual behavior among migrants than non-migrants. Secondly, sex may modify the relationship between migration and HIV risk: social disadvantages to women may increase their migration-related risk of HIV relative to that of men who migrate. Thirdly, various characteristics of individuals may predispose them both to migrate and to engage in higher risk sexual behavior.

Figure 4.A: Factors that link migration to HIV risk in South Africa



I will first determine whether migration and sex independently predict HIV infection in the population, net of the effects of "risk predisposition" and any other covariates of infection. I then will determine whether sex differences in infection rates can be partially predicted by sex differences in patterns of migration, i.e., whether there is a significant interaction between sex and migration, and migration confers a greater HIV risk to women than to men.

Should this hypothesis be confirmed, I will undertake further analyses to clarify whether sex differences in the migration risk associated with HIV are at least in part due to the sex composition of the population of migrants i.e., 'm*igration results in a higher risk of HIV among women than among men, because there are more females among the migrants*, rather than solely due to true sex differences in the 'effect' of migration; i.e., *'migration confers a greater risk to women than to men'*. (Because 'composition' is not part of the causal pathway, it is not displayed in Figure 4.A.) Descriptive data and findings of logistic regression will be used to address the counterfactual question, what would the prevalence of HIV be in male migrants, if men had the same migration risk as women? I will force an 'equality' of migration effect by assigning women's migration-associated HIV risk (derived from the OR for migration for women) to men's distribution of migrants vs. non-migrants, and generate new, *simulated* HIV prevalence estimates for males.[iii] The same exercise will be carried out for females. The simulated and actual estimates will be compared to determine whether sex differences in migration-associated HIV risks are compositional, or are due *only* to sex differences in the 'effect' of migration.

It is possible that both composition *and* sex differences in the 'effect' of migration could influence sex differences in HIV infection. Thus, regardless of whether or not the 'compositional hypothesis' is rejected, I will proceed with analyses to determine a possible causal mechanism to explain any observed sex difference in the risks associated with migration, i.e., *men's and women's behavioral responses to migration differ: female* *migrants engage in higher risk sexual behavior than male migrants*. Should this hypothesis not be supported, i.e., there are no significant differences in the sexual behavior of male and female migrants, the findings point to the 'higher risk environment' hypothesis: female migrants are more likely than male migrants to migrate to destinations high in HIV prevalence, where they have a higher probability of infection for any given act of unprotected sex. *Migration confers a greater risk to women than to men, because female migrants are exposed to sexual networks higher in HIV prevalence than are male migrants*.[iv] With the available data, I cannot directly test this hypothesis. However, should the third hypothesis be supported (sex and migration interact to predict a higher odds of infection for female migrants), and if neither composition nor behavioral differences can account for the finding, the finding would point to this hypothesis as an explanation that should be pursued in further research. Thus, the research questions and associated hypotheses will be addressed in the following sequence:

1.) Are HIV infection rates higher among females than among males, regardless of migration status? *Hypothesis: The odds of HIV infection are higher among females than males.*

2.) Are HIV infection rates higher among migrants than non-migrants, for both sexes? *Hypothesis: The odds of HIV infection are higher among those who migrate relative to those who do not, net of the effects of sex and other covariates.*

3.) Can sex differences in HIV infection rates be partially explained by sex differences in migration patterns? *Hypothesis: The odds of HIV infection are higher for female migrants than for male migrants (and non-migrants of both sexes).* Should this hypothesis be confirmed, I will examine three possible explanations for the finding:

a) *Composition: the HIV risk associated with migration differs for men and women because women are more likely than men to migrate.* The sex composition of the population of migrants may partially account for any observed sex difference in the 'effect' of migration on the odds of HIV infection.

b) *Heterogeneous behavioral consequences: The behavioral consequences of the decision to migrate vary by sex.* Women who migrate may be more likely than their male counterparts to engage in higher risk sexual behavior. Do sex differences in the sexual risk behavior of migrants and non-migrants 'explain' an interaction between sex and migration in the prediction of HIV risk?

c) *Higher risk environment hypothesis: Migration confers a greater risk to women than to men.* There may be differences in HIV prevalence in the sexual networks women and men are exposed to in the destinations to which they migrate.[v] This hypothesis cannot be directly tested using the data available for this study; yet if hypotheses 3. a) and b) are rejected, findings point to the possibility that HIV risk is greater for female migrants than male migrants (and male and female non-migrants) due to higher prevalence levels in their migration destinations. If warranted, I will examine whether sex, migration and behavior together (in a three-way interaction) predict HIV infection risk. This tests whether, for a given level of sexual risk behavior, such behavior places female migrants at greater risk of HIV than it does for male migrants or non-migrants of either sex. The hypothesis to be tested is that sexual behavior affects HIV risk differently for men and women; and the relationship is further modified by whether an individual is a migrant.

Methods

Dataset development. The first round of an annual HIV surveillance study was carried out in the DSA from 2003 to 2004. An 'eligibility list' was generated using ACDIS data using the date of June 1, 2003; those eligible for participation in the HIV survey were all men aged 15 to 54, and all women aged 15 to 49, who were registered members of households and resident within the surveillance area, and a random sample of 12.5% of registered household members within the age range for each sex who resided outside of the surveillance area, on that day; this was intended to be an open cohort to be re-selected annually. The existing ACDIS database at the time was used as sampling frame, and stratification was carried out by sex and by the place where the non-resident was living (i.e. urban center vs. other rural area).

This analysis uses all current available data for the population, and for the non-resident sample. However, rather than to combine the population and the sample I analyze data for the non-residents separately, and focus these analyses on the population. I do so because the estimates for the population are much more stable, and the population much more representative of the 'true' population, than is the case for the sampled non-residents. To explain further: current ADCIS data show that there were 47,001 individuals who were age-eligible for testing (by sex) and were members of at least one household membership on 01 June 2003. Further examination of the database showed that 545 of these individuals lacked essential 'member status observation' data either before 01 June 2003, or within a year following that date. Because very limited time-relevant data would be available for those individuals, they were dropped from the dataset, yielding a final population of 46,456 individuals. Of these individuals, 30,022 (64.6%) are now classified as having been a resident household member on that date, and 16,434 (35.4%) are now known to have been a non-resident household member on that date. The original 12.5% sample of non-residents resulted in the collection of HIV test data for 2,025 sampled individuals, of whom n=1,808 are retrospectively seen to have been eligible for testing on 01 June 2003; of these 1,808 individuals, 530 (29.3%) participated in testing. Yet updated information reveals that only 1,547 of the 1,808 individuals were actually non-resident at the time (261 were not). Thus, of the 16,434 eligible actual non-residents on that date, only 1,547 (9.4%) were sampled, and only 428 (2.6%) participated in testing.

Thus, rather than to pool data from this very specific sample, with limited representativeness, with data from the overall population (and to use the sample weights associated with sample selection probabilities from that time), I analyze them separately and focus this analysis on the n=44,648 individuals eligible for testing who were not included in the original non-resident sample. For some analyses, I further restrict the data to the population of individuals who were truly resident members of households on that date.

According to records of that time, and as described previously (Welz, Hosegood et al. 2007), 19,867 of all eligible individuals were successfully contacted, and it was previously reported that some 58% of contacted individuals consented to test for HIV (56.4% of males and 59.4% of females). Updated data shown in this chapter suggest that 22,092 individuals were successfully contacted; 12,098 (54.8%) of these individuals participated in testing (and met the criteria for this analysis; some individuals who participated in testing are not included in this analysis as it is retrospectively seen that they were not age-eligible, or were not household members on 01 June 2003.)

A limitation of this study is that the outcome measure, HIV infection, is likely to be subject to selection bias, due to systematic differences between those participated in HIV testing and those who did not. Fortunately, data from ACDIS were available for those who opted out of the HIV test survey, permitting analytical comparisons of the characteristics of 'testers' and 'non-testers' in order to determine, to the extent possible, the direction and strength of the selection bias. I corrected the data for sample selection bias on fifteen observable covariates of testing[v] using Propensity Score weighting. The purpose of generating a propensity score is to determine the propensity of responding (i.e., participating in HIV testing) for all of the members of the population, which is then used as a non-response adjustment weight in the analyses. As described by Little and Rubin (2002), the non-response bias on these observable characteristics can be corrected with use of the *Weighted Complete-Case Analysis*; in which respondents are weighted differentially (on the basis of observable characteristics of non-respondents) to make them more representative of the population. In the method, X_i covariates are observed for both respondents and non-respondents; M is the missing data (participation in testing) indicator (where non-respondent = 0 and respondent = 1). The propensity score specification is estimated using a logit model, i.e.:

$$\ln[\Pr(M = 1) / (1 - \Pr(M = 1))] = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + \ldots \beta_i X_i$$

Where $X_i \ldots$ represents the covariates of testing. The predicted probabilities from this model are the 'propensity scores'. I then weight the respondents by dividing the mean HIV test participation rate by the predictions of the regression, i.e. weight=r(mean tested) / Pr(M = 1). This propensity score weight was then used as a frequency weight when generating percentages of the population by certain characteristics, and was used as a frequency weight when fitting the substantive models shown in this chapter.

The dataset used for this analysis also included information from the second round of a Household Socio-Economic Survey (HSE) of individuals and households, which was carried out in the same time period as the first HIV surveillance study, in 2003 and largely the first half of 2004. Of the 46,456 age-and sex-eligible population, HSE round 2 data are available for 42,570 (91.6%). Missing values for non-participants are coded as such for categorical variables in order to retain as large as possible a population for substantive modeling; where values for continuous variables were missing, the missing value was imputed using the mean value for the non-missing population. The dataset also includes information on partnership status and recent pattern of presence in the household, collected prior to the HIV test visit date or 01 June 2003 with the use of other ACDIS questionnaires.

Finally, the dataset uses information on sexual behavior, collected in the same round as the HIV test data, for men and women using the Men's and Women's General Health Forms (MGH and WGH). Participation rates in the first MGH and WGH were low, particularly among men: of the 21,619 age- and membership-eligible males (in the population, not the non-resident sample), only 5,901 (27.3%) participated in the questionnaire; of the corresponding 23,029 females, 11,293 (49%) participated. Moreover, individual item non-response is moderately high for some items (particularly the sensitive sexual behavior measures.) Missing data were coded as such for categorical variables; for continuous variables, missing data were conservatively imputed with appropriate mean values.

Data collection. The Africa Centre's initial data collection in 2000 established the foundation for a longitudinal surveillance system. Routine data collection includes descriptive characteristics of homesteads and households, demographic data on all individuals and detailed reproductive histories for all women aged 15 to 49. Almost annually (in 2001, 2003, 2004 and 2005), the DSS collected data on measures of socioeconomic position of individuals and households (e.g. education, employment, household income and assets), housing and health-care use. During 6-monthly update rounds, data are updated and births, deaths and migrations (both within ACDIS and outside) are recorded.

HIV surveillance. A population-based serological survey for HIV, to be performed annually, was established in 2003 as an additional component of data collection. Every resident adult member of ACDIS is asked to consent to an HIV-test once every year during a data collection round. HIV testing (ELISA) uses the fingerprick dried blood spot method.[vi] The first round of HIV data were collected between June 2003 and December 2004 for all eligible residents. As previously noted, all females aged 15 to 49 years and all males aged 15 to 54 years resident in ACDIS are eligible for HIV-testing; men were included up to age 54 since the age at infection and age at onset of AIDS is typically 5 to 10 years later in men than in women.

Behavioral surveillance. The collection of data on sexual behavior in the MGH and WGH paralleled the surveillance design: since June 2003, behavioral data are collected annually among all eligible residents and in the random, stratified sample of

12.5% of non-residents. The Centre adopted two methods for the collection sexual behavior data: 1) a standard face-to-face interview format; and 2) a “voting box” methodology to reduce the social desirability bias associated with the collection of sensitive data. The two methods were implemented in order to be able to determine what approach is most useful for obtaining valid data on sexual behavior in subsequent annual data collection rounds.

Secret voting methodology. Previous research had shown that data collection methods that combine face-to-face interview with confidential self-completion methods can reduce social desirability bias in surveys of sexual behavior and provide more reliable data on the behavioral determinants of the spread of STIs than other methods (Gregson *et al.*, 2002b). This bias can occur when data are sought on attitudes or experiences that conflict with dominant local social norms: respondents may tend to provide a socially desirable response based on their perceptions of the views of the person(s) conducting the interview. The Africa Centre adapted for its use a methodology which proved acceptable to a rural, basic-literate population in an area of high HIV prevalence.[vii] This methodology combined the guidance of an interviewer to build rapport and motivation and to clarify questions, and respondent self-completion of an answer sheet to guarantee privacy of his or her responses to sensitive questions. In this method, the interviewer reads aloud the questionnaires item, one at a time, and the respondent marks his or her answers in the appropriate box on an answer sheet. Voting boxes have lids that respondents can use as screens to conceal what they write, and are pre-locked with keys held by supervisors. After completing the answer sheet, respondents are instructed to place it into the box. Responses to sensitive questions are not spoken aloud, and information provided is kept secret from interviewers. I evaluated whether there was a statistically significant difference in the responses provided in the context of the two data collection methods in men, women, and the total population, respectively, to determine whether a 'method' variable should be included when fitting substantive models for these analyses. No differences were detected; therefore such a variable was not included.

Variables. As in the previous chapters, several measures of migration and mobility were used for these analyses, but in this chapter the measures are retrospective, valid for the period between the start of the DSS in 2000 until 01 June 2003, the 'eligibility' date for HIV testing. I constructed several dichotomous measures: a measure of any individual or household migration of any type since the start of the DSS (vs. none); any individual in-migration (vs. none) since the start; any individual internal migration (vs. none) since the start; and any individual out-migration (vs. none) since the start. I also constructed more recent versions of these variables, valid for the period of two years prior to 01 June 2003. I also examine the number of migrations by type for the period, and use a summary categorical measure of none, 1 and 2 or more migrations since the start and in the prior two years.

A sensitivity analysis was carried out for the measures of sexual behavior from the MGH and WGH (only those in common for both men and women, so that pooled analyses could be carried out). The variables most predictive of HIV infection were: the reported numbers of partners in the lifetime, past year and concurrently; ever use of a condom; perceived personal risk of HIV infection in the past or present; and previously received counseling and testing for HIV. These were selected for use in further modeling.

As described in Chapter 3, there are systematic differences between the group of individuals who decide to migrate, and those who do not. In Chapter 3, I explored these factors as explanatory variables in migration decision models. In this Chapter, these are treated as 'control' variables, as I am primarily concerned with the direct effect of migration on HIV status, and whether this differs for men and women.

The factors predictive of migration may in turn influence whether or not individuals engage in the higher risk sexual behavior associated with HIV infection. In Figure 4.1, I have termed this set of characteristics "predisposition to risk behavior" for the sake of brevity. On the basis of prior research, and also on the data available to this study, I will test the hypothesis that "risk predisposition" (or, the likelihood of both migrating and being vulnerable to higher risk sexual behaviors) can be predicted by age, employment status, education level, marital/partnership status, and measures of household socio-economic status (infrastructural variables and tertiles of the number of household assets). I also include a measure of whether the individual experienced the loss of another adult in his or her household to AIDS or another cause in the period between the start of the DSS and 01 June 2003. This factor may both predispose an individual to migrate, but also, in the case of AIDS deaths in the household, may be a marker of a greater likelihood of HIV infection in the index individual. (I also include here a measure of whether the individual died between 01 June 2003 and 01 January 2007; of the independent variables used in modeling for this chapter, this variable alone measures an event which occurs – potentially– after the HIV test; in all other cases, independent variables are valid for the period prior to the test.) Having already determined, in the previous chapter, that these factors are associated with the decision to migrate, I confirm these findings in the HIV surveillance-eligible population; any covariates will be included as control variables in the full substantive models described in the next section.

Statistical analysis procedures. Following descriptive analyses, logistic regression modeling will be carried out using a dichotomous measure of HIV infection status (0= HIV-negative and 1= HIV-seropositive test result) as dependent variable in all models. I begin with additive effects models, to examine the independent effects of sex and migration on HIV infection risk, net of the effects of other covariates. I use three models to test the hypothesis that migration increases HIV infection risk, the first using a global measure of migration, the second using a measure of recent mobility, and the third using a measure of migration frequency. I then carry out three multiplicative effects models to explore whether the risk of HIV associated with migration varies by sex, using an interaction term of sex*migration type for each of the three migration variables.

Secondly, I introduce measures of sexual behavior to in a set of models, to test whether they independently predict HIV infection, net of the effects of migration and other covariates. I also explore whether sexual behavioral risk interacts with sex to predict HIV infection, fitting the model with a sex*behavioral risk interaction term. If warranted, I explore any potential three-way interaction between sex, migration, and behavioral risk, to test the hypothesis that women who engage in higher risk behavior and who migrate have the greatest odds of HIV infection, relative to male migrants and non-migrants, and female non-migrants.

For two-tailed tests of the null hypothesis that odds ratio = 1, logistic regression models are used to predict the odds of HIV infection for each group of independent variables. The model is expressed as:

$$\text{Logit} = \log[p_i/1-p_i] = x_i'b$$

$$\text{where } xi'b = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_i x_{i\ldots}$$

denoting the (K+1) x 1 vector of regression coefficients to be estimated (Powers and Xie 2000). Table 1 in this chapter shows the unadjusted odds ratios from univariate logistic regression models of each of the independent variables on each of the dependent variables, with age added as an additional control variable. The selection of final variables for multiple logistic regression models was informed by both the hypotheses and by the level of significance of the associations seen in the univariate models. In some cases, therefore, variables were included in the multiple logistic regression models because of their hypothesized importance on the basis of the prior research, even though their bivariate associations with HIV infection in this analysis were non-significant.

Equations involving interaction terms follow the same logic of expression; for example, a test of the hypothesis that sex interacts with migrant status to predict the odds of HIV infection, controlling for age, is expressed as:

$$\text{Logit} = \log[p_i/1-p_i] = x_i'b$$

$$\text{where } xi'b = \beta_0 + \beta_1 x_1 \; (\beta_2 x_2 \; x \; \beta_3 x_3)$$

with $x_2 \; x \; x_3$ representing the interaction of sex (with female coded as "1") with migrant vs. non-migrant status, and x_1 again denoting the variable for age.

Results. ***Description of the population, and characteristics associated with HIV prevalence.*** Figures 4.1 and 4.2 graphically display the levels of HIV prevalence by age group and sex in the population and the non-resident sample, respectively. As described previously (Welz et al., 2007), recent HIV prevalence in the population is among the highest reported. Overall, in 2003-04, HIV prevalence was 14% among male residents (0.13-0.15, 95% CI) and 28% (0.27-0.29, 95% CI) in their female counterparts. Prevalence peaked at 45% among resident men in the age group 30 to 34, and at 52% among resident women in the age group 25 to 29. Levels of HIV prevalence were yet higher in the sample of non-resident household members, particularly women; yet as shown these estimates are less precise due to the small number of non-residents sampled who also participated in HIV testing (n=530). Overall, prevalence was 36% in non-resident men (0.29-0.43, 95% CI) and 41% in non-resident women (0.34-0.48, 95% CI). Prevalence in non-resident men reached a plateau of 46 to 47% at ages 25 through 34, and peaked at 55% in the oldest age group. In non-resident women, prevalence reached at an extraordinarily high peak of 66% in women ages 25 to 29.

Tables 4.1 and 4.2 shows key characteristics of the population of 12,098 eligible individuals who participated in HIV testing and were *not* part of the non-resident sample. Of these individuals, 11,779 were retrospectively seen, with updated data, to have been residents on 01 June 2003. However, 418 of these individuals were seen retrospectively to have been non-residents on that date, and participated in testing though they were not included in the non-resident sample.

Table 4.1 shows the distribution of migration and mobility patterns and their associations with HIV-infection status in the (non-sampled) populations of men and women, respectively. Unweighted frequencies, weighted row percentages and the findings of simple logistic regression models of the age-adjusted odds of HIV infection risk are shown for each category of migration in men and women. As shown, levels of HIV infection overall are higher among women than among men, and in each migration category, HIV prevalence is higher among those more mobile compared to those more residentially stable. In men, 24.5% of those who ever migrated vs. 18.4% who maintained a stable residence since the start of the DSS were HIV-positive, while in women, 42% of migrants vs. 28.7% of non-migrants were HIV-positive. Men who migrated had 77% higher odds, and women almost double the odds of HIV infection (OR=1.90) compared to their counterparts who did not. Of the patterns of migration since 2000, HIV prevalence was highest among those who had migrated out of the area at least once: 31.1% of men and 48.5% of women who out-migrated (vs. 19.2% of men and 32.2% of women who did not) were HIV-positive. The number of migrations sine 2000 had a clear positive, dose-response relationship with HIV infection risk for women, but not for men: in men, the highest level of infection was seen in men who had migrated once (25.4%, OR=1.90 relative to non-migrants) while in women it was seen in those who had migrated two or more times (45.3%; OR= 2.08 relative to non-migrants.) Table 4.1 also shows a measure of distinct, mutually exclusive migration flows, confirming that out-migration only, leading to non-resident membership in the household, presented the highest level of risk for men (37.2%, OR=3.64) and women (52.8%; OR=2.83), followed by out-migration and in-migration (a flow in either direction). Finally, as suggested by the analyses of prevalence data for non-residents shown in Figure 4.2, non-resident status strongly predicted HIV infection in this population. Male and female non-residents had an approximately 60% higher odds of HIV infection relative to their counterparts who were resident members of households.

The second page of Table 4.1 shows measures of migration and mobility in the more recent past, including migrations in the two years prior to June 2003, and presence in the household in the six months prior to the most recent visit. The more recent measures captured similar levels of infection risk compared to the longer-term measures of migration. Importantly, a measure of short-term mobility, the pattern of absence from the household in the past 6 months, shows a clear, positive, dose-response relationship to prevalent HIV infection: those who had spent few or no nights in the home in the DSA had the highest level of infection (44% and OR=3.64 in men, and 47.3% and OR=2.41 in women, relative to those who had been home every night).

Table 4.2 shows other socio-economic and behavioral characteristics among men and women, respectively, and their associations with prevalent HIV infection in the populations. As shown, the HIV/AIDS epidemic has hit young adults particularly hard: a full 40.7% of men and 52.2% of women aged 25 to 34 were found to be HIV-positive. While the odds of infection rise most dramatically for males by ten-year age increment (with a nine-fold increase for those in the 25 to 34 age group compared to the youngest one), this belies a startling sex disparity in risk in those aged 15 to 24: 6.8% of young men versus a full 26.2% of young women were HIV-positive. Those with a current non-marital partner were also at highest risk of infection: while overall levels of infection were higher for women (45.1%) than men (35.3%) in this category, the odds of infection were higher for men (OR=6.67) than they were for women (OR=3.81) relative to their respective married counterparts. Employment was not associated with HIV infection for men, but conferred a 26% higher HIV infection risk for women, but education level was not associated with risk for either women or men, other than the decreased risk of infection among full-time students relative to those with little or no education.

Continuing to household infrastructure measures, higher levels of prevalent HIV were seen in those with access to better infrastructure, a marker of urbanity and proximity to major corridors of transportation. Relative to their counterparts whose homes were not connected to grid or generator electricity, men had 80% higher odds of HIV and women had 60% higher odds of infection. For women but not men, access to piped water and to a flush or chemical toilet also was associated with heightened HIV risk relative to those without such infrastructure. Among men who later died before January 2007, 72.4% had been HIV-positive, and among women that figure was 86.9%, reflected women's higher overall level of prevalence. For women but not men, having mourned the loss of another adult member of the household to AIDS was significantly associated with an elevated HIV risk (OR=1.41).

Finally, sexual behaviors by HIV infection status are shown for the populations of men and women. As shown, ever having used a condom was a marker of HIV infection risk not in men, but in women. But feeling that one was at risk of HIV in the past or at present was predictive of HIV infection for both men (OR= 3.18) and women (OR=1.56). Having previously received voluntary counseling and testing for HIV also predicted elevated risk for women (who typically receive it in the context of prenatal visits) but not men. Overall, 11.3% of men and 18.9% of women had obtained HIV-VCT prior to the HIV surveillance visit (not shown). In both men and women, those who were HIV-positive reported a statistically significantly higher number of sexual partners than those who were HIV-negative, yet the incremental increase in numbers of partners conferred a particularly heightened risk for women. Each additional lifetime partner increased the age-adjusted odds of infection by 3% for men and 87% for women; for past year partners the age-adjusted odds increased by 19% for men and 2.5 times for women. Each additional current partner increased the odds of infection by 30% for men and doubled the odds of HIV infection for women.

Table 4.3 provides a summary of the characteristics of the population of sampled non-residents who participated in HIV testing. Small numbers in many of the categories for the characteristics render some estimates less stable and hamper our ability to discern associations with HIV infection. Yet the table renders an impression of the characteristics associated with HIV for the non-resident population. In review, levels of HIV prevalence among non-residents were higher than among residents, across sex and age groupings; as shown in Table 4.3, additional mobility among the non-residents conferred no heightening of their already high levels of HIV prevalence. As described in the previous chapter, non-residents tend to be younger, and were less likely to be married and more likely to be employed; yet with the exception of age grouping, an association between these characteristics (and others not shown here) and HIV infection was not detected. A significantly higher mean number of sexual partners over the lifetime, in the past year, and concurrently, was seen in HIV-positive compared to HIV-negative resident women, but not men. The higher risk sexual behavior reported by HIV-positive non-residents finds a parallel in the higher risk behaviors reported by migrants of both sexes (relative to non-migrants), detailed in Table 4.4.

Table 4.4 returns to the non-sampled population of individuals who were eligible for HIV testing on 01 June 2003 (n=46,456), and uses no HIV test data, but rather describes the reported sexual behavior of migrants and non-migrants within the eligible population. For this table, migration was defined as having migrated at least once (in-, out- or internally) since the start of the DSS. Data are shown for the 5,901 men and 11,293 women who participated in the first round of sexual behavior surveys which were conducted at approximately the same time period as the first round of HIV surveillance. T-tests of the differences in mean numbers reported by migrants and non-migrants were carried out in men and women, respectively, assuming unequal variances and a 95% confidence level; chi-square tests were used to test group differences in the categorical variables. As shown, and confirming prior research, men overall reported higher numbers of sexual partners than did women; they were more likely to have ever used a condom; and they were less likely to have ever received voluntary testing and counseling for HIV (HIV-VCT). Among both men and women, migrants reported a significantly higher mean number of lifetime, past year and current partners compared to non-migrants. These findings are graphically displayed as well, in Figure 4.3. Migrants of both sexes were more likely than their non-migrant counterparts to have ever used a condom, to feel that they were at risk of HIV in the past or at present, and to have previously obtained HIV-VCT.

Multiple logistic regression models of HIV infection risk. The remaining tables show the results of a set of multiple logistic regression models carried out to test the study's hypotheses. The models were conducted using data for the non-sampled population who participated in testing (n=12,098), and to enhance the likelihood of detecting clear differences between migrant and non-migrant groups, the data are further restricted to the n=11,677 individuals who are known to have been resident members of households on the eligibility date.

Table 4.5 shows the findings of additive effects models of the HIV infection risk associated with sex and migration, independently and net of the effects of covariates which may mark a "predisposition" to HIV infection as well as to migration (note that the same set of covariates is used in all of the multiple logistic regression models). On the basis of the findings of the logistic regression modeling shown in Table 4.1, I selected three variables for migration and mobility, in sequence, to examine whether observed associations with prevalent HIV infection vary by the way in which migration and mobility are measured, and whether certain measures are more sensitive for detection of an association with HIV. These are: A) a dichotomous measure of at least one vs. no migration in the past two years, B) a continuous variable for the frequency of migration in the past two years (i.e. the sum of migrations), and C) a four-category measure of the degree of absence from the home in the past six months. Model A shows that, net of the effects of all covariates, those who had migrated at least once in the past two years had a 28% higher odds of HIV infection relative to those with a stable residence in the past two years. Model B shows that independent of all other effects, each step increase in the number of migrations in the past two years conferred a 24% higher odds of HIV infection. Model C demonstrates that one's degree of absence from the household in the DSA in the past six months was positively associated with HIV infection risk. Relative to those who spent every night at home in the past six months, those present most nights had a 18% higher odds, and those who spent approximately half or fewer of the nights at home had a 53% higher odds of being HIV-positive (OR=1.53).

The odds ratios for the covariates in models A through C did not differ markedly across the models. Across all models, women had almost double the odds of HIV infection relative to men, net of the effects of migration and the other independent variables (OR=1.97 and 1.96 for models A-C). For the sake of parsimony I summarize here the remaining key findings for model A: the odds of infection were highest in age group 25 to 34 (OR=2.73), relative to the youngest age group; odds of infection peaked in that 10-year group and declined with age thereafter. Across all models, those who achieved Matric or higher level of education had 25% lower odds of infection and those who were current students, 60% lower odds, relative to those with five or fewer years of formal education.

Those with a source of earned income had a 15% higher odds of infection compared to those with no earned income source. Of the household infrastructure variables shown in Table 4.1, only having access to grid or generator electricity was selected for inclusion in the multivariate models, as electricity, piped water and toilet access were highly inter-correlated, and electricity was most sensitive for the prediction of HIV prevalence. Relative to those without an electricity source, those with household electricity had a 54% higher odds of being HIV-positive. As suggested in the descriptive analyses, being married was quite protective against HIV infection: relative to those with a current marital partner, those with no partner had 63% higher odds (OR=1.63) and those with a non-marital partner (whether regular or casual) had almost three times the odds of HIV infection (OR=2.91). In the multivariate models, having mourned the death of another adult household member to AIDS prior to June 2003 was not associated with one's own odds of infection, and this variable is not included in the multivariate models..

In summary, the analyses thus far confirmed the first two hypotheses to be tested in this study: the odds of HIV infection are higher among women than among men, net of the effects of all observable factors that predict infection in this population; and the odds of HIV infection are higher among those who migrate relative to those who do not, net of the effects of sex and other covariates. The next step in this analysis was to determine whether sex differences in HIV infection rates can be partially explained by sex differences in migration patterns. To test the third hypothesis, that the odds of HIV infection are higher for female migrants than for male migrants (and non-migrants of both sexes), I repeated the logistic regression models A through C shown in Table 4.5, but added an interaction term of sex *x* migration to each of the three models. The sex* migration interaction term was significant for measures of migration in the past two years and frequency of migration in the same period, and not significant for the measure of mobility in the past six months. For the sake of parsimony I selected the dichotomous recent migration measure for model 2), shown in Table 4.6, which tested the interaction of sex by migration in predicting HIV infection risk.

Test of the migration x sex interaction for the prediction of HIV infection. In Table 4.6, I show findings of the multiplicative effects model. This was carried out using the 'xi' command in Stata and dummy coding ('i.*migration**i.*sex*') which automatically drops the main effects of sex and migration in the model, and compares multiplicative effects of migration*sex on HIV to the omitted category of male non-migrants. As displayed in the table, a key hypothesis of this study— that migration confers a higher risk of HIV infection for women than it does for men— was confirmed. For men, having migrated at least once in the past two years was not significantly associated with HIV infection. Yet female non-migrants had a 72% higher odds of infection compared to male non-migrants, and female migrants had more than double the odds of HIV infection (OR=2.56) compared to male non-migrants. In sum, sex does modify the effect of migration on HIV infection risk: women's involvement in migration exacerbates their disproportionate HIV infection risk relative to men. The effects of the other covariates on HIV remained stable in this model and were quite similar those seen in Table 4.5.

Given that this key hypothesis was confirmed, I proceeded with an analysis to ascertain whether the sex composition of 'recent migrants' could account for the effect seen in Model 2; i.e., I test hypothesis 3.a) *Composition: the HIV risk associated with migration differs for men and women because women are more likely than men to migrate.* I produced a simulated HIV prevalence level for male recent migrants and compared it to the observed prevalence. I forced an 'equality' of migration effect on the distribution of male migrants vs. non-migrants using women's migration-associated HIV risk (derived from the OR for women). This exercise is shown in Table 4.7. Were the simulated and actual prevalence levels similar, we would conclude that the finding shown in Model 2 is at least in part due to the sex composition of the population of recent migrants. However, as shown, they were quite different: were men to have the same migration 'effect' as women, the HIV prevalence among male migrants would be 32.8% rather than the 19.8% observed. The population of recent migrants and of recent non-migrants is approximately 40% male, and sex composition cannot account for the finding that recent migration presents a greater odds of infection for women than men.

Therefore I proceed with testing hypothesis 3.b), t*he behavioral consequences of the decision to migrate vary by sex.* Note that in Table 4.4 (and Figure 4.3), the sexual behavior of migrants and non-migrants were compared for the total population and in the sub-populations of men and women; t-tests and chi-squared tests were used to test the hypothesis that differences between migrants and non-migrants were not equal to null. In the pooled analyses and in women and men, migrants reported higher risk behaviors than non-migrants. But a statistical sex comparison was not undertaken at that stage. It was apparent that men, whether migrant or non-migrant, still reported higher risk sexual behavior than women: they had a higher mean number of lifetime, past year and concurrent partners. To confirm the apparent finding that male migrants and non-migrants report higher risk behavior than female migrants and non-migrants, I carried out t-tests of sex differences in the numbers of partners reported, within the sub-populations of migrants and non-migrants, respectively. Within both migration categories, men reported significantly higher risk behavior (these findings are not shown.) In sum, hypothesis 3.b) was not supported by the findings: female migrants do not report higher risk behavior than do male migrants (although they certainly reported higher risk behavior than female non-migrants.) The possibility remained, however, that a given level of sexual risk behavior could pose a greater hazard of HIV infection to female migrants than to male migrants (or non-migrants of either sex), if hypotheses 3.c) were true, that female migrants travel to higher prevalence destinations and are exposed to higher-risk sexual networks than are male migrants, or if some other unmeasured aspect of the migration experience rendered its 'behavioral consequences' more hazardous for women. Thus I undertook further modeling to explore the role of sexual behavior in distinguishing the HIV risks of male and female migrants and non-migrants.

Shown in Table 4.8 are the findings of an additive effects and a multiplicative model, incorporating measures of sexual risk behavior for the prediction of HIV infection risk. Model 3 tests the hypothesis that migration, sex and higher risk sexual behavior independently predict HIV infection. This model was carried out essentially to establish whether measures of higher risk sexual behavior are sensitive for the prediction of HIV infection risk, net of the effects of migration, sex and all other covariates; if they were not, further modeling of interactions would not have been warranted. For the models in Table 4.8, I selected the measure of at least one versus no migrations in the past two years prior to the HIV test, and include a measure of perceived risk of HIV in the past or at present. (Measures of condom use and of previous HIV-VCT were inter-correlated and poorly predictive of HIV infection in multivariate models, and therefore were not included.) In Model 3, I include measures of the reported number of sexual partners over the lifetime and in the past year as independent variables. As shown, women had 2.6 times the odds of men, and those who had migrated in the past two years had a 25% higher odds of being HIV-infected. Each additional lifetime partner conferred a 3% increase, and each additional past year partner an 11% increase in the odds of infection, net of the effects of all other predictors. Perceived risk of HIV was associated with actual risk: those who felt they may have been exposed to the virus indeed had a 36% higher odds of being HIV-positive.

Next, I tested, but did not show here, the additive (independent) effect of high risk sexual behavior, with the interaction of sex and migration. This was necessary to determine whether the interaction between migration and sex was partly explained by behavioral risk differences. If when behavioral risk terms were added (to model 2), the interaction term (migration *x* sex) were to lose significance, then we may conclude that this was likely. The interaction term did not, however, lose significance. Thus I fitted

Model 4, which tested the three-way interaction of sex, migration and behavioral risk for the prediction of HIV prevalence. This model tests the hypothesis that migration pattern and sexual behavior are inter-related in the prediction of differential levels of HIV risk for men and women. I selected the reported number of sexual partners over the lifetime as the behavioral risk indicator, though when the same model was carried out using the reported number of partners in the past year, results were similar. The three-way interaction was carried out using the 'xi3' command in Stata, which permits three-way interactions for any combination of continuous and categorical variables. I used, again, dummy coding with the 'i' prefix ('i.*migration**i.*sex***lifetime partners*'), which automatically dropped the main effects of sex, migration and the number of partners from the model, and compares the effect (on HIV risk) of the lifetime number of partners for each migration-by-sex category to the omitted category of male non-migrants. Odds ratios for the interaction term components were constructed from logit model coefficients (the procedure is elaborated in this note.[viii])

As shown, for male non-migrants, each additional lifetime partner conferred a 4% increase in the odds of HIV infection; for male migrants, each additional lifetime number of partners was not significantly associated with HIV infection. In other words, there was no difference between male migrants and non-migrants in the effect that an additional partner had on their risk of HIV infection. For female non-migrants, each additional lifetime partner conferred a 24% increase in the odds of infection, while for female migrants each additional partner increased the odds of infection by almost 50% (OR=1.49). The p-value for the interaction term coefficient in the logit specification of the model was 0.022, warranting confidence in the findings and their display here. The finding suggests that the influence of higher risk sexual behavior (as measured here by the reported number of partners over the lifetime) on prevalent HIV infection is modified both by sex and by participation in migration, net of the effects of other factors that predict infection.

Finally, I also examined the interaction between sexual risk behavior and migration for the prediction of HIV infection risk in women alone. In contrast to the full models discussed above, in this model the reference category would be female non-migrants, and the interaction term effect represented the HIV risk associated with each additional partner for female migrants. This was to rule out the possibility that women's biological vulnerability alone could account for female migrants' greater risk of HIV infection relative to male non-migrants. The interaction term was marginally significant ($p = .06$), providing additional support for the notion that higher risk sexual behavior poses a greater risk to women in the context of migration than apart from it.

In summary, the findings support a key hypothesis of this study that the behavioral consequences of migration, for HIV risk, are disadvantageous to women. However, this is not due to any greater risk behavior on the part of female migrants relative to their male counterparts; rather, higher risk behavior *in combination with* migration places women at higher risk than men of acquiring HIV. Among both migrants and non-migrants, if risk behavior is held constant, women are at greater risk of acquiring HIV infection than are than men subjected to the same level of 'exposure'. This is not surprising given the greater transmissibility of the virus from male to female bodies. Previous analyses in this chapter showed that sexual risk behavior strongly predicted HIV infection risk for men and women, and that migrants of both sexes engaged in higher risk behavior than non-migrants. The hypothesis that migration is associated with higher risk sexual behavior was supported; although the hypothesis that female migrants engage in riskier sex than male migrants was not. The findings in Model 4, however, further extend our understanding of the role of sexual behavior in producing higher infection rates in female than in male migrants: for a given level of risk behavior, female migrants are at a higher risk than female non-migrants, as well as male migrants and non-migrants.

Analysis of the migration patterns associated with incidence. A limitation of this study was that although the independent variables used in its substantive models are valid for the time period preceding the HIV test date, the study is cross-sectional and uses prevalent HIV infection as the dependent variable. In other words, although the data were constructed to maximize the likelihood of achieving temporal consistency, is not possible to know whether the independent variables, chiefly migration, preceded infection. A full study of the patterns of migration associated with HIV incidence is underway, and cannot be undertaken here. However, a simple analysis to compare the migration patterns of those who did and did not HIV sero-convert between the first and the second rounds of HIV surveillance was possible, and the findings of this confirmatory analysis are shown in Tables 4.9 and 4.10. There were 4,155 individuals who were members of households in the DSA on 01 June 2003 and eligible for testing on that date, and who tested HIV-negative in the first round of surveillance, and who also participated in the second round of surveillance. Of these individuals, 192 HIV sero-converted, corresponding to an incidence of 4.6% for the period between rounds. The incidence rate for men was 3.5% and for women, 5.8%. Table 4.9 shows the distribution of patterns of migration which occurred after the first HIV test date and before the second HIV test date for the total population and for men and women, respectively, by sero-conversion group. As shown, any migration, and the sum of migrations, was significantly associated with HIV sero-conversion between rounds in the total population, but this was due to the importance of migration for predicting incidence in women. The highest HIV incidence estimate, at 13.2%, is observed in women who had migrated at least once between the two rounds of HIV surveillance. Estimates of the association between incidence and the number of migrations using the pooled data were suggestive of a positive dose-response relationship.

Table 4.10 shows the findings of a multiple logistic regression model of the factors associated with HIV incidence. As the model uses unweighted data and few independent variables as controls, the findings should be interpreted with caution. However, the main findings of the cross-sectional analyses, that migration was strongly associated with HIV prevalence, are mirrored here. Net of the effects of other covariates, having migrated within the period resulted in 2.5 times the odds of sero-converting, relative to not having done so; those who migrated once had 2.4 the odds, and those who migrated two or more times had nearly triple the odds of sero-converting (OR=2.87) relative to those who were residentially stable. A test of an interaction between migration and sex for the prediction of incidence yielded an insignificant interaction term; possibly the number of sero-converters within each sub-population were too small to detect sex differences in the effect of migration on HIV incidence. This test should be repeated using pooled incidence data from several rounds of surveillance, with a full set of control variables, and with an adjustment for selection bias in testing, before one can state definitive conclusions regarding the role of migration in HIV incidence in men and women in this population.

Discussion. This study has addressed a large gap in the research on migration, gender and HIV/AIDS in southern Africa. The findings of this research underscore that women in the region are not the static, passive recipients of HIV infection from male migrants. As shown in previous chapters, women are participating fully in migration processes in the region, and this chapter shows that, unfortunately, they are also fully experiencing the burden of HIV/AIDS which migration so often confers. Migration appears to enhance women's already high risk of infection, and the sex comparisons undertaken in this chapter suggest that the circumstances surrounding migration present a higher HIV risk to women than to men.

The key findings of the study were that migration confers a higher risk to women than it does to men, and that higher risk sexual behavior, in the context of migration, appears to affect HIV risk for men and women differently: while a given level of sexual risk behavior is more likely to result in infection for women than for men, this is especially the case for women involved in migration. These findings point to the possibility that female migrants travel to 'higher risk environments', destinations higher in prevalence than the common destinations of male migrants, where unprotected sex is much more likely to result in infection. It is also possible that female migrants in this study under-reported their sexual risk behavior; but the magnitude of that under-reporting would have to be great to account for the findings shown here. More detailed studies are needed to elucidate the factors that render migration particularly hazardous for women, and also to explore possibilities for HIV prevention interventions for female migrants. As female migration has become an essential household livelihood strategy in KwaZulu-

Natal (KZN), such efforts are essential to preserve and enhance the beneficial aspects of migration for women and their families, and to stave off its most dire consequence.

Analysis of the reported number of concurrent sexual partners used in this study showed that a small number of individuals reported more than one current sexual partner in this population; somewhat higher numbers of past year partners were reported. While social desirability bias may have affected the estimates shown here, important for this analysis was the finding that migrants had more partners than non-migrants, and this played a role in their greater likelihood of being HIV-positive. Concurrency may not always be a sensitive marker of individual-level infection risk, but at population-level, and particularly for studies of migration and HIV/AIDS, it is an important marker of the degree to which HIV/AIDS is likely to be fueled and sustained in the population. Migrants may be important 'links' to geographically-spread sexual networks, and those who travel frequently and to several destinations especially may unwittingly play a role in connecting diverse sexual networks. The greater the inter-connectedness among sexual networks, the more quickly and broadly HIV may circulate within the population. Studies of migration and HIV/AIDS have traditionally pointed to male migrants as the 'transmitters' of HIV in southern African populations: whether or not this was true earlier in the epidemic, it is no longer the case. I would argue that it is no coincidence that the sustained high levels of HIV prevalence have been observed in this population along with sustained, high levels of mobility. Moreover, this study has supported the hypothesis that the striking sex disparity in HIV prevalence seen in this population *is* in part due to the particularly high risk of HIV faced by female migrants, who, in a context of declining marriage and increasing unemployment, comprise a large and possibly increasing proportion of adult women in KZN.

This study was subject to several limitations. A primary concern would be that migration may be endogenous to HIV infection. That is, HIV infection may in a recursive manner predict migration, if those who are infected may be more likely to migrate in order, for example, to return home to receive care-giving. One possibility for addressing this problem would be to use an 'instrumental variables' approach (as described by Johnston and DiNardo, 1997) to correct for the inflated estimated coefficients that would result from the endogeneity of migration (this measurement error would, in effect, exaggerate the impact of migration on HIV infection risk.) The issue for this study is that it is very difficult to identify an appropriate instrument for migration, i.e. a variable that predicts migration but is entirely uncorrelated with HIV infection. The likeliest "candidates", for example the presence of a pensioner/child-care provider in the household, levels of household or community infrastructure, or labor market-related factors, would in the South African context (with its endemic level of HIV/AIDS) also be associated with the outcome measure. To examine this problem, I carried out the main substantive models shown in this chapter including, at first, those died in the period after the HIV test and behavioral data were collected; I then carried out the analyses with these individuals excluded, and examined the magnitude and direction of the change in estimates values of the coefficients for migration. From this exercise, I observed no change in the direction of the estimates, and the values of the coefficients for migration were very slightly higher. From this I conclude that migration was primarily exogenous to HIV infection in this population.

Another concern, with the cross-sectional design of this study, would be the potential for omitted variable bias in the measure of associations between migration and HIV; as mentioned, I have to the extent possible controlled for this bias by including all available variables which captured a 'risk predisposition', predicting both migration and HIV. Analyses of the sexual behavioral risks associated with HIV infection are subject to a host of limitations, and social desirability bias may affect estimates differently for men and women due to the gendered social norms regarding sexuality and communication (women may tend to under-report their numbers of sexual partners, while men may over-report them.) Incomplete data and systematic item non-response can challenge any study's validity, and the sexual behavior data available for this analysis was by no means complete. While this issue may be particularly serious for social epidemiological studies of levels of risk behavior within a population, this study was primarily concerned with estimating migrant vs. non-migrant group differences in these reported behaviors. While comparisons of reported risk behaviors by *sex* may be particularly subject to bias, I do not anticipate that migrants would be any more or less likely than non-migrants to systematically over-report or under-report risk behavior. That is, any bias in reported behavior due to sex differences in reporting would apply equally to migrants and non-migrants.

Finally, I anticipated the potential for sample selection bias in the outcome measure. As previously mentioned, participation in HIV testing was not universal in the population, and there were non-random differences in the characteristics of those who did and did not consent to HIV testing. I corrected for selection bias on the basis of the observable covariates of HIV testing using the Propensity Score weighting approach. Despite its utility, there are limitations to the Propensity Score weighting methods. While this method adjusts for selection bias on the basis of observed covariates, it cannot adjust for unobserved ones. “This is always a limitation of nonrandomized studies compared to randomized studies, where the randomization tends to balance the distribution of all covariates, observed and unobserved” (Rubin, 1997).

These limitations notwithstanding, the findings of this study have important implications for HIV prevention and care in KwaZulu-Natal. A range of measures of mobility were associated with HIV infection, not only the long-distance, long-term measures often used in migration studies. HIV prevention interventions, including enhanced counseling and testing, therefore should not focus solely on workplace-based programs for stable labor migrants, and indeed, interventions based upon an ‘identity’ of ‘migrant’ would chase a moving target, as the population overall is highly mobile, yet patterns of mobility vary by sex and life stage. Place-based HIV-prevention interventions that ‘catch’ temporary migrants, small-scale-traders and work-seekers at their main migration destinations, may hold more promise for stemming the transmission of HIV in the population. The social networks of migrants, so important for establishing footholds and economic opportunities in new places, may also provide avenues for the transmission of HIV prevention messages and mutual assistance with remaining HIV-negative or accessing HIV/AIDS testing and care. The bottom line: this research points to an urgent need for HIV prevention efforts in a population ravaged by HIV/AIDS, and highlights the particular vulnerability of migrants in the population, especially female migrants, to HIV/AIDS.

Table 4.1: Migration and mobility characteristics of the population by HIV infection status (All age-eligible participants in testing, who were members of households on 01 June 2003*)

Migration and Mobility Characteristic	MEN							WOMEN						
	HIV-		HIV+		Age-adj.			HIV-		HIV+		Age-adj.		
	n	%	n	%	OR	95%	CI	n	%	n	%	OR	95%	CI
Since 01 Jan. 2000 (DSS Start)														
Stable residence	3,099	81.6	441	18.4	1.00			3,718	71.3	1,181	28.7	1.00		
Any migration (in-, out- or internal migration)	1,155	75.5	255	24.5	**1.77**	**1.25**	**2.51**	1,458	58.0	791	42.0	**1.90**	**1.56**	**2.31**
No external in-migration	3,745	79.6	564	20.4	1.00			4,559	67.5	1,614	32.5	1.00		
Any external in-migration	509	77.3	132	22.7	1.28	0.90	1.83	617	57.5	358	42.5	**1.62**	**1.25**	**2.09**
No internal migration	3,882	79.0	633	21.0	1.00			4,645	66.0	1,690	34.0	1.00		
Any internal migration	372	80.5	63	19.5	1.09	0.63	1.89	531	62.2	282	37.8	1.22	0.94	1.59
No external out-migration	4,073	80.8	643	19.2	1.00			4,953	67.7	1,840	32.3	1.00		
Any external out-migration	181	68.9	53	31.1	**2.51**	**1.47**	**4.29**	213	51.5	132	48.5	**2.06**	**1.42**	**2.99**
Frequency of migration														
Stable residence	3,341	81.3	490	18.7	1.00			4,020	70.1	1,324	29.9	1.00		
1 migration since DSS start	736	74.6	160	25.4	**1.90**	**1.27**	**2.84**	900	59.1	504	40.9	**1.75**	**1.40**	**2.18**
≥ 2 migrations since DSS start	177	76.9	46	23.1	**1.73**	**1.01**	**2.94**	256	54.8	144	45.3	**2.08**	**1.42**	**3.04**
Migration flow														
No migration since DSS start	3,341	81.3	490	18.7	1.00			4,020	70.1	1,324	29.9	1.00		
Internal migration only	383	79.7	92	20.3	1.27	0.88	1.84	449	60.6	258	39.4	**1.66**	**1.29**	**2.12**
External out-migration only	58	62.8	17	37.2	**3.64**	**1.63**	**8.11**	50	47.2	34	52.8	**2.83**	**1.56**	**5.12**
External in-migration only	334	79.1	56	20.9	1.51	0.83	2.75	464	63.3	241	36.7	**1.45**	**1.12**	**1.88**
External out & in-migration only (either direction)	100	71.3	34	28.7	**2.44**	**1.33**	**4.47**	126	51.0	74	49.0	**2.41**	**1.45**	**4.01**
Other flows**	38	88.7	7	11.4	0.78	0.29	2.10	67	58.5	41	41.5	1.78	0.87	3.64

Table 4.1 continued on next page

Table 4.1, continued:

Migration and Mobility Characteristic	MEN							WOMEN						
	HIV-		HIV+		Age-adj.			HIV-		HIV+		Age-adj.		
	n	%	n	%	OR	95%	CI	n	%	n	%	OR	95%	CI
2 years prior to 01 June 2003														
Stable residence in past 2 years	3,313	81.1	493	18.9	1.00			3,999	70.5	1,321	29.5	1.00		
Recent migration (in-, out- or internal, past 2 yrs)	941	75.6	203	24.4	**1.71**	**1.20**	**2.45**	1,177	57.2	651	42.8	**1.88**	**1.53**	**2.31**
No external in-migration	3,847	79.2	95	20.8	1.00			4,696	66.8	1,691	33.3	1.00		
Any external in-migration	407	78.9	101	21.1	1.15	0.79	1.66	480	58.7	281	41.3	**1.51**	**1.15**	**1.99**
No internal migration	,977	79.0	652	21.1	1.00			4,783	66.1	1,753	34.0	1.00		
Any internal migration	277	81.2	44	18.8	1.03	0.52	2.02	393	60.9	219	39.1	1.29	0.95	1.75
No external out-migration	4,097	80.9	48	19.1	1.00			4,998	67.6	1,863	32.4	1.00		
Any external out-migration	157	67.9	48	32.2	**2.67**	**1.55**	**4.62**	178	51.0	109	49.0	**2.09**	**1.41**	**3.10**
Frequency of recent migration:														
Stable residence	3,517	80.9	535	19.2	1.00			4,266	69.3	1,453	30.7			
1 migration, past 2 years	612	74.4	129	25.6	**1.85**	**1.21**	**2.83**	747	58.6	415	41.4	**1.71**	**1.35**	**2.17**
2 or more migrations, past 2 years	125	78.4	32	21.6	**1.54**	**0.86**	**2.78**	163	54.1	104	45.9	**2.05**	**1.31**	**3.22**
Short-term mobility														
Household presence, past 6 months†														
Every night	2,612	85.0	352	15.0	1.00			2,991	72.3	933	27.7	1.00		
Most nights	1,423	78.0	300	22.0	**1.62**	**1.28**	**2.04**	1,874	62.9	877	37.1	**1.55**	**1.36**	**1.77**
Approximately half	171	77.9	32	22.1	**2.01**	**1.10**	**3.68**	239	60.0	125	40.0	**1.88**	**1.34**	**2.65**
Few or no nights	48	56.1	12	44.0	**3.64**	**1.45**	**9.15**	72	52.7	37	47.3	**2.41**	**1.39**	**4.18**
Residency status Non-resident*	147	66.5	36	33.5				139	49.7	99	50.3			
Resident on 01 June 2003	4,107	82.1	660	17.9	**0.43**	**0.23**	**0.79**	5,037	68.6	1,873	31.4	**0.44**	**0.30**	**0.65**

Table 4.1 notes: Unweighted frequencies and weighted percentages shown. Percentages are row percentages (showing the percentages HIV+ vs. HIV- within each category in men and women, respectively.) Weights are propensity score weights based upon probability of participation in HIV testing based on

observable predictors of testing. Results of logistic regression models that are statistically significant at $p < .05$ are highlighted in bold print.

* These data are shown for the population eligible for HIV testing on 01 June 2003, who WERE NOT included in the non-resident sample selected for participation in testing at that time. Of the n=44,648 individuals not in the non-resident sample, n=29,761 (66.7%) were retrospectively determined to have been resident members on 01 June 2003, and n=12,098 participated in testing. The n=1,808 individuals in the non-resident sample, of whom n=530 participated in testing, were excluded from analysis shown in Table 1, but are described in Table 3.

** Includes: In- & internal migration only (either direction), Out- & internal migration only (either direction), and In-, out- & internal migration. All categories for this variable are mutually-exclusive.

† Prior to the HIV surveillance visit.

Table 4.2: Other socio-economic and behavioral characteristics of the population by HIV infection status (All age-eligible participants in testing, who were members of households on 01 June 2003*)

Characteristic	MEN							WOMEN						
	HIV-		HIV+		Age-adj.			HIV-		HIV+		Age-adj.		
	n	%	n	%	OR	95%	CI	n	%	n	%	OR	95%	CI
Age group (10-year)**														
15-24	2,968	93.2	130	6.8	1.00			2,875	73.8	702	26.2	1.00		
25-34	469	59.3	284	40.7	**9.43**	**6.05**	**14.70**	732	47.8	698	52.2	**3.07**	**2.42**	**3.90**
35-44	391	65.0	175	35.0	**7.40**	**4.57**	**12.00**	1,035	66.0	434	34.0	**1.45**	**1.12**	**1.88**
45-54 men/45-49 women†	426	63.6	107	36.4	**7.85**	**3.02**	**20.43**	534	77.8	138	22.2	0.80	0.62	1.03
Partnership pattern														
Marital partner	358	82.6	85	17.4	1.00			953	78.1	218	21.9	1.00		
No current partner	2,516	90.6	140	9.4	**2.52**	**1.20**	**5.30**	1,936	78.4	396	21.6	**1.45**	**1.04**	**2.02**
Non-marital partner††	1,147	64.7	459	35.3	**6.67**	**3.84**	**11.58**	2,056	54.9	1,314	45.1	**3.81**	**2.82**	**5.14**
Missing	233	85.0	12	15.0	**3.79**	**1.47**	**9.82**	231	78.1	44	21.9	1.45	0.86	2.45
Employment														
No earned income	1,907	79.5	347	20.5	1.00			2,659	63.8	1,222	36.2	1.00		
Does something to earn money	715	70.0	288	30.0	1.09	0.75	1.58	944	57.7	517	42.3	**1.26**	**1.00**	**1.61**
Refused, missing or NA	1,632	86.3	61	13.7	0.84	0.38	1.86	1,573	78.0	233	22.0	**0.51**	**0.38**	**0.70**
Education level														
None through Standard 5	973	69.2	327	30.8	1.00			1,650	60.9	757	39.2	1.00		
Standard 6 to 9	615	73.4	186	26.6	1.07	0.68	1.68	979	59.8	594	40.2	0.96	0.75	1.23
Standard 10 (Matric) or higher	427	77.3	108	22.7	0.97	0.58	1.63	563	60.4	296	39.6	0.93	0.69	1.25
Full-time student	2,066	98.1	31	1.9	**0.10**	**0.05**	**0.21**	1,789	87.3	225	12.7	**0.19**	**0.14**	**0.26**
Missing	173	64.7	44	35.3	1.50	0.60	3.78	195	59.8	100	40.2	0.96	0.64	1.45

Table 4.2 continued on next page

Table 4.2, continued:

Characteristic	MEN							WOMEN						
	HIV-		HIV+		Age-adj.			HIV-		HIV+		Age-adj.		
	n	%	n	%	OR	95%	CI	n	%	n	%	OR	95%	CI
Household infrastructure														
No electricity	2,027	85.4	254	14.6	1.00			2,699	71.5	823	28.5	1.00		
Has electricity source	2,014	77.5	393	22.5	**1.81**	**1.29**	**2.54**	2,235	60.9	1,030	39.1	**1.59**	**1.31**	**1.94**
Missing	213	65.1	49	34.9	**2.68**	**1.27**	**5.64**	242	60.4	119	39.6	**1.66**	**1.13**	**2.45**
Other water source	2,073	82.3	304	17.7	1.00			2,561	68.9	873	31.1	1.00		
Piped water (private/public)	1,998	79.7	348	20.3	1.30	0.94	1.80	2,411	63.4	995	36.6	**1.27**	**1.05**	**1.54**
Missing	183	64.9	44	35.1	**2.13**	**1.01**	**4.51**	204	59.9	104	40.1	**1.51**	**1.01**	**2.25**
No flush or chemical toilet	2,906	82.4	446	17.6	1.00			3,661	67.4	1,273	32.6	1.00		
Flush toilet/VIP	1,163	77.9	204	22.1	1.43	0.99	2.07	1,308	62.9	593	37.1	**1.23**	**1.01**	**1.49**
Missing	185	64.3	46	35.7	**2.18**	**1.06**	**4.47**	207	59.9	106	40.1	1.41	0.95	2.10
Death after 01 June 2003														
Alive throughout period	4,168	83.8	574	16.2	1.00			5,134	68.4	1,728	31.6	1.00		
Died before 01 Jan. 2007	86	27.6	122	72.4	**8.87**	**5.03**	**15.61**	42	13.1	244	86.9	**13.72**	**8.32**	**22.60**
Adult AIDS deaths in household before June '03														
No prior adult AIDS death	3,545	80.4	558	19.6	1.00			4,365	66.8	1,543	33.2	1.00		
≥ 1 other adult member died of AIDS, Jan. '01- June '03	709	73.6	38	26.4	1.47	0.82	2.64	811	59.2	429	40.8	**1.41**	**1.13**	**1.76**
Reported sexual behavior														
Never used condom	924	69.8	237	30.1	1.00			1,551	61.6	791	38.4	1.00		
Ever used condom	818	76.5	217	23.5	1.18	0.77	1.82	290	48.3	231	51.7	**1.86**	**1.31**	**2.63**
Missing	2,512	84.9	242	15.1	0.69	0.42	1.13	3,335	69.8	950	30.2	**0.76**	**0.63**	**0.92**

Table 4.2 continued on next page:

Table 4.2, continued:

Characteristic	MEN							WOMEN						
	HIV-		HIV+		Age-adj.			HIV-		HIV+		Age-adj.		
	n	%	n	%	OR	95%	CI	n	%	n	%	OR	95%	CI
Reported sexual behavior														
Does not perceive self to be at risk	2,385	86.2	303	13.8	1.00			3,169	70.7	971	29.3	1.00		
Perceives self to be at high risk of HIV	490	61.9	151	38.1	**3.18**	**1.97**	**5.13**	655	59.5	369	40.5	**1.56**	**1.25**	**1.94**
Missing	1,379	76.3	242	23.7	**1.65**	**1.14**	**2.39**	1,352	60.5	632	39.5	**1.55**	**1.24**	**1.94**
Never tested for HIV	2,619	81.8	358	18.2	1.00			3,252	69.4	1,042	30.6	1.00		
Ever tested for HIV (previous to visit)	321	70.4	116	29.6	1.43	0.88	2.30	781	64.7	360	35.3	**1.22**	**1.00**	**1.50**
Missing	1,314	77.3	222	22.7	1.16	0.72	1.85	1,143	59.4	570	40.6	**1.55**	**1.23**	**1.95**
Reported sexual behavior	**Mean**	**SD**	**Mean**	**SD**				**Mean**	**SD**	**Mean**	**SD**			
Lifetime number of sexual partners	5.11	5.12	7.02	5.42	**1.03**	**1.00**	**1.06**	1.57	1.00	2.18	1.13	**1.87**	**1.73**	**2.03**
Past year number of sexual partners	1.43	1.37	1.80	1.27	**1.19**	**1.10**	**1.29**	0.66	0.43	0.82	0.39	**2.54**	**2.05**	**3.15**
Concurrent partnerships	1.00	0.89	1.26	0.69	**1.30**	**1.18**	**1.45**	0.65	0.42	0.76	0.37	**2.01**	**1.66**	**2.43**

Table 4.2 notes: Row percentages shown, separately for men and women, respectively; percentages are weighted and frequencies are unweighted. Weights are propensity score weights based upon probability of participation in HIV testing.
*As in Table 4.1, these data are show for the population who were eligible for testing on 01 June 2003 and who were not included in the non-resident sample selected for participation in HIV testing at that time.
** The odds ratios given for the model regressing HIV test result on 10-year age group by sex has only one independent variable (i.e. unlike the other models shown in this table, single year of age is not included as an additional variable.)
† Women only up to age 49 were eligible for HIV testing; men up to age 54 were eligible.
†† This category mainly comprised of those with a regular non-marital partner: of n=23,893 in the category, only 1,683 reported a casual partner. HIV prevalence was lower among those reporting a casual partner (20.3%) than among those with a regular partner (43.4%) and similar to the level of those with a marital partner (20.4%).

Table 4.3: Characteristics of individuals in the non-resident sample who participated in first round of HIV surveillance, by sex

Characteristic	MEN							WOMEN						
	HIV-		HIV+		Age-adj.			HIV-		HIV+		Age-adj.		
	n	%	n	%	OR	95%	CI	n	%	n	%	OR	95%	CI
Any migration: Stable non-resident since 01 Jan. 2000	107	66.1	55	34.0	1.00			93	57.8	68	42.2	1.00		
Any migration (in-, out- or internal migration)	66	72.5	25	27.5	0.88	0.49	1.59	69	59.5	47	40.5	0.99	0.60	1.62
Frequency of migration:														
Non-resident since Jan. 2000	109	66.5	55	33.5				93	57.4	69	42.6			
1 migration since DSS start	45	68.2	21	31.8	1.10	0.58	2.08	52	64.2	29	35.8	0.80	0.46	1.39
2 or more migrations	19	82.6	4	17.4	0.49	0.16	1.54	17	50.0	17	50.0	1.42	0.67	2.99
Age group 15-24**	70	82.4	15	17.7				87	70.7	36	29.3			
25-34	58	58.6	41	41.4	3.30	1.66	6.55	34	39.1	53	60.9	3.77	2.11	6.73
35-44	23	62.2	14	37.8	2.84	1.19	6.76	27	57.5	20	42.6	1.79	0.89	3.59
45-54 men/45-49 women†	22	68.8	10	31.3	2.12	0.83	5.39	14	70.0	6	30.0	1.04	0.37	2.91
Partnership Marital partner	31	73.8	11	26.2				13	100.0	-	0.0			
No current partner	50	79.4	13	20.6	2.61	0.76	8.97	50	84.8	9	15.3	--	--	--
Non-marital partner††	88	62.9	52	37.1	3.57	1.41	9.04	97	48.0	105	52.0	--	--	--
Missing	4	50.0	4	50.0	9.95	1.69	58.66	2	66.7	1	33.3	--	--	--
Employment No income	65	69.2	29	30.9				81	60.9	52	39.1			
Does something to earn money	87	66.4	44	33.6	0.85	0.46	1.58	47	48.0	51	52.0	1.65	0.96	2.83
Refused, missing or NA	21	75.0	7	25.0	0.79	0.30	2.10	34	73.9	12	26.1	0.57	0.27	1.21
Reported sexual behavior	**Mean**	**SD**	**Mean**	**SD**				**Mean**	**SD**	**Mean**	**SD**			
Lifetime no. of sexual partners	6.34	4.64	6.69	3.98	1.00	0.94	1.06	1.94	1.10	2.35	0.93	1.49	1.13	1.97
Past year no. of sexual partners	1.88	1.21	1.85	1.01	1.02	0.81	1.30	0.82	0.32	0.91	0.39	2.23	1.06	4.69
Concurrent partnerships	1.37	1.00	1.34	0.76	0.97	0.72	1.31	0.79	0.31	0.82	0.29	1.34	0.60	2.97

Table 4.3 notes: Data are unweighted. Data are shown for the n=530 individuals eligible for testing on 01 June 2003 who were part of the non-resident sample

selected at that time, who participated in HIV testing.

Table 4.4: Sexual behavior of migrant and non-migrants, of household members on 01 June 2003 who were eligible for HIV testing and who participated in WGH and MGH surveys

	MEN					WOMEN				
	Migrants* (n=1,742)		Non-migrants (n=4,159)		Diff.	Migrants* (n=4,001)		Non-migrants (n=7,292)		Diff.
Reported sexual behavior	mean	std. dev.	mean	std. dev.	*p*	mean	std. dev.	mean	std. dev.	*p*
Lifetime number of sexual partners	5.13	5.98	4.28	5.66	***	1.75	1.28	1.48	1.23	***
Past year number of sexual partners	1.45	1.59	1.22	1.47	***	0.70	0.56	0.62	0.50	***
Concurrent partnerships	1.00	1.09	0.82	1.02	***	0.66	0.46	0.61	0.50	***
	n	%	n	%	*p*	n	%	n	%	*p*
Ever used a condom	685	39.3	1,223	29.4	***	579	14.5	733	10.1	***
Never used a condom	627	36.0	1,387	33.4		1,775	44.4	3,123	42.8	
Missing	430	24.7	1,549	37.2		1,647	41.2	3,436	47.1	
Perceives self to be at high risk of HIV**	389	22.3	708	17.0	***	806	20.1	1,240	17.0	***
Does not perceive self to be at risk	1,288	73.9	3,277	78.8		2,986	74.6	5,595	76.7	
Missing	65	3.7	174	4.2		209	5.2	457	6.3	
Ever received voluntary counseling & testing for HIV (prior to visit)	296	17.0	539	13.0	***	1,012	25.3	1,435	19.7	***
Never previously received VCT for HIV	1,432	82.2	3,572	85.9		2,958	73.9	5,800	79.5	
Missing	14	0.8	48	1.15		31	0.77	57	0.78	

Table 4.4 notes: Data shown in Table 4 are shown for the total population eligible for HIV testing on 01 June 2003 who participated in the WGH and MGH surveys (n=5,901 men and n=11,293 women participated in the first round of the sexual behavior surveys.) Data for those who were part of the non-resident sample and who also participated in the WGH and MGH (n=225 women and n=253 men) were excluded form the analyses shown here (and their behavioral characteristics are shown in Table 3). For continuous variables, T-tests of differences between migrants and non-migrants carried out in men and in women, respectively, assuming unequal variances and a 95% confidence level for the hypothesis that the differences are not equal to 0. For categorical variables, the chi-square test was used, also with a 95% confidence level.

*Migration in Table 4 defined as at least one change of residence (in-migration, out-migration or internal migration) since January 2000.

** Respondent agrees with either of the following questions: "is there anything that happened to you in the past that may have put you at risk of becoming infected with HIV?" or "are you currently in a situation where you may be at risk of becoming infected with HIV?"

Table 4.5: Multiple logistic regression models of HIV infection risk (All age-eligible participants in testing, who were resident members of households on 01 June 2003) (Models 1.A-C)

HIV test result (1=positive)	1) HIV= SEX + MIGRATION											
	A) MIGRATION IN PAST 2 YEARS				B) FREQUENCY OF MIGRATION				C) MOBILITY IN PAST 6 MONTHS			
	OR	***p***	**95% CI**		**OR**	***p***	**95% CI**		**OR**	***p***	**95% CI**	
A) Migrated in past 2 years												
Stable residence in past 2 years	1.00											
Any migration (in-, out- or internal)	1.28	0.001	1.10	1.49	--	--	--	--	--	--	--	--
B) Sum of migrations in past 2 years	--	--	--	--	1.24	0.001	1.09	1.42	--	--	--	--
C) Household presence, past 6 months												
Every night									1.00			
Most nights	--	--	--	--	--	--	--	--	1.18	0.00	1.06	1.32
Approximately half	--	--	--	--	--	--	--	--	1.53	0.00	1.19	1.97
Few or no nights	--	--	--	--	--	--	--	--	1.53	0.08	0.94	2.47
Sex *Male*												
Female	1.97	0.000	1.71	2.26	1.96	0.000	1.71	2.25	1.96	0.00	1.70	2.25
Age group *15-24*	1.00											
25-34	2.73	0.000	2.28	3.28	2.78	0.000	2.32	3.34	2.80	0.00	2.32	3.38
35-44	1.73	0.000	1.39	2.14	1.76	0.000	1.42	2.18	1.76	0.00	1.42	2.19
45-54 men/45-49 women	1.34	0.050	1.00	1.80	1.37	0.038	1.02	1.84	1.35	0.04	1.01	1.82
Education level *0 - Standard 5*	1.00											
Standard 6 to 9	1.03	0.676	0.88	1.21	1.04	0.664	0.89	1.21	1.03	0.69	0.88	1.20
Standard 10 (Matric) or higher	0.75	0.007	0.61	0.93	0.74	0.006	0.60	0.92	0.75	0.01	0.60	0.92
Full-time student	0.41	0.000	0.32	0.53	0.42	0.000	0.32	0.54	0.42	0.00	0.32	0.53
Missing	1.59	0.084	0.94	2.69	1.59	0.085	0.94	2.68	1.55	0.10	0.91	2.63
Employment *No earned income*	1.00											
Does something to earn money	1.15	0.078	0.98	1.34	1.16	0.062	0.99	1.35	1.15	0.07	0.99	1.34
Refused, missing or NA	0.47	0.000	0.36	0.61	0.47	0.000	0.37	0.61	0.47	0.00	0.36	0.61
Household infrastructure *No electricity*	1.00											
Has electricity source	1.54	0.000	1.36	1.76	1.55	0.000	1.36	1.77	1.52	0.00	1.33	1.73
Missing	1.78	0.009	1.15	2.74	1.79	0.009	1.16	2.76	1.79	0.01	1.15	2.80

Table 4.5 continued on next page

Table 4.5, continued:

HIV test result (1=positive)	1) HIV= SEX + MIGRATION A) MIGRATION IN PAST 2 YEARS				B) FREQUENCY OF MIGRATION				C) MOBILITY IN PAST 6 MONTHS			
	OR	***p***	**95% CI**		**OR**	***p***	**95% CI**		**OR**	***p***	**95% CI**	
Partnership pattern *Marital partner*	1.00				1.00				1.00			
No current partner	1.63	0.000	1.30	2.05	1.64	0.000	1.30	2.06	1.67	0.00	1.33	2.10
Non-marital partner	2.91	0.000	2.41	3.52	2.91	0.000	2.41	3.52	2.94	0.00	2.43	3.54
Missing	2.20	0.008	1.23	3.93	2.22	0.007	1.25	3.95	2.25	0.00	1.32	3.84
N	11,677				11,677				11,677			
Wald χ^2 ***(df)***	1206.5 (16)				1207.54 (16)							

Table 4.5 notes: The data shown in Table 5 are weighted with the propensity score weight. Data are shown for the population of resident members of households on 01 June 2003 who were eligible for HIV testing, participated in testing, and who were not only not part of the non-resident sample, but who were also retrospectively determined, with updated data, to have been resident members of the household on the eligibility date.

Table 4.6: Multiple logistic regression models of HIV infection risk (All age-eligible participants in testing, who were resident members of households on 01 June 2003) (Model 2)

	2) HIV= SEX * MIGRATION			
HIV test result (1=positive)	**OR**	***p***	**95% CI**	
Sex *Male (non-migrant)*				
Female (non-migrant)	1.72	0.000	1.49	1.99
Migrated in past 2 years				
Stable residence in past 2 years				
Any migration (in-, out- or internal)	--	--	--	--
Sex * Migration				
Male: Recent migration	0.99	0.959	0.75	1.31
Female: Recent migration	2.56	0.019	1.59	4.11
Age group *15-24*				
25-34	2.74	0.000	2.28	3.29
35-44	1.75	0.000	1.41	2.17
45-54 men/45-49 women	1.35	0.044	1.01	1.81
Education level *None - Standard 5*				
Standard 6 to 9	1.04	0.640	0.89	1.21
Standard 10 (Matric) or higher	0.75	0.007	0.61	0.92
Full-time student	0.41	0.000	0.32	0.53
Missing	1.60	0.079	0.95	2.70
Employment *No earned income*				
Does something to earn money	1.15	0.068	0.99	1.34
Refused, missing or NA	0.47	0.000	0.36	0.61
Household infrastructure *No electricity*				
Has electricity source	1.54	0.000	1.35	1.75
Missing	1.76	0.010	1.15	2.71
Partnership pattern *Marital partner*				
No current partner	1.62	0.000	1.29	2.04
Non-marital partner	2.89	0.000	2.39	3.49
Missing	2.19	0.007	1.24	3.89
N	**11,677**			
Wald χ^2 ***(df)***	**1,214.36 (17)**			

Table 4.6 notes: The data shown in Table 6 are weighted with the propensity score weight. Data are shown for the population of resident members of households on 01 June 2003 who were eligible for HIV testing, participated in testing, and who were not only not part of the non-resident sample, but who were also retrospectively determined, with updated data, to have been resident members of the household on the eligibility date.

Table 4.7: Analysis of the sex composition in effect of recent migration on HIV prevalence among residents: Observed and simulated

		Unweighted		Observed prevalence (weighted)	Observed OR (unadjusted)	Simulated prevalence: Females' migration 'effect' used
Males		**N HIV +**	**N HIV -**	**HIV+**		**HIV+**
	Recent migrant	174	842	19.8%	1.19	32.8%
	Non-migrant	486	3,265	17.2%	1	10.2%
				Observed prevalence (weighted)	**Observed OR (unadjusted)**	
Females		**N HIV +**	**N HIV -**	**HIV+**		
	Recent migrant	282	1,080	39.3%	1.67	
	Non-migrant	1,690	3,957	27.8%	1	

Table 4.7 notes: Weighted data used, although unweighted frequencies are shown in Table 7. Data are for the population eligible for HIV testing on 01 June 2003 who participated in testing, who were resident members of households on that date. Unadjusted odds ratios (using the weighted frequencies) used to calculate a simulated level of HIV prevalence for men if the odds of infection for male migrants were that of female migrants.

Table 4.8: Multiple logistic regression models of HIV infection risk (All age-eligible participants in testing, who were resident members of households on 01 June 2003) (Models 3 & 4)

HIV test result (1=positive)	3) HIV= SEX + MIGRATION + BEHAVIORAL RISK				4) HIV= SEX* BEHAVIORAL RISK*MIGRATION			
	OR	***p***	**95% CI**		**OR**	***p***	**95% CI**	
Sex *Male*								
Female	2.58	0.000	2.20	3.03	--	--	--	--
Migrated in past 2 years								
Stable residence in past 2 years								
Any migration (in-, out- or internal)	1.25	0.004	1.08	1.46	--	--	--	--
Lifetime no. of sexual partners	1.03	0.000	1.02	1.05	--	--	--	--
Past year no. of sexual partners	1.11	0.014	1.02	1.20	--	--	--	--
Sex* Lifetime number of partners* Recent migration								
Male Non-migrant * Partner number	--	--	--	--	1.04	--	1.02	1.05
Male Migrant * Partner number	--	--	--	--	1.02	--	0.96	1.09
Female Non-migrant * Partner number	--	--	--	--	1.24	--	1.12	1.36
Female Migrant * Partner number	--	--	--	--	1.49	0.022	1.09	2.04
Sexual risk perceptions & behavior								
Does not perceive self to be at risk								
Perceives self to be at risk of HIV	1.36	0.001	1.13	1.64	1.38	0.001	1.15	1.65
Missing	1.29	0.001	1.11	1.49	1.28	0.001	1.10	1.48
Age group *15-24*								
25-34	2.63	0.000	2.19	3.16	2.53	0.000	2.11	3.04
35-44	1.65	0.000	1.32	2.06	1.55	0.000	1.24	1.94
45-54 men/45-49 women	1.27	0.121	0.94	1.72	1.19	0.270	0.88	1.61

Table 4.8 continued on next page

Table 4.8, continued:

HIV test result (1=positive)	3) HIV= SEX + MIGRATION + BEHAVIORAL RISK				4) HIV= SEX* BEHAVIORAL RISK*MIGRATION			
	OR	***p***	**95% CI**		**OR**	***p***	**95% CI**	
Education level *None-Standard 5*								
Standard 6 to 9	1.03	0.695	0.88	1.21	1.04	0.597	0.89	1.22
Standard 10 (Matric) or higher	0.73	0.003	0.59	0.90	0.73	0.004	0.59	0.90
Full-time student	0.43	0.000	0.33	0.55	0.44	0.000	0.34	0.57
Missing	1.51	0.118	0.90	2.54	1.52	0.119	0.90	2.57
Employment *No earned income*								
Does something to earn money	1.14	0.103	0.97	1.33	1.15	0.065	0.99	1.35
Refused, missing or NA	0.49	0.000	0.38	0.63	0.51	0.000	0.40	0.66
Household infrastructure *No elec.*								
Has electricity source	1.55	0.000	1.36	1.77	1.52	0.000	1.33	1.73
Missing	1.76	0.010	1.15	2.70	1.71	0.014	1.11	2.63
Partnership pattern *Marital*								
No current partner	1.70	0.000	1.35	2.14	1.63	0.000	1.30	2.05
Non-marital partner	2.86	0.000	2.36	3.46	2.69	0.000	2.22	3.26
Missing	2.26	0.005	1.28	4.00	2.10	0.014	1.17	3.78
N	11,677				11,677			
Wald χ^2 ***(df)***	1247.44 *(20)*				1271.62 *(23)*			

Table 4.8 notes: The data shown in Table 8 are weighted with the propensity score weight. Data are shown for the population of resident members of households on 01 June 2003 who were eligible for HIV testing, participated in testing, and who were not only not part of the non-resident sample, but who were also retrospectively determined, with updated data, to have been resident members of the household on the eligibility date.

† *p*- value of the coefficient for the three-way interaction term in the logit specification of the model.

Table 4.9: Patterns of migration associated with incident HIV infection, by sex, among members of households eligible for testing on 01 June 2003 who also participated in the second round of HIV surveillance

Migration* between 1st and 2nd HIV surveillance rounds	Total					Men					Women				
	Did not seroconvert		HIV sero-converted			Did not seroconvert		HIV sero-converted			Did not seroconvert		HIV sero-converted		
	n	row %	n	row %	*p*	n	row %	n	row %	*p*	n	row %	n	row %	*p*
Sum of migrations					<.0001					0.250					<.0001
No migrations	3,632	95.9	156	4.1		1,469	96.8	48	3.2		2,163	95.2	108	4.8	
1 migration	283	90.4	30	9.6		126	95.5	6	4.6		157	86.7	24	13.3	
2 or more	48	88.9	6	11.1		21	91.3	2	8.7		27	87.1	4	12.9	
Any migration					<.0001					0.188					<.0001
No migration between rounds	3,632	95.9	156	4.1		1,469	96.8	48	3.2		2,163	95.2	108	4.8	
1 or more migrations	331	90.2	36	9.8		147	94.8	8	5.2		184	86.8	28	13.2	
Total	**3,963**		**192**			**1,616**		**56**			**2,347**		**136**		

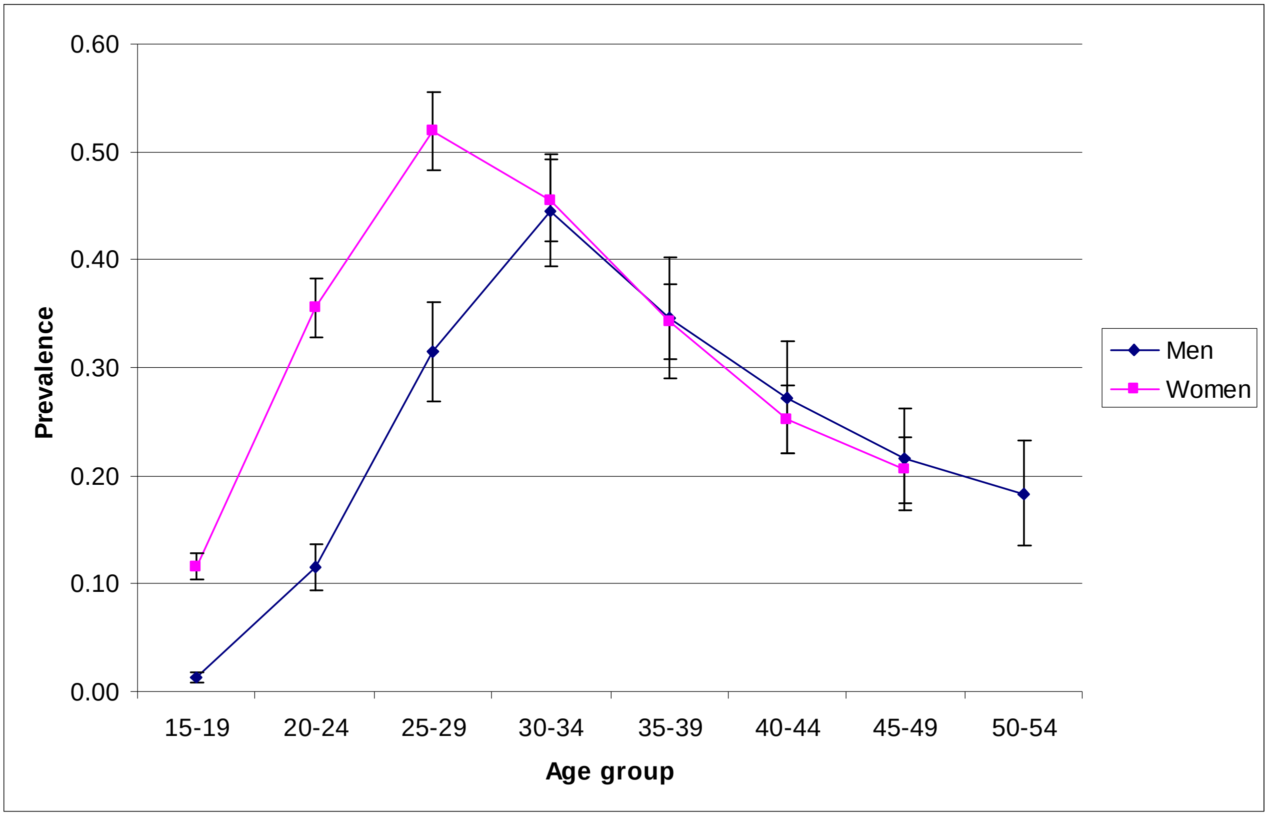
Table 4.9 notes: Data are unweighted. Data are shown for the population of members of households on 01 June 2003 who were eligible for HIV testing, participated in testing, and had an HIV-negative test result in the first round of HIV surveillance. No further exclusions to the data were made.

Table 4.10: Multiple logistic regression of patterns of migration associated with incident infection

	Model 1: Any migration				**Model 2: Number of migrations**			
HIV-seroconversion	**OR**	***p***	**95% CI**		**OR**	***p***	**95% CI**	
Sex (M*ale*)	1.00				1.00			
Female	1.71	0.001	1.24	2.36	1.71	0.001	1.24	2.36
Age group (*15-24*)	1.00				1.00			
25-34	1.78	0.002	1.23	2.58	1.79	0.002	1.24	2.58
35-44	0.71	0.125	0.46	1.10	0.71	0.127	0.46	1.10
45-54 men/45-49 women	0.55	0.091	0.28	1.10	0.55	0.091	0.28	1.10
Any migration (*No migrations*)	1.00							
At least 1 migration	2.46	0	1.68	3.62	--	--	--	--
Migration (*No migrations*)								
1 migration	--	--	--	--	2.40	0.000	1.58	3.62
2 or more migrations	--	--	--	--	2.87	0.018	1.20	6.85
N	4,155				4,155			
Likelihood ratio χ^2 *(df)*	48.79 (5)				48.93 (6)			

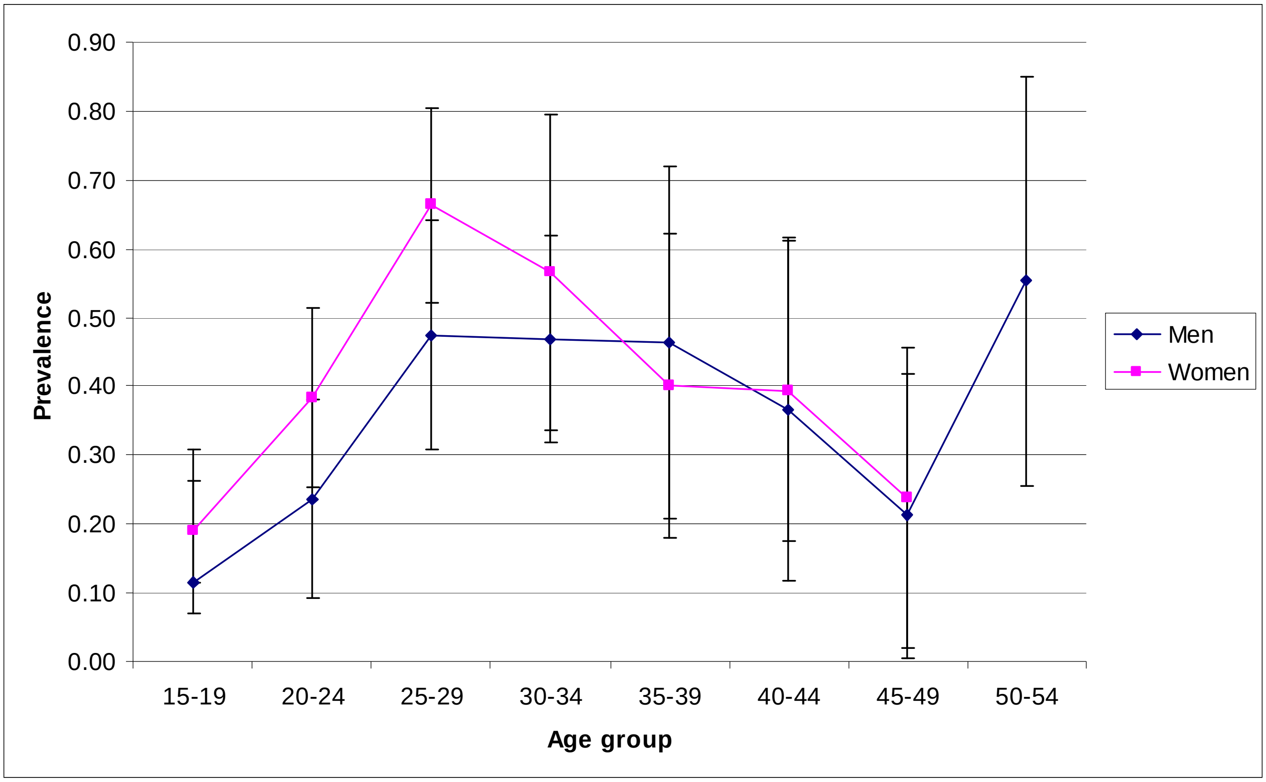
Table 4.10 notes: Data are unweighted. Data are shown for the population of members of households on 01 June 2003 who were eligible for HIV testing, participated in testing, and had an HIV-negative test result in the first round of HIV surveillance. No further exclusions to the data were made.

Figure 4.1: HIV prevalence by sex and age group, age-eligible resident members of households on 01 June 2003 (95% CI)



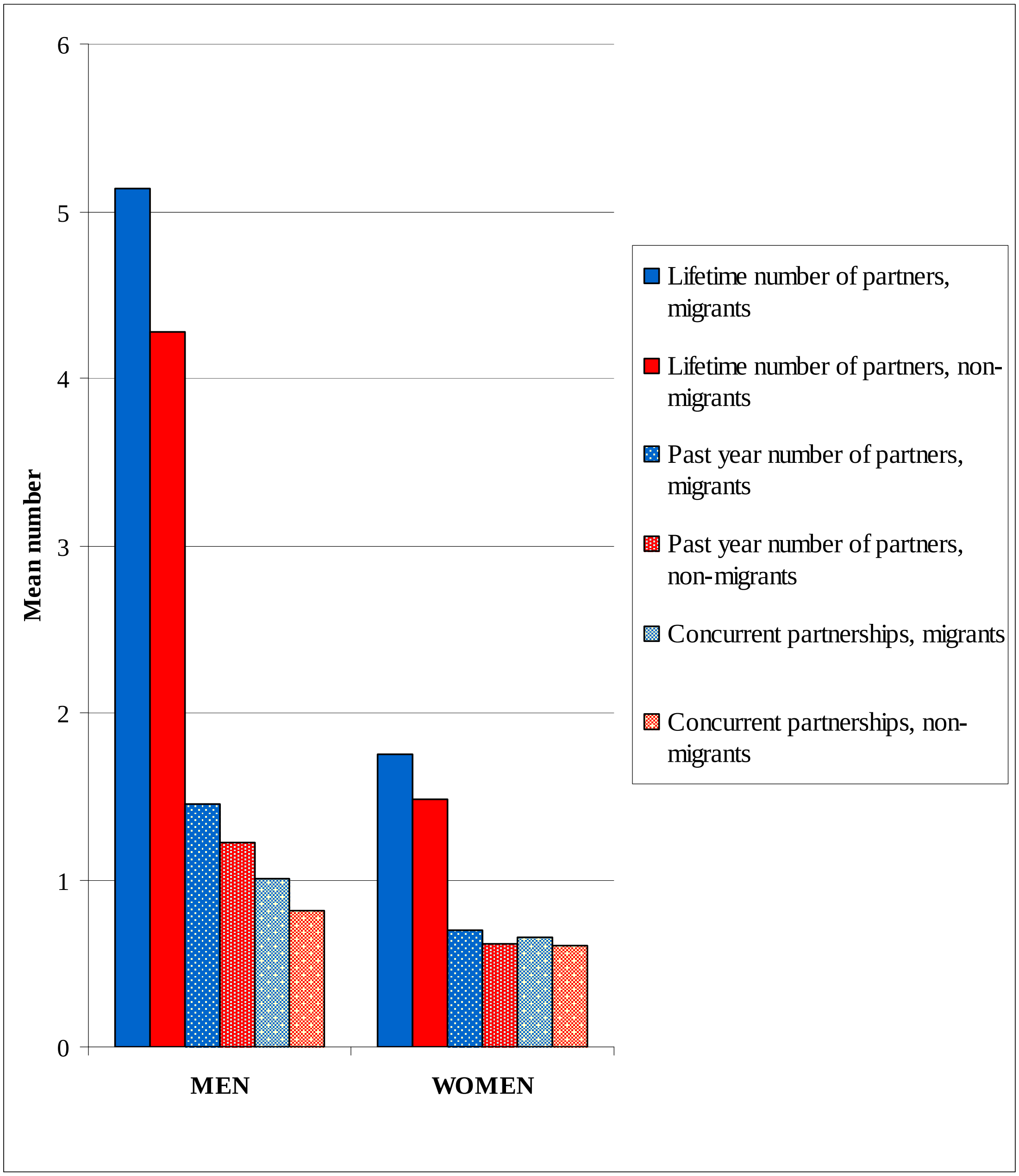
Note: Estimates based on population HIV surveillance data collected between June 2003 and December 2004. Data are unweighted.

Figure 4.2: HIV prevalence on 01 June 2003 by sex and age group, non-resident members of households (95% CI)



Note: Estimates based on population HIV surveillance data collected between June 2003 and December 2004 in a stratified random sample of non-residents. Data are weighted using sample selection probabilities based upon the data generated in 2003.

Figure 4.3: Mean reported number of lifetime, past year and concurrent sexual partners, male and female migrants and non-migrants



Notes

[i] The most recent of these studies found HIV prevalence among those aged 15-49 living in informal settlement areas surrounding cities was 25.8%, compared to prevalence rates of 17.3% in rural informal areas and 13.9% in urban and rural formal settlement areas. (Shisana, O., T. Rehle, et al., 2005).

[ii] See also Desmond et al. for a similar discussion, of Tanzanian women supplementing meager earnings and irregular business with transactional sex. (Desmond, N., C. F. Allen, et al., 2005).

[iii] This method is adapted from those used by Yu Xie (1990) and David Lam (1992).

[iv] This hypothesis cannot be directly measured with the available data; my intent is to examine whether alternatives to this hypothesis can be ruled out. Conclusive evidence to support it requires further research beyond the scope of this dissertation study.

[v] A thorough exploration of the data, and sensitivity analyses, revealed that the following were the measurable characteristics of the population associated with participation in the first round of HIV testing: sex; age group; whether the individual died before 01 January 2007, or remained alive; partnership status; employment status; education level; tertile of household assets; whether ever internally migrated since the start of the DSS; whether in-migrated since the start; whether the individual was resident on 01 June 2003 (using updated information); degree of presence in the household in the previous 6 months; whether or not present in the night prior to the visit; and household infrastructural variables related to electricity, access to a flush or chemical toilet and access to a piped water supply.

[vi] All individuals tested for HIV have the opportunity to learn their results if they wish; pre- and post-result counseling, confirmatory tests and results are available at community-based counseling centers through a unique pin-number given to individuals when they are tested. These services are provided in non-clinic locations in each fieldworker area over the 3 months during, and for 1 month after the HIV testing round in that area.

[vii] This methodology was evaluated in a randomized, controlled trial in Manicaland, Zimbabwe (Gregson et al. 2002). Results showed that respondents were more likely to report experience of unprotected sex with casual partners when the "voting box" method was used. In a follow-up study (Gregson *et al.*, 2004a), the effectiveness of the method for reducing "social desirability" bias had declined in the population.

[viii] The three-way interaction term odds ratios were constructed from coefficients from the multivariate logit model.

The interaction term had the following components:

var 1: migrant status (0=non-migrant, 1=migrant)
var 2: sex (0=male, 1=female)
var 3: lifetime number of sex partners (integer, continuous from 0)

The relevant model output is shown here:

```
------------------------------------------------------------------------------
             |               Robust
HIVResult_~t |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
_Irecentmi~1 |    .081485   .1849693     0.44   0.660    -.2810481    .4440182
    _Isexn_1 |   .3923639   .1147424     3.42   0.001     .1674729    .6172549
    LifePart |   .0351599   .0092401     3.81   0.000     .0170496    .0532701
   _Ire1Xse1 |  -.1175616   .2643986    -0.44   0.657    -.6357733      .40065
    _Ire1XLi |  -.0154615   .0232725    -0.66   0.506    -.0610747    .0301518
    _Ise1XLi |   .1767059   .0407898     4.33   0.000     .0967594    .2566524
_Ire1Xse1XLi |   .2021876   .0880368     2.30   0.022     .0296386    .3747366
```

The variable labeling in the output above corresponds to the following construction:

var 1	_Irecentmi~1
var 2	_Isexn_1
var 3	LifePart
var 1 * var 2	_Ire1Xse1
var 1 * var 3	_Ire1XLi
var 2 * var 3	_Ise1XLi
var 1 * var 2 * var 3	_Ire1Xse1XLi

The odds ratios (and corresponding 95% CIs) for Table 8 were constructed as follows:

1. The effect of var 3 (lifetime number of partners) when var 1=0 and var 2 =0 (male non-migrants):

   EXP (0.04) = 1.04

2. The effect of var 3 (lifetime number of partners) when var 1=1 and var 2 =0 (male migrants)

   EXP (0.04 + -0.02) = 1.02

3. The effect of var 3 (lifetime number of partners) when var 1=0 and var 2 =1 (female non-migrants)

   EXP (.04 + .18) = 1.24

4. The effect of var 3 (lifetime number of partners) when var 1=1 and var 2 =1 (female migrants)

   EXP (.04-.02+.18+.20) = 1.49

A similar example with more detail is in "Applied Logistic Regression" by Hosmer and Lemeshow, Wiley, 1989, pp. 101-103.

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