Sex ratios of HIV prevalence: evidence from the DHS

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Abstract

Amid growing concern of a ‘feminizing’ global HIV/AIDS pandemic, new nationally representative HIV seroprevalence studies from the Demographic and Health Surveys (DHS) make possible for the first time an assessment of variation in the sex ratios of HIV prevalence. This paper analyzes variation in the female-to-male ratios of HIV prevalence estimated in 16 recent DHS from Africa. Results confirm that while in the context of generalized epidemics, women tend to have higher HIV prevalence than men, prevalence sex ratios vary widely across countries, reflecting highly disparate burdens of disease by gender in some populations. Prevalence sex ratios are associated with several commonly identified correlates of HIV prevalence, such as the prevalence of other sexually transmitted diseases and summary measures of socio-economic status, inter alia. However, multivariate models explain very little of the variation in prevalence sex ratios observed across regions in the 16 DHS surveys.

Background

Worldwide, women are estimated to make up fully half of the 33.2 million people living with HIV/AIDS in 2007 (UNAIDS 2007). In some countries with high HIV prevalence—including Lesotho, Namibia, and Zimbabwe—there are an estimated three women infected with HIV for every two men and, among young adults aged 15-24 years, HIV-infected women outnumber HIV-infected men by as many as three to one (UNAIDS 2006). Both biological and social forces are blamed for women’s higher risk of HIV infection relative to men, especially within the context of generalized HIV/AIDS epidemics (defined as having adult HIV prevalence greater than 1 per cent) where heterosexual sex is the main mode of HIV transmission.

In the wake of widespread concern of a ‘feminizing’ global HIV/AIDS pandemic (Giffen 1998; Dworkin and Ehrhardt 2007), the latest *AIDS Epidemic Update* from UNAIDS, the Joint United Nations Programme on HIV/AIDS, emphasizes that while some major world regions are experiencing increases in the percentage women among people living with HIV, women as a percentage of the global number infected has held relatively stable for at least a decade. While the estimated number of women living with HIV globally is rising with time, the number of men living with HIV is increasing at about the same rate, such that the percentage women among people living with HIV worldwide does not change.

While the global sex-distribution of HIV prevalence has remained stable at 50 per cent over recent years, the same cannot be said for several regional epidemics. Figure 1 is reproduced from the UNAIDS *2007 AIDS Epidemic Update* and displays the estimated percentage female among people living with HIV over the period 1990 to 2007 for the major world regions most affected by AIDS. While the data clearly do not support the notion of a feminizing pandemic worldwide, several major world regions continue to see increases in the percentage women among those infected. In the Caribbean, the estimated percentage of adults living with HIV who were women was 37 per cent in 2001, and rose to 43 per cent in 2007. The percentages women among people living with HIV in Latin America, Asia and Eastern Europe are also growing slowly, showing increases of about five percentage points over the last seven years. In sub-Saharan Africa, the region most affected by the AIDS epidemic, almost 61 per cent of the 22.5 million people living with HIV in 2007 were women, with very little upward movement since the year 2000.

Two explanations are commonly offered to elucidate differences across populations in the percentage women among those infected with HIV. The first is often cited to explain regional variation and points to differing modes of transmission as chiefly responsible for observed sex-differences in epidemics. HIV may be transmitted from an infected person to a susceptible person by sharing needles used to inject drugs, through heterosexual intercourse, through sexual intercourse between men, via contaminated blood products or equipment used in medical procedures, and vertically from mother to child during pregnancy, delivery or breastfeeding (Graham 2001; CDC 1993). In sub-Saharan Africa, the region with the largest proportion women among those living with HIV at 61 per cent, heterosexual sex is the dominant mode of HIV transmission (UNAIDS 2006). In the remaining regions, other modes of transmission including injecting drug use and sex between men are believed to account for a relatively larger proportion of HIV infections (UNAIDS 2006), tipping the sex-balance of HIV infection toward men.

A second explanation is often invoked to describe variation in the sex distribution of HIV prevalence across countries within regions, especially in sub-Saharan Africa where the heterosexual mode of transmission is common to most countries. This explanation points to the maturity of the epidemic as the important determinant of the sex distribution of HIV infections. In the early years of an epidemic driven by heterosexual transmission, HIV cases tend to be concentrated among female commercial sex workers and their clients such that male prevalence exceeds female prevalence. Over time, female prevalence increases as the wives and non-marital partners of those male clients become infected, eventually shifting the balance of HIV prevalence to women (Gregson and Garnett 2000; Carpenter et al. 1999). Thus, all else equal, older epidemics are expected to display a more feminine distribution of HIV prevalence.

In practice, these generalizations about the sex-specific dynamics of HIV epidemics are drawn based on only scant empirical evidence of the relative burdens of disease among men and women. Direct estimates of sex-specific HIV prevalence are not widely available. For the 57 countries with generalized epidemics in 2005, sentinel surveillance of pregnant women attending antenatal clinics (ANC) is the primary source of HIV prevalence information (Ghys et al. 2006). Because the population samples targeted by ANC, by definition, exclude men, it is not possible to assess directly the relative impact of the disease on men and women through these data.

The dearth of two-sex HIV surveillance means that alternative methods are required to derive sex-specific estimates of HIV prevalence for regions and countries. In producing their biennial country-level estimates of sex-specific HIV prevalence for countries that rely exclusively upon ANC for HIV epidemic surveillance, UNAIDS utilizes an assumed female-to-male HIV prevalence ratio to infer male prevalence from the observed female prevalence (Garcia-Calleja et al. 2006). For mature generalized epidemics, UNAIDS assumes that HIV prevalence among women (the percentage of women aged 15 to 49 years who are living with HIV) is 1.5 times the HIV prevalence among men. For the majority of the 57 countries that UNAIDS produced generalized epidemic estimates for in 2005, the sex-specific HIV prevalence estimates reflect ANC estimates combined with the assumed prevalence ratio, rather than any HIV prevalence measured directly in men.

The assumed female-to-male HIV prevalence ratio of 1.5 utilized in the UNAIDS estimation procedure was selected based on evidence from a number of recent surveys that have enabled direct estimation of adult HIV prevalence in both sexes. The majority of these nationally representative population-based surveys were completed since 2001 when the Demographic and Health Surveys (DHS) programme first included biomarkers for HIV testing within the DHS conducted in both Mali and Zambia (Garcia-Calleja et al. 2006). Since then, at least 25 countries have completed HIV prevalence surveys that permit comparison of adult prevalence measured in women and men. The pool of completed surveys represents a wide range of HIV epidemic experiences. Table 1 lists the 25 two-sex HIV prevalence surveys completed since 2001. Adult HIV prevalence measured in the surveys ranges from a low 0.6 per cent of adults infected with HIV in both Cambodia and Senegal, to a high 22 per cent of adults infected with HIV according to the 2004 Lesotho DHS.

The surveys yield some of the first direct evidence that the HIV prevalence sex ratios vary across epidemics observed in different countries. Figure 2 displays the female-to-male HIV prevalence ratios and associated 95 per cent confidence intervals estimated in the 25 surveys. Prevalence sex ratios are very close to or even below 1.0 for several countries, including Burkina Faso, Cambodia, the Dominican Republic, and Niger, indicating that male HIV prevalence meets or exceeds female HIV prevalence. For other countries, namely Côte d'Ivoire, Guinea, and Senegal, the observed sex ratios of HIV prevalence exceed 2.0, indicating a much larger burden of disease among women compared to men. The width of the 95 per cent confidence intervals associated with the sex ratios of HIV prevalence varies widely across countries, depending upon the survey sample size and adult HIV prevalence. For the vast majority of the prevalence ratio estimates, the 95 per cent confidence intervals contain the UNAIDS assumed ratio 1.5. For five countries— Burkina Faso, Cambodia, the Dominican Republic, Haiti and the United Republic of Tanzania—the prevalence sex ratio and associated 95 per cent confidence interval lay entirely below 1.5. For another three countries— Côte d'Ivoire, Kenya, and South Africa—the sex ratio of HIV prevalence and associated confidence interval falls entirely above 1.5.

That countries where injecting drug use and sex between men account for a substantial number of HIV infections, such as Cambodia, the Dominican Republic, and Haiti, display among the lowest sex ratios of HIV prevalence, lends support to the transmission mode explanation of variation in the sex distribution of infection. But the variation between countries that are otherwise similar with respect to important modes of transmission—Kenya and the United Republic of Tanzania, for example, where heterosexual transmission accounts for nearly all new HIV infections—suggests that this explanation is insufficient.

To evaluate whether the maturity of the epidemic additionally explains the observed variation in the HIV prevalence sex ratio, Figure 3 shows the sex ratios plotted against the year the first AIDS case was reported in each country. All of the countries that have carried out national prevalence surveys reported their first AIDS cases between the years 1981 and 1993. If the length of time since the epidemic began were associated with a higher female-to-male ratio of HIV prevalence, then we would expect that those countries with an earlier epidemic onset would display the highest prevalence sex ratio. Consistent with that hypothesis, Figure 3 shows a slightly downward sloping association between the prevalence sex ratio and the year of the first AIDS case report, but it is a weak association at best, driven largely by the low 1.2 female-to-male prevalence ratio measured in Equatorial Guinea, a country that recorded its first AIDS case six years later than the other countries of Africa. Among the remaining countries, observed prevalence sex ratios vary widely across all start years for an epidemic.

Based on the limited evidence available from the 25 national two-sex HIV prevalence surveys, it seems that both popular explanations—differing mode of transmission and epidemic maturity—fail to explain much of the variation in the sex ratio of HIV prevalence across countries with generalized epidemics. If existing explanations are insufficient, then what factors determine the sex distribution of HIV infection in populations with otherwise similar epidemics? This paper seeks to understand the possible sources of variation in the female-to-male ratio of HIV prevalence observed across countries and across regions within countries of sub-Saharan Africa with generalized epidemics sustained by heterosexual transmission. Toward that end, a conceptual framework of the determinants of HIV prevalence is elaborated to generate hypotheses of possible sources of variation in the prevalence sex ratio. Those hypotheses are then tested using the results of 16 recent Demographic and Health Surveys (DHS) conducted in sub-Saharan Africa that included biomarkers for HIV testing among both male and female respondents. Strengths and limitations of evidence provided by the DHS are discussed.

Conceptual framework

More than two decades of bio-medical, epidemiological and sociological research has identified numerous risk factors for HIV infection and determinants of HIV epidemics. In formulating hypotheses as to the potential sources of variation in the sex ratio of HIV prevalence, it is important to begin with a careful consideration of those determinants. A conceptual framework provides a useful structure for understanding the linkages between the various risk factors and how they may come together to influence the sex distribution of HIV risk (Garnett 2007).

Figure 4 illustrates a conceptual framework that has been adapted for this analysis based upon earlier frameworks presented by Zaba and colleagues (2005) and Boerma and Weir (2005), who sought to understand the many sources of variation in the HIV epidemics observed across populations. The framework is built upon the proximate determinants terminology used widely by demographers to explain variation in fertility across populations (Bongaarts 1982). A key feature of the approach is that it specifies a set of proximate determinants through which all other risk factors must operate in order to influence the probability of an event – in this case the development of an HIV/AIDS epidemic. The risk factors are organized within the conceptual framework consistent with the fundamental principles of infectious disease epidemiology.

As there is no cure for AIDS, the number of people living with HIV in a closed population (no migration) at a given time is entirely a function of past HIV incidence (new infections) and mortality among those infected with HIV. The right-hand side of the conceptual framework illustrates the dependence of the primary outcome of interest, HIV prevalence, on the other two outcomes, HIV incidence and AIDS-related mortality. Both of these outcomes, in turn, are determined by the set of proximate determinants displayed in the center of the framework.

Because the focus of this paper is on generalized epidemics driven by heterosexual HIV transmission, only the proximate and background determinants associated with heterosexual exposure and transmission are included in the framework. The first category of proximate determinants of an HIV epidemic describes patterns of exposure to infection in the population. Among these is the degree of sexual activity in the population, sometimes measured as the proportion of the population that is sexually active or the number and types of sexual partnerships formed. Multiple sexual partners (Quigley et al. 1997; Wawer et al. 1994; Zablotska et al. 2006), premarital sexual activity (Bongaarts 2007), and commercial sexual activity (Auvert et al. 2001; Zablotska et al. 2006), for example, have all been linked to heightened HIV risk. In addition, patterns of sexual mixing between population subgroups that display different characteristics with respect to age (Auvert et al. 2001; Beagle and Ozler 2006) or sexual activity (Anderson et al. 1991) have been shown to be important determinants of the course of an HIV epidemic. The degree of temporal overlap in individuals' sexual partnerships, termed 'concurrency', is also recognized as a crucial factor in facilitating the spread of HIV through a sexual network (Morris and Kretzschmar 1997).

A second set of proximate determinants describes the efficiency of HIV transmission, given a sexual exposure. Women and men are not equally susceptible to HIV infection through heterosexual contact, a fact that has led HIV to be rightly termed a "biologically sexist" microbe (McBarnett 1988). Male-to-female transmission repeatedly has been found to be more efficient than female-to-male transmission. One highly-controlled prospective study of HIV serodiscordant heterosexual couples estimated average transmission probabilities per sexual contact of .0015 for male-to-female transmission and .0009 for female-to-male transmission (Mastro and de Vincezni 1996). Women's greater biological susceptibility has been variously attributed to the greater exposed surface area in the female genital tract compared to the male genital tract, higher concentrations of HIV in seminal fluids than in vaginal fluids, the larger amount of semen than vaginal fluids exchanged during intercourse, and greater potential for injury to the cell wall during intercourse for women compared to men (Moss et al. 1991; Pettifor et al. 2004).

Apart from fundamental differences in biologic vulnerabilities, several factors may alter men's and women's susceptibility to acquiring HIV infection through sexual intercourse. Male circumcision, for example, has long been hypothesized to lower risk of HIV infection in men, and recent randomized trials of the use of male circumcision to protect against HIV transmission have shown that circumcision reduces the risk of HIV infection in men between 48 and 60 per cent (Auvert et al. 2004; "Circumcision Halves H.I.V. Risk, U.S. Agency Finds" New York Times, December 14, 2006). In addition, coinfection with certain sexually transmitted infections (STI) are believed to enhance the heterosexual transmission probabilities of HIV by a factor ranging from two to five, although a handful of studies have estimated an even larger effect (Fleming and Wasserheit 1999). Studies generally agree that ulcerative infections (including herpes simplex virus type 2 (HSV-2), syphilis and chancroid) result in greater HIV infectiousness than non-ulcerative infections (such as gonorrhea and Chlamydia) (Røttingen, Cameron and Garnett 2001). Women tend to have higher symptomatic STI prevalence than men (Aral et al. 2006), but because STI affect both *infectivity of* and *susceptibility to* HIV, it is unclear whether STI comorbidities contribute to disproportionately more HIV infections in women or men (Røttingen, Cameron and Garnett 2001). Lastly, as Stillwaggon (2006) aptly points out, the biological mechanisms that lead STI to promote HIV transmission are the same as for other HIV cofactors that are not sexually transmitted. For example, malnutrition and parasite infection are two additional factors known to undermine immune system response and which may contribute to HIV risk in sub-Saharan Africa in particular.

The risk of HIV infection given a sexual exposure is further determined by a small number of behaviours that proximately alter the risk of HIV infection given a sexual exposure. Most effective among these behaviours is condom use. Condoms protect against sexual transmission of HIV in both men and women by establishing a barrier that prevents transfer of the body fluids that harbor the virus. Male condoms, when used correctly, are estimated to be effective in preventing penile-vaginal HIV transmission 87% of the time (Davis and Weller 1999), with some variation expected depending on the brand and type of condom. Female latex condoms are used much less frequently than male condoms and are somewhat less effective in preventing HIV transmission (Elias and Coggins 1996).

An additional subset of proximate determinants influences the transmission efficiency of HIV by determining the viral load among infected individuals. Viral load, which varies by duration of infection (Pilcher et al. 2004) and treatment with antiretroviral therapy (ART)

(Nicastri et al. 2005), has been identified as a key predictor of HIV transmission, with evidence of a dose-response relationship (Quinn et al. 2000; Riore et al. 1997). A multicenter longitudinal study of ART in 2,460 HIV-infected patients found no differences between men and women in terms of the multiple virological and immunological outcomes measured during the study period (Nicastri et al. 2005). Thus, the independent effect of the HIV viral load in the infected partner on the risk of HIV is not expected to vary by sex.

The numerous background characteristics listed on the left-hand side of the conceptual framework are linked to HIV risk only through the various proximate determinants. A masculine population sex ratio and young population age structure are thought to be associated with greater prevalence of high-risk sexual behaviours such as rapid turnover in sexual partnerships and commercial sexual activity (Over and Piot 1993). Urban areas tend to have higher HIV prevalence compared to rural areas, probably due to patterns of sexual activity and partnership formation that facilitate disease transmission (Drain et al. 2004). Religion and socioeconomic status are also correlated with risk behaviours and with mixing patterns that determine risk of exposure to infected individuals (Over 1998). Population mobility has been associated with HIV risk both because migrants who spend repeated or extended periods away from home may have greater opportunity or incentive to engage in high-risk partnerships and because migration creates a potential bridge for HIV infection between high-prevalence and low-prevalence areas (Quigley et al. 1997; Wawer et al. 1994; Lagarde et al. 2003).

Programmes to improve HIV/AIDS-related knowledge aim to reduce risky behaviour and increase use of protective measures such as condoms. The quality of and access to health infrastructure may be associated with HIV risk by contributing to HIV/AIDS knowledge, improving the availability of condoms, treating STI coinfections and parasitic infections, and providing access to ART leading to decreased viral load and thus lower transmission efficiency. Finally, gender inequality is thought to be associated with HIV risk because it limits women's bargaining power in sexual relationships, thereby reducing women's ability to protect themselves from infection transmitted from a male partner (Bajos and Marquet 2000). Furthermore, where barriers to women's formal labour market participation exist, transactional sex may be more prevalent.

The majority of research linking the various proximate and background determinants to HIV risk have focused on associations observed on the level of the individual. Fewer studies have aimed to describe HIV epidemic risk measured on the population scale. Only a handful of ecological analyses have demonstrated that a number of the proximate and background determinants included in the conceptual framework are key to understanding variation in the HIV prevalence observed across populations. The '4 Cities Study', a multicenter cross-sectional study carried out in four African cities in 1997 and 1998, found that rates of male circumcision were strongly associated with HIV prevalence. Young age at first marriage, young age of women at sexual debut, and large age differences between spouses also showed statistically significant differences across the high- and low-prevalence cities (Carael and Holmes 2001). A 1998 study by Mead Over found that between one-half and two-thirds of the variation in HIV prevalence estimated for the urban populations of 72 countries could be explained by eight summary measures of background risk factors including the age of the epidemic, GNP per capita, percent foreign born, percent Muslim, the Gini index of inequality, the male-female literacy gap, the sex ratio of the adult population, and percent of the population in the military. Aral and colleagues (2006) updated Over's 1998 study to show that the addition of gonorrhea and syphilis prevalence further improves the explanatory power of the model—both are positively associated with urban HIV prevalence.

If the conceptual framework displayed in Figure 4 accurately depicts the determinants of HIV incidence and prevalence, then one might reasonably hypothesize that differences in those determinants between men and women will contribute to observed gender differences in HIV prevalence. We have seen that women are biologically more susceptible to HIV infection through heterosexual sex relative to men. Because male circumcision further lowers the probability of female-to-male transmission relative to male-to-female transmission[1], it is expected that populations with a higher percentage of males circumcised will have a higher female-to-male ratio of HIV prevalence. It is further expected that gender-differences in the prevalence of STI coinfections will influence the sex ratio of HIV prevalence, although the direction of that association is less certain as STI coinfections are believed to enhance both the

[1] Turner et al. 2007 found no evidence of a protective effect of male circumcision for the female partners of circumcised men.

infectivity of the HIV-infected partner and the susceptibility to infection of the non-infected partner.

Other proximate determinants hypothesized to be associated with the prevalence sex ratio describe patterns of sexual partnering. Sexual activity that takes place prior to marriage carries a greater risk of HIV infection because these relationships are often likely to be short-term or casual. Where women's duration of premarital sexual exposure tends to be longer than men's, as indicated by comparisons of ages at first sex and marriage and the prevalence of premarital sexual activity, female-to-male ratios of HIV prevalence are expected to be higher. The sex ratio of HIV prevalence is also anticipated to be positively associated with the prevalence of polygamous marriage, an indicator of concurrent partnerships that exposes multiple women through sex with one single man.

In addition to those proximate determinants discussed above, several background characteristics are hypothesized to be associated with the female-to-male HIV prevalence ratio. The female-to-male sex ratio of the total adult population is expected to be negatively associated with the HIV prevalence sex ratio for two reasons. First, the population sex ratio is intrinsic to the sex ratio of HIV prevalence calculation shown in Equation 1.

$$ {}_{35}PR_{15} = \frac{\frac{{}_{35}N_{15}^{F+}}{{}_{35}N_{15}^{F}}}{\frac{{}_{35}N_{15}^{M+}}{{}_{35}N_{15}^{M}}} \qquad (1) $$

Where *PR* is the female-to-male ratio of HIV prevalence, ${}_{35}N_{15}^{F+}$ is the number of females aged 15 to 49 years living with HIV, ${}_{35}N_{15}^{F}$ is the total number of females aged 15 to 49 years, ${}_{35}N_{15}^{M+}$ is the number of males aged 15 to 49 years living with HIV, and ${}_{35}N_{15}^{M}$ is the total number of males aged 15 to 49 years.

Rearranging that equation, we arrive at Equation 2, where the prevalence sex ratio is expressed as the quotient of the female-to-male ratio of the number of adults living with HIV over the sex ratio of the adult population.

$$ {}_{35}PR_{15} = \frac{\frac{{}_{35}N_{15}^{F+}}{{}_{35}N_{15}^{M+}}}{\frac{{}_{35}N_{15}^{F}}{{}_{35}N_{15}^{M}}} \tag{2} $$

Thus, holding the sex ratio of the number living with HIV constant, a greater female-to-male ratio of the adult population would reduce the sex ratio of HIV prevalence. Second, that masculine sex ratios have been associated with a higher prevalence of risky sexual behaviours and higher HIV prevalence (Over 1998), may also influence the prevalence sex ratio.

Because the age distribution of HIV infection tends to be younger for women compared to men, a population with a younger age structure is expected to have a higher female-to-male HIV prevalence ratio (Gregson and Garnett 2000). Lastly, it is expected that where access to education, the labour market, and information on HIV/AIDS and prevention is equitable across genders, the distribution of HIV infection will also be more equitable.

Data

The Demographic and Health Survey (DHS) HIV prevalence surveys are currently the most well suited to address questions of sex-specific risk for HIV infection and sex ratio dynamics in HIV epidemics on a national scale. The DHS use a standardized questionnaire and HIV testing procedure, thereby facilitating comparisons both within and across countries. The DHS of sixteen countries located in sub-Saharan Africa, the region of the world most affected by the AIDS epidemic, are utilized in the analysis. The countries include Burkina Faso, Côte d'Ivoire, Cameroon, Ethiopia, Ghana, Guinea, Kenya, Lesotho, Malawi, Mali, Niger, Rwanda, Senegal, the United Republic of Tanzania, Zambia, and Zimbabwe[2]. With the exception of two countries,

[2] Data for the restricted Uganda AIS were not accessed in time to include in the analysis.

Côte d'Ivoire and the United Republic of Tanzania, where specialized AIDS Indicator Surveys (AIS) were conducted, the surveys used here are Standard DHS.

All 16 countries are experiencing HIV epidemics fueled by heterosexual transmission (UNAIDS 2006). As a subset of the 26 surveys discussed in the introduction, the sixteen countries included in the analysis represent a wide range of both HIV prevalence and sex ratios of HIV prevalence. Table 2 displays the sex-specific HIV prevalence among the population aged 15-49[3], the female-to-male ratio of HIV prevalence, and associated confidence intervals for the 16 countries. Adult HIV prevalence begins as low as 0.6 per cent in Senegal. At the high end of the HIV prevalence range is Lesotho with 22.9 per cent of DHS-sampled adults HIV positive, followed by Zimbabwe with 18.1 per cent of adults infected with HIV at the time of the survey. Female-to-male ratios of adult HIV prevalence estimated from the 16 surveys range from a low of 1.0 in Burkina Faso to a high 2.2 in Côte d'Ivoire.

The validity of HIV prevalence estimates and prevalence sex ratios derived from the DHS surveys depends on the absence of bias in survey coverage and participation. Response rates for the DHS, presented in Table 3, are similar to those reported in other population based surveys (Buve et al. 2001; Garcia-Calleja et al. 2006). Burkina Faso and Cameroon reported the highest response rates; close to 90 per cent agreed to be interviewed and to provide a blood sample for HIV testing. The lowest rates of participation in the HIV test portion of the DHS surveys were observed in Malawi where 70.4 per cent of eligible women and only 63.3 per cent of eligible men completed the HIV test. Two categories of non-response are identified: (1) refusal to provide a sample for the HIV test portion of the survey; and (2) absence from the home or other missing test result, which includes inconclusive tests resulting from sample collection or laboratory error. For women, refusal to participate in the HIV test portion of the survey accounts for a larger proportion of non-response than absence from the home or other missing result. For men, the opposite is the case: absence from the home or other missing test result account for the majority of non-response for the HIV test.

[3] Because the age distribution of HIV prevalence tends to be older for males relative to females, the exclusion of prevalence among the population older than 49 years in calculating the prevalence sex ratios will tend to inflate the estimate. While some DHS include males older than 49 years among eligible respondents, these are excluded from the prevalence sex ratio shown here in order to compare the prevalence sex ratios for the same age range across the 16 surveys.

To assess the potential impact of non-response on DHS HIV prevalence estimates, Mishra and colleagues (2006) analyzed possible bias due to test refusal in the eight countries for which DHS HIV test data were available at the time of their study. The authors concluded that in the context of generalized HIV epidemics, the population-based DHS are able to provide reliable national and regional estimates of HIV prevalence. However, that across all countries response rates were consistently higher for women compared to men raises important concern about potential bias in the measured sex ratio of HIV prevalence. The female-to-male test coverage ratio, shown in the final column of Table 3, indicates that in Lesotho and Zimbabwe, eligible female respondents were more than 20 per cent more likely to have a completed HIV test than male respondents. The female-to-male test coverage ratio is positively correlated with HIV prevalence (r=0.59). A weaker association is observed across the 16 surveys between the HIV prevalence sex ratio and the female-to-male test coverage ratio. They are negatively correlated (r=-0.15). While Mishra and colleagues did not explicitly set out to evaluate the validity of sex ratio measures obtained in the DHS, the results of their analysis permits an assessment of these data. The authors used individual characteristics recorded in the DHS/AIS for Burkina Faso, Cameroon, Ghana, Kenya, and the United Republic of Tanzania to predict sex-specific HIV prevalence among non-tested respondents and then adjust the estimated population HIV prevalence accordingly. HIV prevalence sex ratios calculated from their adjusted sex-specific HIV prevalence show only small changes from those based on tested respondents. For Burkina Faso, the adjusted prevalence sex ratio is 0.97, compared to the directly measured 0.94. [4] For Cameroon, the adjusted sex ratio is 1.69, compared to 1.73. For Ghana, the prevalence sex ratio is 1.60 adjusted, and 1.63 directly measured, and for the United Republic of Tanzania, the adjusted and directly measured sex ratios are 1.21 and 1.23, respectively. The largest difference in the adjusted and directly measured sex ratios among the five countries is in Kenya, where the adjusted ratio is 1.75 and the raw sex ratio is 1.85.

In spite of the potential biases to the measures of HIV prevalence and the prevalence sex ratio obtained in the DHS/AIS, these surveys remain the best available source of sex-specific

[4] The sex ratios of HIV prevalence calculated from Mishra et al. 2006 differ somewhat from those presented in Tables 1 and 2 because Mishra et al. used the full age range for each survey (up to age 54 or 59 for men, depending upon the survey), whereas the sex ratios in Tables 1 and 2 are based only upon the adult population aged 15-49 for both men and women.

measures of national HIV prevalence. An eye toward the potential biases in the HIV epidemic indicators is maintained in the proceeding analysis and interpretation of the results.

Methods

From the individual survey responses in the 16 DHS, summary measures that correspond to each of the proximate and background components of the conceptual framework are created on the both the country level and the level of the DHS administrative region. In defining each of the summary measures, the population of interest is restricted to males and females between the ages of 15 and 49 years and appropriate survey weights are used.

Two indicators are constructed to assess the relationship between factors that influence the sexual transmission efficiency of HIV and sex ratios of HIV prevalence. First, the percentage of male respondents who reported having been circumcised is calculated for the 15 countries for which a circumcision item was included in the survey (excludes Zambia). The second summary measure associated with transmission efficiency describes the female-to-male ratio of the percentage of adults who report STI symptoms (discharge or sores in the genital area) or diagnosis in the previous 12-month period. Self-report of STI symptoms is not a perfect measure of STI prevalence. Because certain STI are more likely to be symptomatic in women than in men (Aral et al. 2006), this proxy measure will tend to overstate the female-to-male ratio of STI prevalence. This bias is expected to be similar for all countries and regions, and the sex ratio of STI symptoms is presumed to be highly correlated with the sex ratio of prevalent STI.

An additional two indicators are constructed to facilitate assessment of the relationship between sexual partnership patterns and the sex ratio of HIV prevalence. First is the female-to-male ratio of the percentage of the adult population reporting having engaged in premarital sexual intercourse. This variable serves as a proxy indicator of the sex ratio of casual or short-term sexual partnerships that pose higher risk for HIV infection. This measure is chosen instead of the more commonly considered indicator of the number of sexual partners because it is anticipated to be measured with less error.[5] The second indicator that describes sexual

[5] That women tend to understate the number of unique sexual partners, while men tend to overstate sexual partnership is common to many surveys of sexual behaviour.

partnership patterns, the percentage of women current marriages that are polygynous (one man married to two or more wives), stands in as a measure of partnership concurrency. While this indicator does not necessarily correspond to the prevalence of concurrent non-marital partnerships, it is the only DHS variable available across the surveys that permits any assessment of concurrency.

Several summary measures of background characteristics hypothesized to be associated with the sex ratio of HIV prevalence are also constructed from the DHS. Demographic indicators of the female-to-male ratio of the adult population and the percentage of the adult population in the youngest age range 15 to 24 years are constructed based upon the household roster collected for each DHS. Summary measures of socioeconomic status include the female-to-male ratios of the percentage of respondents with primary education and above, with secondary education and above and the percentage of adults employed at the time of the survey. To represent disparities between men and women in occupation type among those employed, the female-to-male ratio of the percentage of adults employed in the professional occupational category (including professional, managerial, technical, clerical and sales) is also constructed. Lastly, the female-to-male ratio of the percentage of adults who agree that it is possible to take action to avoid contracting AIDS (e.g., use condoms, limit sexual activity to one partner, abstain from sexual activity, etc.) is constructed as a measure of gender inequality in HIV/AIDS knowledge.

Bivariate analysis on the country level is undertaken to assess whether the sex ratios of HIV prevalence observed in the 16 DHS surveys are correlated with the relevant components identified in the conceptual framework. Multivariate weighted least squares regression analysis is utilized to explore the associations between the population characteristics summarized on the level of DHS region and the sex ratio of HIV prevalence observed in those regions at the time of the survey. Because the dynamics of generalized epidemics—those with adult HIV prevalence greater than 1 per cent—differ from concentrated or low-level epidemics (UNAIDS 2006), the regression analyses are restricted to DHS regions with adult HIV prevalence greater than 1 per cent. In recognition of the high degree of variation in the width of the confidence intervals surrounding the point estimates of the HIV prevalence sex ratio, the multivariate analysis is weighted according to the inverse of the variance of the dependent variable.

Results

Table 4 displays the summary measures of the proximate and background determinants as calculated for the 16 countries. In nine of the 15 countries for which data on male circumcision are available in the DHS, greater than 90 per cent of male respondents report that they are circumcised. Guinea and Niger have the highest rates of male circumcision, with more than 99 per cent of males circumcised, while Rwanda and Zimbabwe have the lowest male circumcision rates, with around 10 per cent of male respondents reporting having been circumcised.

According to self-reports among DHS respondents, prevalence of STI symptoms or diagnosis over the year leading up to the survey varies widely across the 16 countries. Respondents in Guinea and Mali report the highest prevalence of STI symptoms or diagnosis at close to 23 per cent. Respondents to the Ethiopia DHS were least likely to report STI symptoms or diagnosis in the past year, at only 1.35 per cent. As expected given that many STI are more often symptomatic in infected women than infected men, the female-to-male ratio of STI symptom or diagnosis prevalence is greater than one in the majority of the 16 countries. In Guinea, women were more than four times more likely than men to report STI symptoms or diagnosis in the past 12 months. Counter to expectations, the female-to-male ratio of STI symptoms or diagnosis falls just below 1.0 for four countries: Mali, Niger, the United Republic of Tanzania and Zambia.

Summary measures of sexual partnership patterns also vary widely across the 16 countries. In four countries—Côte d'Ivoire, Kenya, the United Republic of Tanzania and Zimbabwe—premarital sexual activity is reported by more than half of respondents. The highest prevalence of premarital sexual activity was estimated for Côte d'Ivoire at 66.9 per cent. Niger had the lowest prevalence of reported premarital sexual activity at 8.63 per cent. In 15 of the 16 countries, women were less likely than men to have reported premarital sexual activity; the female-to-male ratio of premarital sex is well below 1.0. Only in Zambia were adult women more likely than men to have reported premarital sexual activity. Polygamous marriage is common in many of the 16 countries. In Burkina Faso, Ghana, Guinea, and Mali, more than half of reported marriages are polygamous, while in the United Republic of Tanzania, less than 10 per cent of marriages are polygamous.

A high degree of variation across countries is also observed in the summary measures of background characteristics associated with HIV risk. The majority of the 16 countries display relatively feminine adult population sex ratios, which is not surprising given that a number of these countries experience emigration of men at higher rates than women in addition to lower mortality rates for women relative to men. Niger and Guinea show the highest sex ratios of the adult population, with 1.3 females between the ages of 15 and 49 years for every male in that age range. The lowest adult population sex ratios are observed in Malawi (1.0) and Lesotho (0.99). Less variation is seen across countries in the adult population age structure. The percentage of the population aged 15 to 49 years that is in the 15 to 24 years age category ranges from a low of 37 per cent in Niger and Guinea to a high 47 per cent in Lesotho.

For most of the 16 countries, the summary measures presented in Table 4 indicate that women face disadvantages relative to men in education and employment. These disadvantages tend to be greatest in Burkina Faso, Ethiopia, Guinea, Niger, and Senegal, where women are substantially less likely to have completed primary or secondary education compared to men. In contrast, in Lesotho and Mali, female respondents were more likely than male respondents to have completed primary or secondary education. In eight of the 16 countries—Burkina Faso, Ghana, Guinea, Lesotho, Mali, Rwanda, the United Republic of Tanzania and Zambia—women were about as likely or even more likely than men to report being employed at the time of the survey. In most countries, women were considerably more likely than men to be employed in a ‘professional’ occupation (including professional, technical, managerial, clerical and sales), with the exception of Cameroon and Rwanda, where men were more likely to report being employed in this category.

Lastly, in most of the 15 countries where data were collected on HIV/AIDS knowledge (excludes Zimbabwe) women were almost as likely as men to correctly state that it is possible for a person to avoid contracting AIDS. One notable exception is Niger where women were nearly

40 per cent less likely than men to report that AIDS is avoidable. In Lesotho, women were 8 per cent more likely than men to agree with the statement.

The proximate determinants of HIV risk describe the patterns of exposure to HIV infection and the efficiency of HIV infection given an exposure. It is hypothesized that these proximate determinants or gender differences in the proximate determinants are associated with the female-to-male ratio of HIV prevalence because they determine differential exposure and disease transmission by sex. Figure 5 plots the HIV prevalence sex ratio against the proximate determinants of HIV risk. The top-left chart in Figure 5 shows the prevalence sex ratio plotted against the percentage of adult males circumcised for the 15 countries with available circumcision data. Consistent with the hypothesis, the percentage of males circumcised is positively correlated with the female-to-male HIV prevalence ratio, although that relationship does not appear very strong (r=0.290). More notable is the stronger and association between the female-to-male ratio of STI prevalence and the HIV prevalence sex ratio (r=0.678). Plotting the summary measures of sexual partnership patterns – the sex ratio of premarital sexual activity and the percentage of marriages that are polygamous – reveals no apparent association with the HIV prevalence sex ratio (r=0.083 and r=0.055, respectively).

Figures 6 and 7 plot the sex ratio of HIV prevalence against the summary measures of background characteristics. No association is evident between the demographic measures reflecting the adult population sex ratio or age structure and the female-to-male ratio of HIV prevalence. Sex ratios of educational attainment also show little association with the HIV prevalence sex ratio. Several countries where women's education is much lower relative to men's, including Côte d'Ivoire, Ethiopia, Guinea, and Senegal have among the highest sex ratios of HIV prevalence. However, other countries with large gender disparities in education, namely Burkina Faso and Niger, display the lowest female-to-male ratios of HIV prevalence.

The female-to-male ratio of the percentage currently employed (top-left chart of Figure 7) shows little relationship to the prevalence sex ratio (r=-0.091), while the sex ratio of the percentage employed in the professional occupational category displays a fairly strong, positive association with the female-to-male HIV prevalence ratio across the 16 countries (r=0.475). As there is little variation in the sex ratio of the percentage who agree that it is possible for a person to avoid contracting AIDS (a measure of HIV/AIDS knowledge), the lower chart in Figure 7 also shows little relationship between that indicator and the HIV prevalence sex ratio.

Up to this point, associations measured on the level of the country have done little to illuminate potential sources of variation in the HIV prevalence sex ratio. What few relationships were detected—male circumcision, gender disparities in education and occupational category—were weak with little explanatory power. The most striking correlation observed was between the sex-ratio of STI prevalence and the HIV prevalence sex ratio. The absence of relationships observed on the country level does not necessarily mean that the indicators explored in Figures 6 and 7 are not important determinants of the prevalence sex ratio. Especially for large heterogeneous countries, these summary measures may mask the variation that exists in HIV epidemics that develop and are sustained on a smaller geographical scale. In order to assess the variation that occurs in the sex ratio of HIV prevalence across HIV epidemics measured on a smaller, local scale, the epidemic indicators and summary measures are constructed on the level of the DHS administrative region. Table 5 describes the HIV epidemic variation across regions within countries.

The number of DHS administrate regions varies by country. While in the United Republic of Tanzania 21 separate regions were defined and accommodated in the AIS sampling procedure, Malawi has only 3 administrative regions in its DHS. Because the focus of this paper is on generalized epidemics, the regions included for analysis are restricted to those with adult HIV prevalence as measured in the surveys greater than or equal to 1.0 per cent. This restriction reduces the number of regions included across the 16 surveys from 167 to 141.

Summary statistics for the HIV epidemic indicators, proximate determinants, and background characteristics are displayed in Table 6. The adult HIV prevalence measured in the 141 regions ranges from a low of 1.0 per cent to a high of 29.5 per cent, with a mean prevalence of 7.1 per cent. A measure of the sex ratio of HIV prevalence is estimated for 140 regions; the Kidal region of Mali is excluded due to zero HIV prevalence measured among men in that sample. The female-to-male HIV prevalence ratio ranges from 0.2 to 5.4. The mean prevalence ratio is 1.7 and 65 per cent of regions fall between 1.0 and 2.2 (the range of prevalence sex ratios measured on a national scale across the 16 surveys).

Weighted least squares regression is carried out to assess the relationships between the proximate determinants and background characteristics and the sex ratio of HIV prevalence. The dependent variable for the regressions is the female-to-male HIV prevalence ratio. Observations are weighted according to the inverse of the variance of the prevalence sex ratio such that regions where the prevalence sex ratio was measured with greater precision are given more weight in the fitting the models. Table 7 presents the results of multivariate analysis of the association between sex differences in the proximate determinants and background characteristics associated with HIV prevalence and the female-to-male ratio of HIV prevalence measured at the level of the region. Model 1 includes as independent variables only the proximate determinants associated with transmission efficiency. As with the bivariate analysis for countries, both indicators are positively associated with the HIV prevalence sex ratio. A 25 percentage point increase in the percentage of males circumcised is associated with an increase in the HIV prevalence sex ratio of 0.1. An increase in the female-to-male ratio of STI prevalence of 2.4 (one standard deviation) is associated with a rise in the prevalence sex ratio of 0.26. These two variables explain nearly 13 per cent of the total variation in the sex ratio of HIV prevalence (adjusted R^2=0.127) observed across 131 regions with HIV prevalence greater than 1 per cent (excludes the nine regions of Zambia, where male circumcision was not assessed).

Model 2 considers only the proximate determinants that describe sexual partnership patterns in the region. Again, both the female-to-male ratio of the percentage of adults who report premarital sexual activity and the percentage of marriages that are polygamous are positively associated with the sex ratio of HIV prevalence. The effect sizes are weak, however, and the two variables together explain just under 3 per cent of the total variation in the female-to-male HIV prevalence ratio across regions.

Model 3 includes as independent variables four background characteristics identified in the conceptual framework: the female-to-male ratio of the adult population, the percentage of adults in the youngest age group 15 to 24 years, the female-to-male ratio of the percentage who completed secondary education, and the sex ratio of employment in a "professional" occupation. Only the latter two show statistically significant associations with the dependent variable, and these are extremely weak. A one standard deviation increase in the sex ratio of secondary education (0.3) decreases the prevalence sex ratio by 0.09, while a one standard deviation increase in the female-to-male ratio of professional occupation (1.0) increases the sex ratio of HIV prevalence by 0.1. The four background characteristics considered in Model 3 explain less than 2 per cent of the total variation in the sex ratio of HIV prevalence across regions.

Model 4 adds the variables that describe sexual partnership patterns to those that determine transmission efficiency. There is little improvement in fit for Model 4 compared to Model 1, which included only the transmission efficiency variables. The coefficients for male circumcision, the sex ratio of STI prevalence and the percentage of marriages polygynous weaken somewhat in this combined model compared to models 1 and 2, and the female-to-male ratio of premarital sexual activity loses statistical significance. Model 5 further adds the background characteristics to the model with transmission efficiency and sexual partnership patterns. Contrary to what is expected given that the background characteristics are anticipated to be associated with HIV risk only through the proximate determinants, the addition of the background characteristics strengthens somewhat the associations between the sex ratio of premarital sexual activity and polygamous marriage, respectively, with the HIV prevalence sex ratio. The coefficient on the sex ratio of secondary education loses statistical significance, while the coefficient on the female-to-male ratio of professional occupation increases. The combined model, however, explains only 17 per cent of the total variation in the HIV prevalence sex ratio.

Discussion

Achieving an improved understanding of the roles of sex and gender in HIV/AIDS epidemics is critical to the future of AIDS research and initiatives aimed at prevention and treatment of the disease. The UNAIDS approach to fighting AIDS emphasizes that the first step is to "know your epidemic" (UNAIDS 2006). This means understanding how disease is spread and who is most affected. Fundamental to "knowing your epidemic" is identifying the sex-distribution of those infected and acknowledging how sex and gender interact with HIV epidemics to shape the burden of disease.

When direct estimates of HIV prevalence are not available for both men and women, an alternative method must be used to infer male prevalence from the female prevalence measured via ANC surveillance. UNAIDS assumes a female-to-male adult HIV prevalence ratio of 1.5 in estimating sex-specific prevalence from ANC data for countries with generalized epidemics. However, evidence from 25 recent two-sex national HIV prevalence surveys indicates that for some countries, this assumption may not accurately reflect the true sex ratio of HIV prevalence. The 2003-04 Tanzania AIS, for example, detected a female-to-male HIV prevalence ratio of 1.2. UNAIDS incorporated the Tanzania AIS sex ratio into their 2005 round of HIV prevalence estimates for that country, to estimate that 7.7 per cent of women and 6.3 per cent of men were living with HIV at the end of 2005. Had the assumed sex ratio of 1.5 been used instead, the estimated prevalence among women and men would have been 8.4 percent and 5.6 per cent, respectively.

In addition to providing HIV prevalence estimates for both men and women, the recent DHS HIV prevalence surveys have enabled analysis of the relationships between several factors commonly associated with HIV prevalence and the HIV prevalence sex ratio. The analysis presented here of 16 DHS/AIS for countries of sub-Saharan Africa reveals that a handful of HIV epidemic determinants are linked to the prevalence sex ratio measured across regions within the 16 countries, but taken together these indicators explain less than 20 per cent of the overall variation in the female-to-male HIV prevalence ratio.

Two variables—the percentage of males circumcised and the female-to-male ratio of STI prevalence—show the strongest relationships to the prevalence sex ratio; both are positively correlated with it. Male circumcision likely widens the gap between the female-to-male and male-to-female sexual transmission probabilities of HIV, contributing to the disproportionately feminine distribution of HIV prevalence in populations where male circumcision is common. The female-to-male ratio of STI prevalence is associated with the HIV prevalence sex ratio probably because STI elevate susceptibility to HIV infection, but also because many of the important proximate and background determinants of HIV risk are determinants of STI risk as well. Thus while this indicator was included in the analysis under the ‘transmission efficiency’ heading, it likely additionally encompasses many of the components of sexual partnership patterns and background characteristics.

The analysis presented here faces several important limitations arising from both the data and the model. While the DHS are currently the best available empirical data source for evaluating sex-specific HIV prevalence on a national scale, a number of limitations remain that hinder an analysis of both the extent of the variation that exists in the sex ratio of HIV prevalence and the potential determinants of that variation. With only the 16 country surveys disaggregated to include 141 regions with generalized HIV epidemics, many of the observed associations across regions fail to satisfy tests of statistical significance. In addition, the wide confidence intervals surrounding the HIV prevalence sex ratio estimates make it difficult to identify meaningful variation in the sex-distribution of infection across countries.

Differential non-response among men and women potentially biases the measures of the HIV prevalence sex ratio, although based on the analysis of non-response conducted by Mishra and colleagues (2006), these biases are expected to be small. An additional potential source of bias in the HIV prevalence sex ratio estimates from the DHS arises because the sampling procedure includes only the household population. To the extent that persons not living in households (i.e., those living on the street or institutions including prisons, boarding schools, military barracks, refugee camps and brothels) display a different sex distribution of HIV prevalence relative to the household population, bias will be introduced to the prevalence sex ratio estimates. However, because the proportion of non-household residing persons within the total population tends to be small (Mishra et al. 2006), these biases are also expected to be small. As surveys of sex-specific HIV prevalence among the non-household populations become available, their results should be incorporated into analyses of HIV prevalence sex ratios.

Lastly, the results of this study are limited in that not all components of the conceptual framework are included in the analytic models. Many of those components are not captured in many household surveys, although an increasing number of DHS are including items on a number of important indicators included within the conceptual framework. Anthropometric measures associated with nutrition, information on ART, and modules that aim to assess gender equality and gender-based violence are included in several of the completed DHS and AIS and many of those surveys presently underway. That the analysis presented here has considered only sex differences in HIV *prevalence* and has not considered the important contributions of sex-specific *incidence* and *mortality,* further restricts the interpretation of the results. The single cross-sectional surveys available for each country do not currently permit an empirical study of the relationships between sex-specific incidence, prevalence and mortality on a national scale. Mathematical models and smaller-area community-cohort studies have proven useful for evaluating these dynamics (e.g. Gregson and Garnet 2000), but no empirical study has been able to assess whether and how trends over time in the sex-distribution of HIV infection varies across countries. More and improved measures of sex-specific HIV epidemic dynamics and the many proximate and background components of the conceptual framework will facilitate enhanced understanding of the roles of sex and gender therein in influencing the sex distribution of disease burden within populations affected by AIDS.

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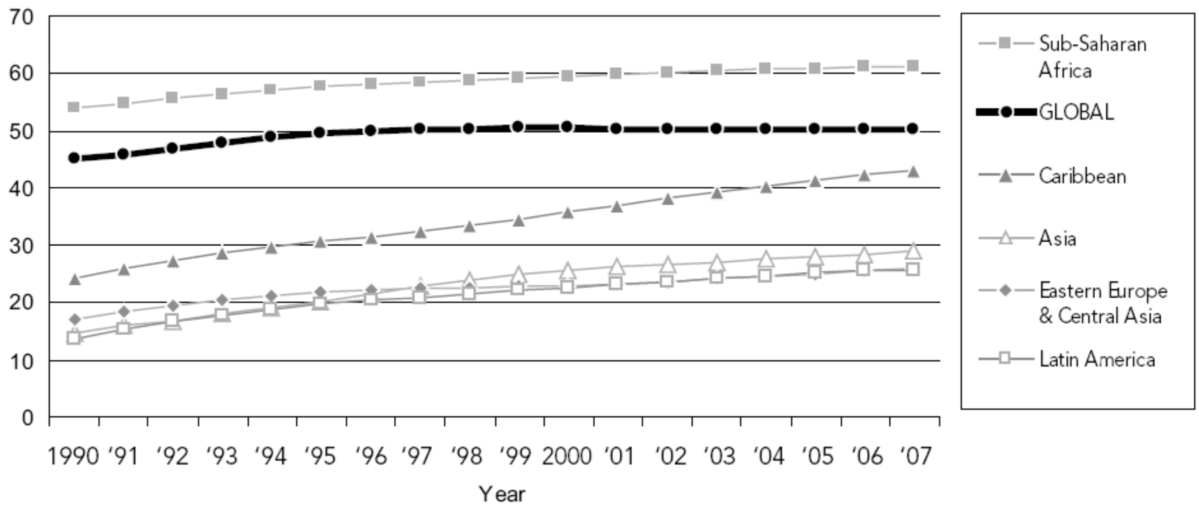
Figure 1. Percentage of adults (age 15+) living with HIV who are female, 1990-2007



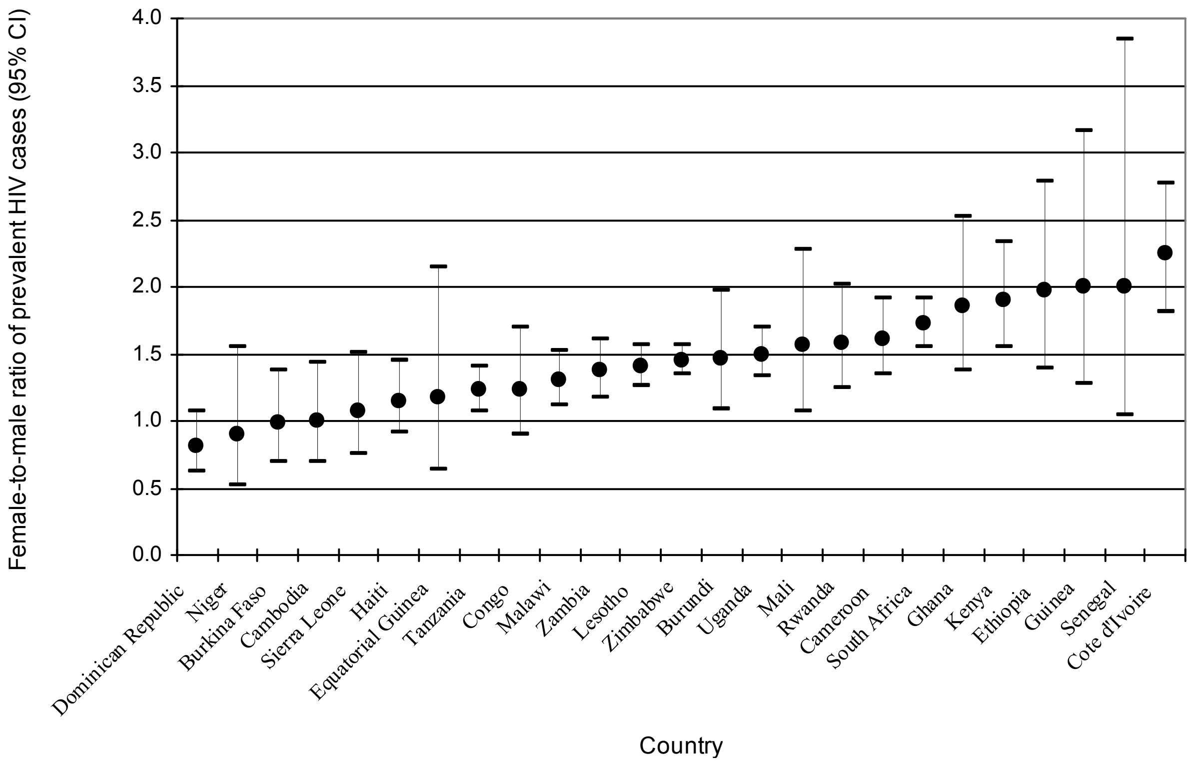
Source: UNAIDS *2007 AIDS Epidemic Update*. Geneva: UNAIDS.

Table 1. National population-based two-sex HIV prevalence surveys.

Country	Year	Survey type	Age range (years)		Sample size		HIV prevalence			F-to-M ratio
			F	M	F	M	F	M	Total	
Burkina Faso	2003	DHS	15-49	15-59	4,086	3,065	1.8	1.9	1.8	1.0
Burundi	2002	HH survey	>12	>12	2,909	2,660	3.8	2.6	3.6	1.5
Cambodia	2005	DHS	15-49	15-49	8,638	7,229	0.6	0.6	0.6	1.0
Cameroon	2004	DHS	15-49	15-59	5,227	4,672	6.6	4.1	5.4	1.6
Congo	2003	HH survey in urban areas	15-49	15-49	1,657	1,796	4.7	3.8	4.2	1.2
Côte d'Ivoire	2005	AIS	15-49	15-49	5,183	4,503	6.4	2.9	4.7	2.2
Dominican Republic	2002	DHS	15-49	15-49	12,514	14,455	0.9	1.1	1.0	0.8
Equatorial Guinea	2004	HH survey	15-49	15-49	863	586	3.4	2.9	3.2	1.2
Ethiopia	2005	DHS	15-49	15-59	7,142	6,778	1.9	0.9	1.4	2.0
Ghana	2003	DHS	15-49	15-59	5,097	4,047	2.7	1.5	2.2	1.9
Guinea	2005	DHS	15-49	15-59	3,875	2,502	1.9	0.9	1.5	2.0
Haiti	2005	DHS	15-49	15-59	5,368	5,094	2.3	2.1	2.2	1.2
Kenya	2003	DHS	15-49	15-59	3,151	2,851	8.7	4.6	6.7	1.9
Lesotho	2004	DHS	15-49	15-59	3,758	3,305	25.9	18.4	22.9	1.4
Malawi	2004	DHS	15-49	15-54	4,071	3,797	13.3	10.2	11.8	1.3
Mali	2001-02	DHS	15-49	15-59	3,854	2,978	2.1	1.3	1.8	1.6
Niger	2006	DHS	15-49	15-59	4,889	3,839	0.7	0.8	0.7	0.9
Rwanda	2005	DHS	15-49	15-59	5,679	4,339	3.6	2.3	3.0	1.6
Senegal	2005	DHS	15-49	15-59	4,521	3,004	0.8	0.4	0.6	2.0
Sierra Leone	2005	HH survey	15-49	15-49	4,812	3,496	1.6	1.5	1.5	1.1
South Africa	2005	HH survey	>2	>2	5,650	3,595	20.2	11.7	10.2	1.7
Uganda	2004-05	AIS	15-49	15-49	9,294	7,425	7.5	5.0	6.4	1.5
United Republic of Tanzania	2003-04	AIS	15-49	15-49	7,154	6,196	7.7	6.3	7.0	1.2
Zambia	2001-02	DHS	15-49	15-59	2,689	2,418	17.8	12.9	15.6	1.4
Zimbabwe	2005-06	DHS	15-49	15-54	6,947	5,848	21.1	14.5	18.1	1.5

F: Female; M: Male; DHS: Demographic and Health Survey; HH: Household; AIS: AIDS Information Survey
Sources: Demographic and Health Surveys and Garcia-Calleja et al. 2006.

Figure 2: Female-to-male HIV prevalence ratios and 95% confidence intervals estimated from nationally representative population-based surveys.



Sources: Demographic and Health Surveys and Garcia-Calleja et al. 2006.

Figure 3: Female-to-male HIV prevalence ratios and year of first AIDS case reported.

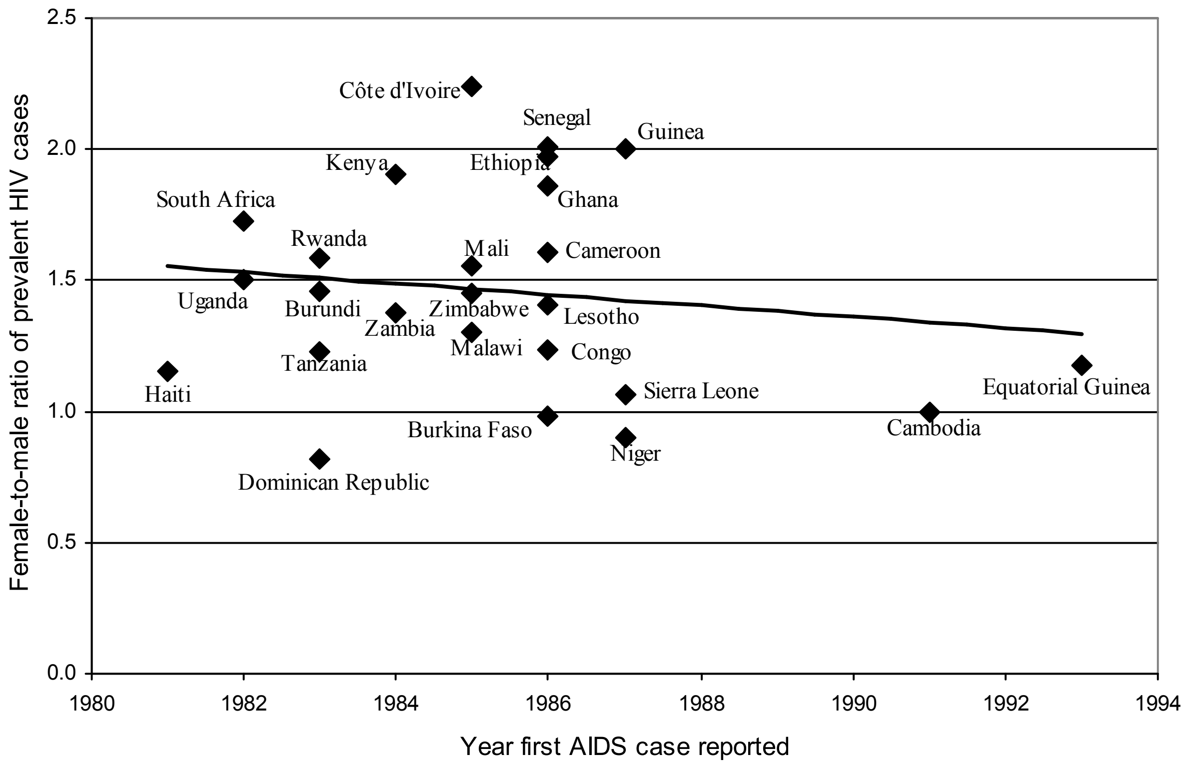
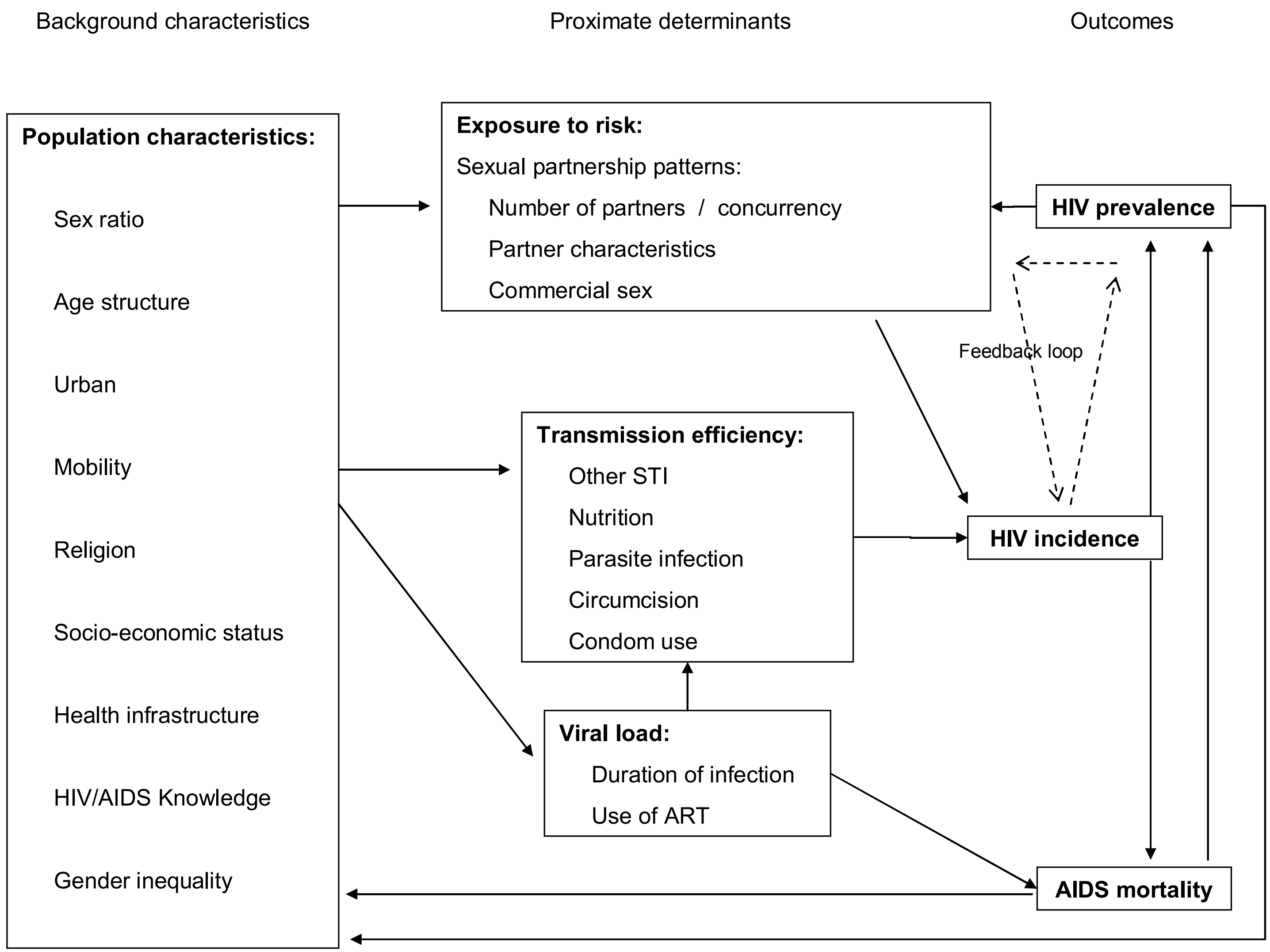


Figure 4. Conceptual framework for HIV epidemic risk in a population where heterosexual sex is the predominant mode of transmission.



Adapted from the conceptual frameworks presented by Zaba et al. (2005) and Boerma and Weir (2005).

Table 2. HIV epidemic indicators for 16 African DHS and AIS.

Country	Year(s)	Test rate (per cent)		HIV prevalence among adults aged 15-49 [confidence interval]			Female-to-male ratio of HIV prevalence
		Male	Female	Male	Female	Total	
Burkina Faso	2003	85.8	92.3	1.9 [1.4 - 2.3]	1.8 [1.4 - 2.2]	1.8 [1.5 - 2.2]	1.0 [0.7 - 1.4]
Cameroon	2004	89.9	92.1	4.1 [3.6 - 4.7]	6.6 [6.0 - 7.3]	5.4 [5.0 - 5.9]	1.6 [1.4 – 1.9]
Côte d'Ivoire	2005	76.3	79.1	2.9 [2.3 - 3.4]	6.4 [5.7 - 7.1]	4.7 [4.3 - 5.2]	2.2 [1.8 - 2.8]
Ethiopia	2005	75.6	83.4	0.9 [0.7 - 1.2]	1.9 [1.5 - 2.2]	1.4 [1.2 - 1.7]	2.0 [1.4 – 2.8]
Ghana	2003	80.0	89.3	1.5 [1.1 - 1.8]	2.7 [2.3 - 3.2]	2.2 [1.9 - 2.5]	1.9 [1.4 - 2.5]
Guinea	2005	88.2	92.5	0.9 [0.6 - 1.3]	1.9 [1.5 - 2.3]	1.5 [1.2 - 1.8]	2.0 [1.3 - 3.2]
Kenya	2003	70.3	76.3	4.6 [3.8 - 5.3]	8.7 [7.7 - 9.7]	6.7 [6.1 - 7.4]	1.9 [1.6 - 2.3]
Lesotho	2004	68.0	80.7	18.4 [16.7 – 20.1]	25.9 [24.3 – 27.4]	22.9 [21.7 - 24.0]	1.4 [1.3 - 1.6]
Malawi	2004	63.3	70.4	10.2 [9.0 - 11.4]	13.3 [12.0 - 14.6]	11.8 [10.9 - 12.7]	1.3 [1.1 - 1.5]
Mali	2001	75.6	85.2	1.3 [0.9 – 1.7]	2.1 [1.6 – 2.5]	1.8 [1.5 – 2.1]	1.6 [1.1 – 2.3]
Niger	2006	85.2	92.0	0.8 [0.5 - 1.1]	0.7 [0.5 – 1.0]	0.7 [0.5 - 0.9]	0.9 [0.5 - 1.6]
Rwanda	2005	95.6	97.3	2.3 [1.8 - 2.7]	3.6 [3.1 - 4.1]	3.0 [2.7 - 3.4]	1.6 [1.3 – 2.0]
Senegal	2005	75.5	84.5	0.4 [0.2 - 0.6]	0.8 [0.5 - 1.0]	0.6 [0.4 - 0.8]	2.0 [1.1 – 3.8]
United Republic of Tanzania	2003-04	77.0	83.5	6.3 [5.6 – 6.9]	7.7 [7.0 - 8.4]	7.0 [6.6 - 7.5]	1.2 [1.1 - 1.4]
Zambia	2001-02	73.1	79.2	12.9 [11.4 - 14.5]	17.8 [16.1 - 19.4]	15.6 [14.4 - 16.7]	1.4 [1.2 - 1.6]
Zimbabwe	2005-06	63.4	75.9	14.5 [13.6 - 15.4]	21.1 [20.1 - 22.1]	18.1 [17.4 - 18.8]	1.5 [1.4 - 1.6]

DHS: Demographic and Health Survey; AIS: AIDS Information Survey
Confidence intervals are calculated based upon the sex-specific sample sizes and HIV prevalence reported for each survey.

Table 3. HIV test coverage rates for 16 DHS/AIS HIV prevalence surveys

	Women			Men			Adult HIV prev. (%)	F-to-M ratio of HIV prev.	F-to-M ratio of test coverage
	Tested	Refused	Absent/ other/ missing	Tested	Refused	Absent/ other/ missing			
Burkina Faso	92.3	4.4	3.4	85.8	6.6	7.6	1.8	1.0	1.1
Cameroon	92.1	5.4	2.4	89.8	5.6	4.6	5.4	1.6	1.0
Côte d'Ivoire	79.1	10.6	10.2	76.3	11.1	12.5	4.7	2.2	1.0
Ethiopia	83.4	13.4	3.3	75.6	16.9	7.3	1.4	2.0	1.1
Ghana	89.3	5.7	5.0	80.0	10.7	9.4	2.2	1.9	1.1
Guinea	92.5	5.0	2.5	88.2	8.5	3.4	1.5	2.0	1.0
Kenya	76.3	14.4	9.3	70.3	13.0	16.6	6.7	1.9	1.1
Lesotho	80.7	12.0	7.3	68.0	16.6	15.5	22.9	1.4	1.2
Malawi	70.4	22.5	7.1	63.3	21.9	14.8	11.8	1.3	1.1
Mali	85.2	n/a	n/a	75.6	n/a	n/a	1.8	1.6	1.1
Niger	92.0	4.5	3.6	85.2	6.1	8.7	0.7	0.9	1.1
Rwanda	97.3	1.1	1.6	95.6	1.9	2.5	3.0	1.6	1.0
Senegal	84.5	9.9	5.5	75.5	16.0	8.4	0.6	2.0	1.1
United Republic of Tanzania	83.5	12.3	4.3	77.0	13.9	9.1	7.0	1.2	1.1
Zambia	79.2	15.4	5.3	73.1	4.8	12.1	15.6	1.4	1.1
Zimbabwe	75.9	13.2	10.8	63.4	17.4	19.2	18.1	1.5	1.2

F: Female; M: Male; Prev.: prevalence; n/a: data not available
Sources: ORC Macro final reports

Table 4: Summary measures of proximate determinants for countries

	Burkina Faso	Côte d'Ivoire	Cameroon	Ethiopia	Ghana	Guinea	Kenya	Lesotho
HIV epidemic indicators								
HIV prevalence (%)	1.84	4.71	5.44	1.44	2.15	1.50	6.73	22.86
HIV sex ratio (F/M)	0.98	2.24	1.61	1.97	1.86	2.00	1.90	1.40
Transmission efficiency								
Males circum. (%)	90.28	96.57	93.12	92.36	95.41	99.13	83.89	46.77
STI prevalence (%)	3.77	13.11	9.57	1.35	5.33	23.10	3.33	11.74
STI sex ratio (F/M)	1.35	2.55	1.38	1.59	2.20	4.12	1.37	1.30
Sexual partnership patterns								
Pre-mar sex (%)	28.47	66.90	47.78	14.31	48.31	33.45	60.04	43.08
Pre-mar sex ratio (F/M)	0.46	0.73	0.64	0.42	0.80	0.30	0.67	0.52
Poly. Marriage (%)	55.84	21.69	46.98	32.85	52.46	60.44	37.09	20.42
Background characteristics								
Pop. sex ratio (F/M)	1.18	1.12	1.06	1.04	1.22	1.31	1.05	0.99
Pop. age 15-24 (%)	43.55	45.00	44.94	42.93	39.03	37.55	44.16	47.33
Primary education (%)	23.32	55.33	81.54	41.46	77.01	29.97	89.36	94.58
Prim. educ. sex ratio (F/M)	0.53	0.70	0.86	0.56	0.86	0.43	0.93	1.15
Secondary education (%)	10.67	29.50	43.70	14.51	58.56	16.93	31.64	36.25
Sec. educ. sex ratio (F/M)	0.47	0.48	0.72	0.56	0.77	0.33	0.79	1.32
Employed (%)	86.52	72.68	65.46	48.79	77.38	79.55	65.86	45.05
Employed sex ratio (F/M)	1.06	0.87	0.85	0.39	1.01	1.11	0.82	0.98
Employed prof. (%)	19.35	35.72	6.22	22.86	30.03	32.62	28.66	22.10
Employ prof. sex ratio (F/M)	1.28	2.49	0.38	3.80	1.99	1.85	1.47	1.50
AIDS avoidable (%)	90.84	77.39	87.05	72.10	81.20	76.91	89.10	85.21
AIDS avoid. sex ratio (F/M)	0.95	0.87	0.89	0.84	0.93	0.90	0.94	1.08

(continued on next page)

Table 4 (continued).

	Mali	Malawi	Niger	Rwanda	Senegal	United Republic of Tanzania	Zambia	Zimbabwe
HIV epidemic indicators								
HIV prevalence (%)	1.76	11.83	0.74	3.03	0.61	7.03	15.57	18.11
HIV sex ratio (F/M)	1.56	1.30	0.90	1.59	2.01	1.23	1.38	1.45
Transmission efficiency								
Males circum. (%)	92.15	21.22	99.41	9.80	98.32	69.82	n/a	10.32
STI prevalence (%)	22.48	6.91	2.66	3.02	7.57	4.87	5.20	7.15
STI sex ratio (F/M)	0.98	1.51	0.98	1.83	3.22	0.88	0.98	1.52
Sexual partnership patterns								
Pre-mar sex (%)	25.70	40.86	8.63	25.24	16.75	53.54	43.06	53.47
Pre-mar sex ratio (F/M)	0.85	0.50	0.17	0.37	0.18	0.62	1.12	0.36
Poly. Marriage (%)	52.25	31.54	48.20	35.76	46.46	9.77	15.74	44.89
Background characteristics								
Pop. sex ratio (F/M)	1.14	1.00	1.33	1.20	1.21	1.12	1.03	1.16
Pop. age 15-24 (%)	40.15	44.82	37.32	45.62	44.20	41.74	44.79	46.34
Primary education (%)	22.57	79.95	20.91	78.62	43.93	82.78	87.93	97.03
Prim. educ. sex ratio (F/M)	1.17	0.87	0.49	0.92	0.69	0.88	0.98	0.97
Secondary education (%)	10.51	17.93	8.44	10.46	18.16	9.61	29.96	67.33
Sec. educ. sex ratio (F/M)	1.13	0.57	0.39	0.75	0.50	0.76	1.06	0.87
Employed (%)	39.04	22.47	33.46	9.40	40.68	22.93	5.62	24.85
Employed sex ratio (F/M)	0.98	0.76	0.56	1.30	0.60	0.97	1.16	0.59
Employed prof. (%)	64.58	62.17	56.14	68.28	50.88	83.52	57.05	48.06
Employ prof. sex ratio (F/M)	1.11	1.17	1.49	0.64	1.82	1.25	1.75	1.92
AIDS avoidable (%)	63.44	95.83	60.87	92.66	81.55	90.72	85.92	n/a
AIDS avoid. sex ratio (F/M)	1.01	0.96	0.64	0.91	0.98	0.96	0.97	n/a

n/a: data not available

Figure 5. Scatter plots of proximate determinants and the sex ratio of HIV prevalence.

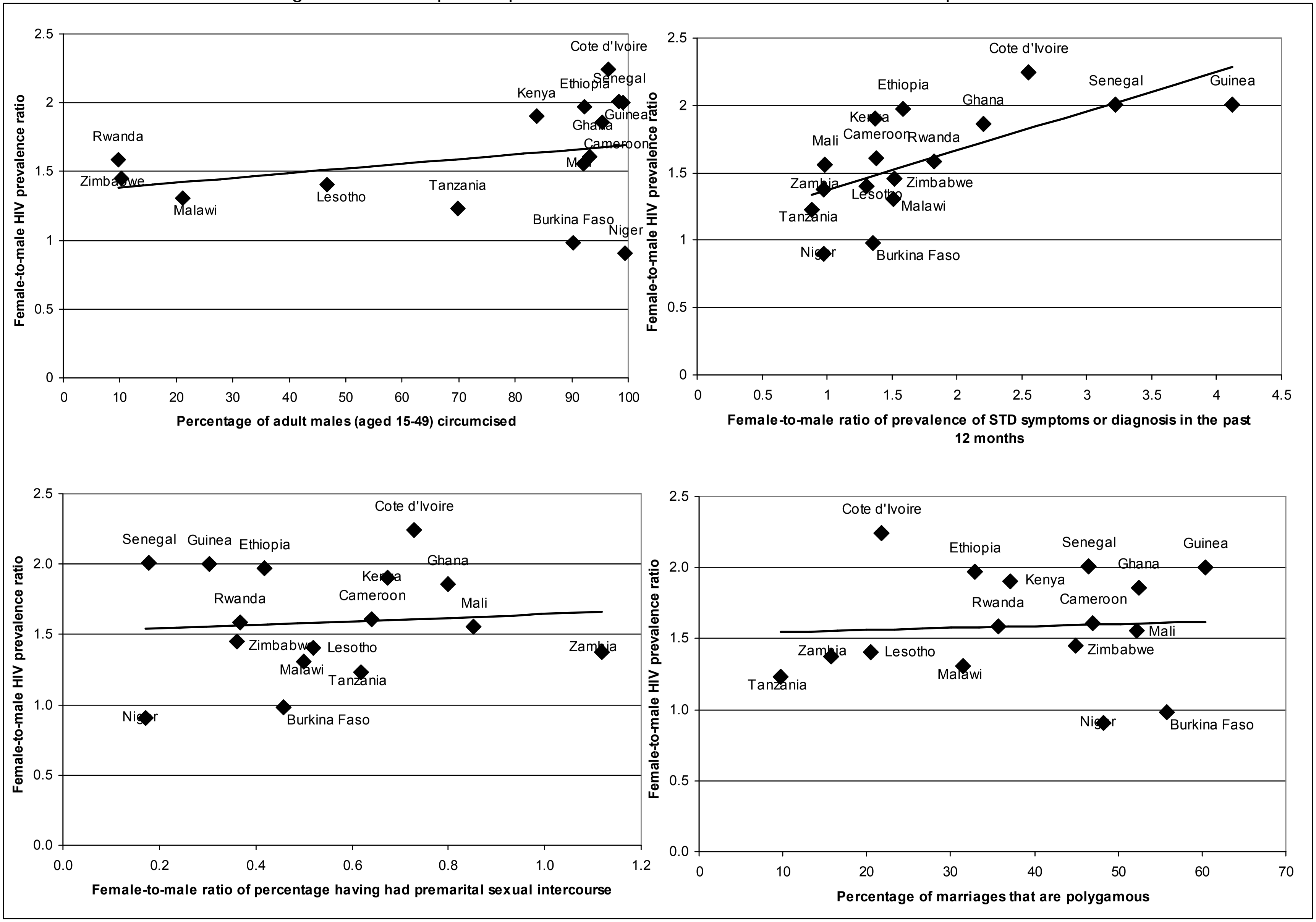


Figure 6: Scatter plots of background determinants and the sex ratio of HIV prevalence (1).

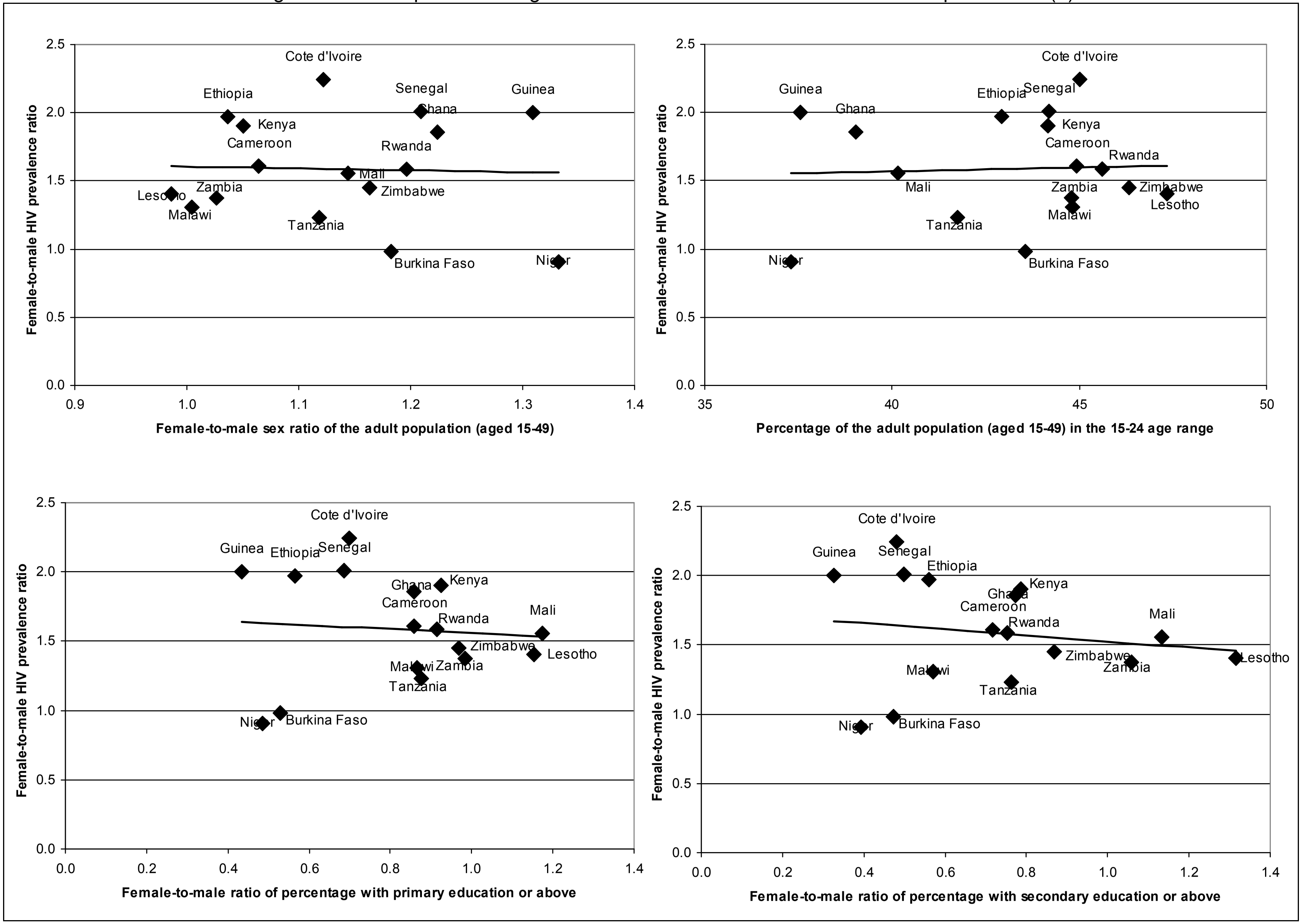


Figure 7. Scatter plots of background determinants and the sex ratio of HIV prevalence (2).

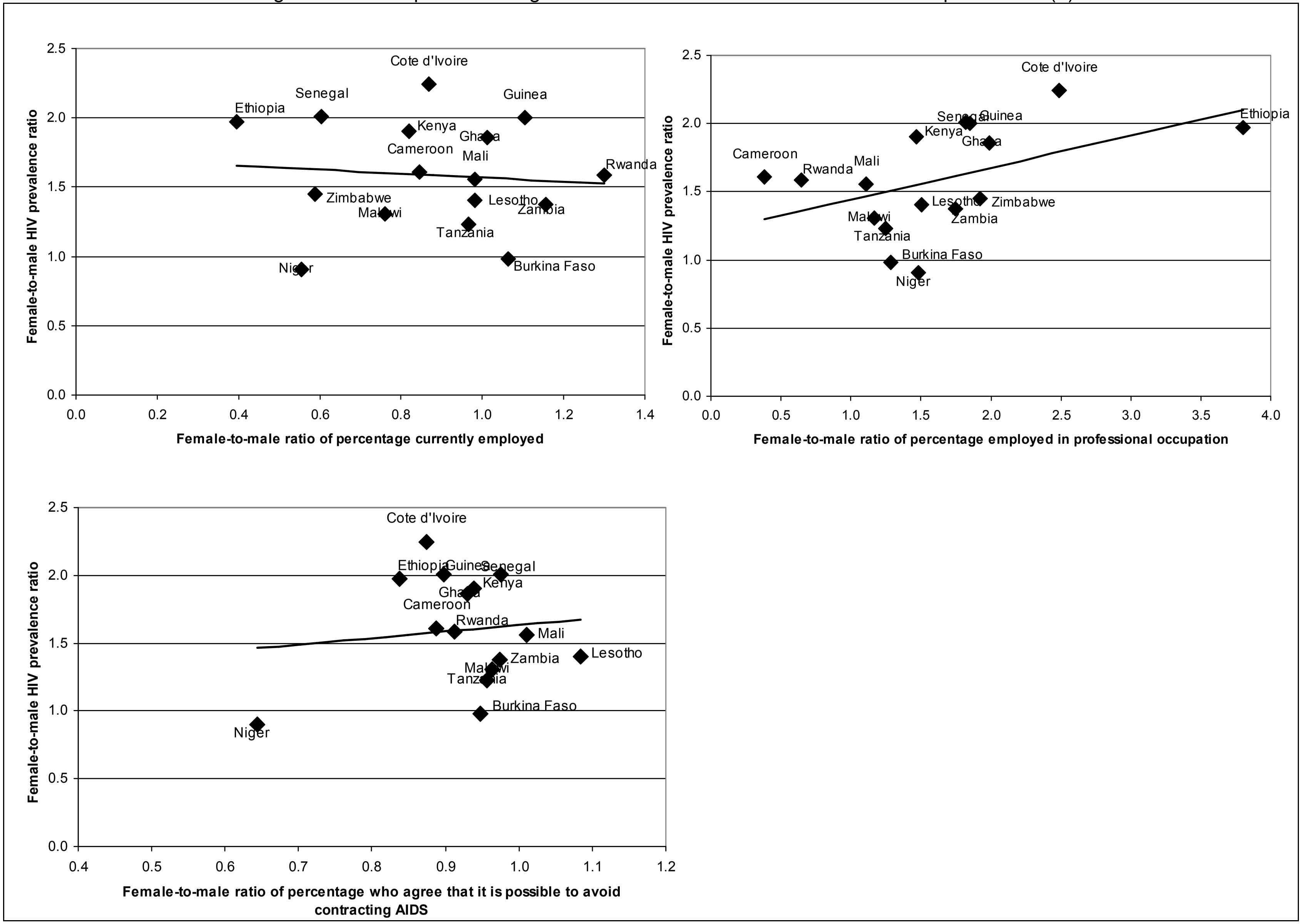


Table 5: Summary measures of HIV prevalence and the prevalence sex ratio across regions by country.

	Burkina Faso	Cameroon	Côte d'Ivoire	Ethiopia	Ghana	Guinea	Kenya	Lesotho
N regions	14	12	11	11	10	8	8	10
N regions with HIV prevalence > 1.0 per cent	10	12	11	8	9	6	7	10
Summary statistics for regions with adult HIV prevalence > 1.0 per cent								
HIV prevalence								
Mean	2.20	5.81	4.13	3.21	2.15	1.62	7.12	21.68
SD	1.04	2.45	1.31	1.57	0.88	0.36	4.02	3.46
Minimum	1.14	1.73	1.71	1.38	1.11	1.19	3.96	17.55
Maximum	4.18	8.81	6.12	6.04	3.73	2.13	15.14	29.46
HIV sex ratio								
Mean	1.11	1.74	2.32	2.05	2.47	2.17	2.25	1.49
SD	0.54	0.69	0.80	1.31	1.65	1.70	1.15	0.34
Minimum	0.18	0.64	1.17	0.83	0.39	0.83	1.39	1.03
Maximum	2.03	3.18	3.60	5.03	5.17	5.44	3.99	2.04

Table 5. (continued)

	Malawi	Mali	Niger	Rwanda	Senegal	Tanzania	Zambia	Zimbabwe
N regions	3	9	8	12	11	21	9	10
N regions with HIV prevalence > 1.0 per cent	3	7	4	12	2	21	9	10
Summary statistics for regions with adult HIV prevalence > 1.0 per cent								
HIV prevalence								
Mean	10.72	1.78	1.44	2.99	2.00	6.32	14.49	18.25
SD	6.00	0.47	0.29	1.60	0.17	3.18	4.70	1.75
Minimum	6.48	1.04	1.06	1.61	1.88	2.00	8.31	15.10
Maximum	17.58	2.51	1.72	7.59	2.13	13.52	22.03	20.78
HIV sex ratio								
Mean	1.42	1.95	1.32	1.69	3.45	1.35	1.42	1.50
SD	0.46	0.86	0.67	0.55	1.09	0.52	0.30	0.15
Minimum	1.03	0.90	0.69	0.95	2.68	0.73	0.93	1.22
Maximum	1.93	3.04	2.24	2.82	4.21	2.67	2.03	1.75

N: number; SD: standard deviation

Table 6. Summary statistics for regions

Variable name	N regions	Mean	SD	Minimum	Maximum
HIV epidemic indicators					
HIV prevalence (%)	141	7.1	6.7	1.0	29.5
HIV sex ratio (F/M)	140	1.7	0.9	0.2	5.4
Transmission efficiency					
Males circumcised (%)	132	70.5	35.3	1.8	100.0
STI prevalence (%)	141	7.9	6.9	0.4	32.3
STI sex ratio (F/M)	141	2.1	2.4	0.2	16.6
Sexual partnership patterns					
Pre-marital sex (%)	141	42.5	17.9	7.7	76.1
Pre-marital sex ratio (F/M)	141	0.6	0.3	0.1	1.9
Poly. Marriage (%)	141	34.2	17.2	3.4	70.2
Background characteristics					
Pop. sex ratio (F/M)	141	1.1	0.1	0.9	2.0
Pop. aged 15-24 (%)	141	43.5	4.0	31.6	51.3
Primary education (%)	141	68.2	28.3	6.0	99.7
Prim. educ. sex ratio (F/M)	141	0.8	0.2	0.3	1.4
Secondary education (%)	141	26.1	21.7	2.2	89.7
Sec. educ. sex ratio (F/M)	141	0.8	0.3	0.2	1.9
Employed (%)	141	66.9	17.5	19.0	97.7
Employed sex ratio (F/M)	141	0.9	0.4	0.1	3.6
Employed prof. (%)	141	23.0	16.2	0.9	71.6
Employ prof. sex ratio (F/M)	141	1.7	1.0	0.0	5.2
AIDS avoidable (%)	131	83.6	12.3	37.2	99.0
AIDS avoid. sex ratio (F/M)	131	0.9	0.1	0.5	1.2

F: Female; M: Male; prof.: professional

Table 7: Multiple regression results for the female-to-male ratio of HIV prevalence
(weighted by inverse of variance of HIV Sex Ratio)

	Model 1 β (se)	Model 2 β (se)	Model 3 β (se)	Model 4 β (se)	Model 5 β (se)
Intercept	1.188***	1.071***	1.765**	0.811***	0.556
	(0.088)	(0.189)	(0.766)	(0.197)	(0.811)
Transmission efficiency					
Pct. males circumcised	0.004***			0.003**	0.003**
	(0.001)			(0.002)	(0.002)
STI sex ratio	0.107***			0.102***	0.098***
	(0.033)			(0.034)	(0.034)
Sexual partnership patterns					
Pre-marital sex ratio		0.404**		0.428	0.549*
		(0.202)		(0.286)	(0.287)
Pct. marriages poly.		0.007**		0.006*	0.007*
		(0.003)		(0.003)	(0.004)
Background characteristics					
Pop. sex ratio			-0.414		-0.519
			(0.416)		(0.42)
Pct. pop. aged 15-24			0.007		0.014
			(0.015)		(0.015)
Secondary educ. sex ratio			-0.290*		-0.124
			(0.16)		(0.164)
Employed prof. sex ratio			0.099*		0.121**
			(0.05)		(0.051)
N regions	131	140	140	131	131
R^2	0.141	0.043	0.046	0.171	0.226
Adjusted R^2	0.127	0.029	0.017	0.144	0.175

SE: standard error; n: number of observations;
* indicates statistically significant at p<0.10
** indicates statistically significant at p<0.05
*** indicates statistically significant at p<0.01