Variations in HIV prevalence between urban areas in sub-Saharan Africa: do we understand them?

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Introduction

The World Health Organization (WHO) has estimated that at the end of 1994 more than 18 million people worldwide were infected with HIV, including more than 11 million in sub-Saharan Africa. It is further estimated that over 90% of adult HIV infections in sub-Saharan Africa are attributable to sexual transmission between men and women. Transfusion of infected blood probably accounts for less than 10% of the infections, and transmission through scarification and inadequately sterilized needles and syringes as well as homosexual contact are believed to be minor factors in the African HIV epidemic [1]. Although this predominantly heterosexual mode of HIV transmission prevails in all regions of sub-Saharan Africa, there are marked variations in the prevalence of HIV infection. Prevalence rates in urban areas are usually higher than in rural areas, but even when attention is restricted to large urban areas there are still big variations. For instance in 1991 the HIV prevalence among pregnant women was 1.6% in Yaoundé (Cameroun), 3.1% in Kinshasa (Zaïre) and 29.7% in Kampala (Uganda) [2]. WHO estimates that 50–65% of the HIV infections in sub-Saharan Africa have occurred in east and central Africa, which account for only 15% of the total population of sub-Saharan Africa [1].

In this paper we outline the evidence for heterogeneity in the spread of HIV infection in different urban areas in sub-Saharan Africa, and discuss the possible determinants of this differential spread of HIV and the implications for the design of interventions.

Differential spread of HIV in urban areas in sub-Saharan Africa

In developing countries, reported AIDS cases usually grossly underestimate the actual number of AIDS cases. In these countries serial measurements of the HIV prevalence in selected subgroups of the population are more useful in monitoring the spread of HIV infection [3].

Table 1 gives trends in HIV prevalence from samples of pregnant women attending antenatal clinics or delivering at a maternity hospital in selected cities in sub-Saharan Africa. Most of the data were extracted from the AIDS database of the United States Bureau of the Census [2]. A city was selected only if data were available for at least 3 years. Nearly all prevalence rates given were estimated on a sample of at least 300 pregnant women. The three main possible sources of bias in the comparison of these rates include the testing strategy used and the performance of the laboratory, selection of the sentinel sites and coverage of the antenatal clinics selected. In attempting to address these biases the following criteria were used to select prevalence data: (1) the serum was tested by enzyme-linked immunosorbent assay (ELISA); (2) if data from only one sentinel site were used, they were from the largest antenatal clinic or maternity hospital in town, or alternatively, prevalence rates from different sentinel sites were given as a range; and (3) as far as possible serial measurements taken at the same sentinel sites were used. Moreover, the variations in prevalence between the different cities shown in the table are so marked that they cannot be fully explained by differences in testing performance and selection bias of the sentinel population.

HIV prevalence is influenced by the incidence and duration of infection, and variations in the prevalence might be partly explained by differences in the natural history of HIV infection between different regions. Such differences, however, are unlikely to account for the big variations in prevalence shown in Table 1. Moreover, a few studies that have estimated the incidence of HIV infection in child-bearing women in Kinshasa, Kigali, and Blantyre and Lilongwe (Malawi) indicate that the differences in HIV prevalence shown in Table 1 mirror differences in incidence [6–8]. Three studies estimated

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Table 1. Trends in HIV seroprevalence (%) among pregnant women in selected cities in sub-Saharan Africa.

	1985	1986	1987	1988	1989	1990	1991	1992	1993
Central Africa									
Kinshasa (Zaïre)		6.3	6.0	5.5	5.9	3.6	3.1		
Brazzaville (Congo)			3.9	3.1	4.0	7.3	9.0	4.0	
Bangui (République Centrafricaine)		4.7	5.2	6.9	8.0	6.5–9.0			
Libreville (Gabon)				0.5			1.3 [4]		1.8
Yaoundé (Cameroun)				1.5	0.2–1.1	1.3	1.6–2.1	1.0–2.0	
West Africa									
Abidjan (Côte d'Ivoire)*		3.0	2.6–7.0		5.5	4.0–9.6	9.5	13.6†	
Cotonou (Benin)			0.0			0.4	0.0		
Maiduguri (Nigeria)			0.0	2.3	0.1	0.2			
East Africa									
Kampala (Uganda)	10.7	13.4	24.1	24.3	24.5	27.0	29.7	29.5	
Kigali (Rwanda)				32.0	23.2–30.4	25.1		31.6	33.4
Bujumbura (Burundi)		16.3	17.5				15.5	19.9	
Lusaka (Zambia)	8.0		11.6		24.5			33.6 [5]	
Nairobi (Kenya)	2.0	2.8		5.7		6.8–17.5	13.0–15.8	15.0	
Dar es Salaam (Tanzania)							12.5	11.6	16.1
Blantyre (Malawi)	2.0	2.0–4.2	8.2	18.6	18.6	21.9	25.9	27.2	31.6

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the incidence on the basis of serial measurements of the prevalence in pregnant women attending the same antenatal clinics [6–8]. The study in Kinshasa [6] made allowance for the higher mortality and decreased fertility of infected women compared to uninfected women and estimated the annual incidence at 0.9% between 1986 and 1989. In Kigali no such allowance was made and the annual incidence was conservatively estimated at 3–5% for 1989–1990 [7]. The study in Lilongwe and Blantyre [8] allowed for an assumed rate of return to the antenatal clinic and reported an annual incidence of 7.5–10% for 1987–1989.

The AIDS epidemic has reached different cities at different times. However, the length of time that has elapsed since the virus was introduced cannot be the only explanation for the different trends in HIV prevalence. This is clearly demonstrated in Fig. 1, which shows trends in HIV prevalence in pregnant women from a selection of cities. The trends are very different, even for cities where the epidemic most probably started around the same time, like Kinshasa, Kampala, Kigali and Lusaka, where the first AIDS cases were discovered around 1983 [9–12], and Abidjan and Yaoundé, where the first AIDS cases were reported in 1985 and 1986 [13,14]. For Francistown (Botswana), it is not clear whether the virus was introduced in the early 1980s or the late 1980s, but it is obvious that the epidemic curve in this town is very different from those in the other towns.

In summary, it is clear that the spread of HIV infection has been most rapid and most extensive in east African cities, where the HIV prevalence among pregnant women is now consistently above 10%, and in some parts considerably higher. In central African cities the HIV prevalence is generally rather lower, rarely reaching 10% among pregnant women. In some cities in central Africa it appears that endemic prevalence levels have been reached. In Kinshasa, for example, the HIV prevalence recorded from samples of pregnant women did not increase between 1986 and 1991. Cities in west Africa show a more heterogenous picture. In some urban populations the prevalence of HIV infection has remained low so far (e.g. Cotonou, Maiduguri), whereas in others HIV has spread rapidly and widely (e.g. Abidjan).

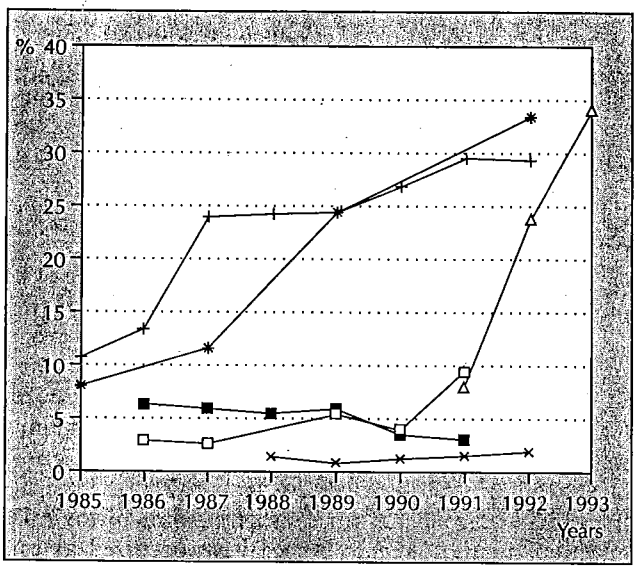

Fig. 1. Trends in HIV prevalence among pregnant women in selected cities in sub-Saharan Africa. ■—■, Kinshasa; +—+, Kampala; *—*, Lusaka; □—□, Abidjan; ×—×, Yaoundé; △—△, Francistown.

Determinants of heterosexual spread of HIV

The probability that a person becomes infected by HIV during a sexual contact is the product of the probability that a susceptible individual has intercourse with an infected individual and the probability that during this

sexual encounter the virus is transmitted. Table 2 gives an overview of the main determinants of each of these probabilities.

Table 2. Main determinants of the risk of HIV infection.

Sexual exposure to HIV⟶	Transmission of HIV⟶	Infection
Pattern of sexual mixing	Sexual practices	
Extent of concurrent p'ships	Other STD	
Rate of partner change	Circumcision	
	Condom use	
	Virus subtype	
	Disease stage	

p'ships, partnerships. STD, sexually transmitted diseases.

Sexual exposure to HIV

Simulation modelling exercises have highlighted the importance of sexual mixing patterns in the spread of HIV infection. The parameters of sexual behaviour that have been found to be crucial include (1) the proportion of men and women in different sexual activity classes, the level of sexual activity being defined as the rate of partner change and the frequency of sexual contact per partnership; (2) the extent to which subjects of different activity classes and different age groups mix; and (3) the frequency of concurrent partnerships [15–17]. In populations where men have frequent contacts with a small group of high-activity women, such as prostitutes, and some contacts with low-activity women, explosive epidemics can be expected [15]. The epidemics in east Africa appear to fit this kind of mixing pattern.

Studies on prostitute contacts in different areas are difficult to compare with each other because of differences in the definition and the meaning of 'sex in exchange for money' in different cultural contexts. Still, there are suggestions of marked variations in the frequency of commercial sex in different areas, which might explain some of the heterogeneity of the HIV/AIDS epidemic in sub-Saharan Africa. In Kigali, out of a sample of 301 male civil servants, 79% reported at least one sexual contact with a prostitute in the past year [18]. Of the married men, 40% had had contact with a prostitute, and 91% of the single men. In a study in Bulawayo, Zimbabwe, 24% of men in the general population reported having had sexual intercourse with a prostitute in the past month [19]. In contrast, a study among employees of a textile factory and a bank in Kinshasa showed that only 28% of HIV-infected men and 22% of uninfected men had had sexual contact with a prostitute over the past 2 years [20]. In Ekiti, Nigeria, fewer than 1% of the non-marital sexual partners of men were identified as prostitutes [21].

Among commercial sex workers, large differences have been found in the prevalence and incidence of HIV infection and in the number of clients per time unit. In two research projects in Nairobi [22] and Kinshasa [23], prostitutes were recruited in a similar way, through a clinic established in each city in an area known for prostitution, which makes the two studies more comparable. In Nairobi, in 1987, the annual incidence of HIV infection among prostitutes was 38 per 100 woman-years. These women had an average of 35 clients per week [22]. In contrast in Kinshasa, during the first 6 months of 1988 the HIV incidence was 12 per 100 woman-years and the average number of clients was 8.6 per week [23]. Two possible explanations for these differences in the average number of clients per week are (1) there are similar proportions of both prostitutes and clients, but clients in Kinshasa have, on average, a lower frequency of contacts with prostitutes; and (2) there are proportionately more prostitutes in Kinshasa to meet a similar demand for sexual services. The study among employees, cited above, suggests that the first explanation is more likely. These data suggest that the frequency of sexual contact with prostitutes is higher in Nairobi than in Kinshasa, leading to a higher incidence and prevalence of HIV infection in prostitutes in Nairobi and, consequently, more rapid and widespread epidemics of HIV infection in the general population.

The extent of networks of concurrent partnerships has been suggested as a major determinant of the heterosexual spread of HIV [24]. An underlying assumption is that high viraemia during a relatively short period in the early stages of the infection is associated with high infectivity. In this case the rate of spread of HIV from prostitutes via men into the general female population may be more rapid if men have several concurrent partners, rather than an equivalent number of serially monogamous partners. A study on networking conducted in five countries in sub-Saharan Africa found large variations in the proportions of men having more than one regular sex partner, as well as in the proportions of men who have non-regular sexual partners alongside their regular sexual partners [25]. For instance, among urban men in the Côte d'Ivoire and Niger, about 9% have three regular partners, while in Uganda, Lusaka (Zambia) and Tanzania this proportion is about 4%. Of the men with three regular partners in the Côte d'Ivoire, 78% also had non-regular partners, while in Niger this proportion was only 38.5%. It is believed that in Kinshasa the widespread and socially accepted practice of having a mistress ('deuxième bureau') reduces the need for sexual services from prostitutes and provides some protection against the spread of HIV [26]. This might be an explanation for the relatively low and stable prevalence of HIV infection in Kinshasa.

From a public health point of view it is not only a question of which sexual behaviours should be changed but also of how this may be achieved. Description of the socio-economic context that determines sexual behaviour is thus essential. It has been suggested that the male : female ratio in the general population together with women's status and attitudes towards female sexuality are important factors in determining sexual mixing patterns [27,28]. In towns where women have a relatively high social status, where there is a permissive attitude towards women's sexuality and where the male : female

ratio approaches 1, sexual activity may be more evenly distributed across the general female population, rather than being concentrated in a small group of prostitutes, and the spread of HIV may be slower [27,28].

Sexual practices

Studies on HIV-discordant couples in Europe and the United States have shown that sexual intercourse during menses is associated with an increased risk of HIV infection in male partners of female index cases, but not in female partners of male index cases [29,30]. Similarly, in a study in rural Uganda there was a suggestion that men exposed to menstrual blood had an increased risk of HIV infection [31], whereas no evidence was found of increased risk associated with sex during menses in prostitutes in Kinshasa and pregnant women in Kigali [32,33].

In Europe and the United States, anal intercourse is strongly associated with HIV infection in women, even if couples engaged in it infrequently [29,30,34]. Among prostitutes in Kinshasa no difference was found between women reporting anal intercourse and those not reporting a history of anal intercourse [32,35]. Little is known about the practice of anal intercourse in sub-Saharan Africa, but it is believed to be uncommon. In the Kinshasa studies, 7–14% of prostitutes reported engaging in anal intercourse at least once.

Intercourse with a dry and tight vagina, so called 'dry sex', has been described as a fairly common sexual practice in large parts of Zaïre, Zambia, Zimbabwe, Kenya and Uganda, and also in Sénégal, Mali, Benin and Côte d'Ivoire [36–39]. About one-third of women interviewed in Lusaka, Zambia, occasionally engaged in this practice, by using intravaginal substances or mopping up vaginal secretions [37]. It is biologically possible that this practice is associated with an increased risk of infection, because of trauma to the genital mucosa. In Zambia this association has been demonstrated [40], but among Kinshasa prostitutes there was no evidence of an increased risk [32]. The effect of this sexual practice on the spread of HIV in sub-Saharan Africa is not clear. It is, for instance, interesting that in Rwanda, Burundi and southern Uganda, where the rate of spread of HIV infection in urban populations is explosive, the norm of good sexual practice is the reciprocal flow of secretions between two partners [41]. This suggests that so-called dry sex is probably not a major determinant of the rate of spread of HIV infection.

In conclusion, some sexual practices, like anal intercourse, are associated with a marked increase in the risk of HIV infection, but for other practices the risks are less clear. In order to be a major determinant of the heterogeneity in spread of HIV in Africa, sexual practices must not only increase the transmission of HIV but also be more common in some regions than in others. The few data that are available on the risks associated with sexual practices in Africa and on their prevalence rates suggest that they are not a major cause of the differences in the course of the HIV epidemic in different regions in Africa.

Condom use

Condom use, especially between one-off partners, may go some way towards explaining the differences in the spread of HIV infection among heterosexual populations between industrialized and developing countries [42]. Before the mid- to late 1980s condom use was rare in virtually all regions in sub-Saharan Africa. Though in some countries considerable progress has been made on the promotion and sale of condoms since the mid-1980s, it seems unlikely that a large part of the differences in HIV prevalence between different regions in Africa can be explained by differences in condom use.

Other sexually transmitted diseases

There is now strong evidence that other sexually transmitted diseases facilitate HIV transmission. The evidence comes from studies on viral shedding in genital fluids and from epidemiological research [43]. Genital ulcer disease is generally associated with a higher odds ratio for HIV infection than for non-ulcerative sexually transmitted disease [32,44]. Results obtained from simulation models also suggest that other sexually transmitted diseases are important factors in the spread of HIV infection. Data from a cohort study in rural Uganda have been used to estimate that over 90% of cumulative HIV infections, in the first 10 years of the epidemic up to 1990, may be attributable to other sexually transmitted diseases [45]. Differences in the prevalence and mix of other sexually transmitted diseases (ulcerative and non-ulcerative) might thus be a major factor in explaining the differential spread of HIV infection in sub-Saharan Africa, independently of sexual behaviour.

Studies on pregnant women and on prostitutes suggest that there are large variations in the prevalence and mix of other sexually transmitted diseases between different regions of sub-Saharan Africa [46]. Syphilis and chancroid are believed to be more widespread in the general population in eastern and southern Africa than in west Africa. Among HIV-seronegative prostitutes in Kinshasa the prevalence of genital ulcer disease was 3%, while in Nairobi it was 15% [32,44]. Several studies on pregnant women in southern Africa have shown seroprevalence levels of active syphilis of over 5% to more than 10% [46–48], while in Kinshasa and in Abidjan the prevalence was around 1% [49] (M.O. Diallo, V. Traoré-Ettiegne, M. Mathieu, *et al.*, manuscript submitted for publication). The high prevalence levels of 7–10% found in Sénégal, The Gambia and Cameroun may, at least in part, be due to infection by non-venereal treponematoses [46,50,51]. There are no good comparative data on the prevalence of chancroid in different regions. Most reports on chancroid came from eastern and southern Africa [52–56], but it is also prevalent among men presenting with genital ulcer disease in Dakar, Sénégal [59], and among HIV-seropositive prostitutes in Abidjan,

Côte d'Ivoire (P. Ghys, M.O. Diallo, V.E. Traoré, *et al.*, manuscript submitted for publication).

There are several possible explanations for these variations in the prevalence of sexually transmitted disease. These include (1) differences in sexual behaviour (rate of partner change and sexual mixing patterns); (2) differences in access to and use of effective treatment; and (3) variations in the prevalence of other factors that may increase the risk of certain sexually transmitted diseases, such as circumcision and genital hygiene. Though there are some good data on the prevalence of sexually transmitted disease in different regions of sub-Saharan Africa, it is very difficult to make valid comparisons because of the lack of comparative data on sexual behaviour and other risk factors for sexually transmitted diseases.

Circumcision status

Two ecological studies published in 1989 and 1990 reported a correlation between lack of male circumcision and prevalence of HIV infection in sub-Saharan Africa [58,59]. Numerous groups have sought an association between lack of circumcision and risk of HIV infection at the individual level. Several found a strong association, but others failed to do so [60,61].

It is biologically possible for lack of circumcision to increase the susceptibility to HIV infection of uninfected men and also the infectivity of seropositive men. Circumcision might have both direct and indirect effects on the probability of HIV transmission. The thinner epithelium on the glans and prepuce of the uncircumcised man is a less effective barrier against the invasion of microorganisms. Uncircumcised men are also more susceptible to infection through small abrasions in the foreskin, greater vulnerability to balanitis and a higher susceptibility to ulcerative sexually transmitted diseases [60–62]. While it remains unclear how far lack of circumcision increases the risk of HIV infection, the evidence for a protective effect of circumcision against ulcerative sexually transmitted diseases, possibly through better genital hygiene is more consistent and convincing [62–66]. It is interesting that some areas of Africa where circumcision is not practised, mainly eastern and southern Africa, have the highest rates of syphilis in pregnant women. If lack of circumcision is a major determinant of the differential spread of HIV infection, as postulated by several researchers, it is important to determine whether circumcision has a direct effect on the transmission of HIV or has a protective effect against HIV infection through its protective effect against ulcerative sexually transmitted diseases.

Transmissibility of the virus

Besides the two virus types, HIV-1 and HIV-2, all eight HIV-1 subtypes so far identified and the group O HIV-1 strains have been found in sub-Saharan Africa [67]. There is strong epidemiological evidence for a higher transmissibility of HIV-1 than HIV-2. This has been related to higher circulating levels of virus in HIV-1 infection than HIV-2 infection [68].

However, very little is known about the transmissibility of the different HIV-1 subtypes. *In vitro* studies have demonstrated important differences in the biological properties of HIV-1 variants which might be associated with differences in transmissibility, including cell tropism, cytopathicity and interaction with CD4 receptors [69]. Nevertheless, there is very little epidemiological evidence so far of differences in transmissibility between different HIV-1 subtypes. A study on couples in Thailand showed that the HIV seroconcordance rate was higher if the male index case was infected with subtype E than if he was infected with subtype B [70].

Any inferences about the differential spread of HIV in sub-Saharan Africa being due to differences in distribution of subtypes are hampered by a lack of systematic subtype gene mapping. Very few studies on subtypes concern isolates from more than 10 patients and it is therefore impossible to draw any conclusions about the distribution of different subtypes in different regions of sub-Saharan Africa.

Conclusions

The HIV/AIDS epidemic in sub-Saharan Africa is unique because the predominant mode of transmission in all regions is sexual contact between men and women. The large variations in the course of the epidemic are poorly understood. As discussed in this paper there are a number of hypotheses on the determinants of these variations, ranging from differences in sexual mixing patterns to differences in transmissibility of virus subtypes. The explanation for the heterogeneity in the spread of HIV infection in sub-Saharan Africa is most likely to be found in a complex interplay between behavioural and biological factors. This paper has given a brief overview of the available data that go part of the way towards confirming some hypotheses regarding sexual behaviour patterns and co-factors in the transmission of HIV. However the data are too few and have little comparability between different countries.

Under the leadership of the WHO Global Programme on AIDS, a multicentre study has been planned to explore, in a standardized way, differences in sexual behaviour, the prevalence of conventional sexually transmitted diseases and circumcision as determinants of the differential spread of HIV in sub-Saharan Africa.

A clearer understanding of the mechanisms underlying the differential spread of HIV in sub-Saharan Africa is essential for the design of better targeted and more feasible interventions to slow the spread of the infection, whether in the area of sexual behaviour change or vaccine development. Circumcision, for example, has been suggested as a possible intervention and proposals have been made to study its feasibility and acceptability. However, there is still much uncertainty about whether circumcision provides any protection against HIV infection

and, if so, whether this is a result of its protective effect against genital ulcer disease. The latter question is less academic than it appears at first sight. If circumcision does exert its protective effect by reducing the risk of genital ulcer disease, then is it more feasible to focus interventions on increasing the rate of circumcision (with associated complications) or attempt to improve treatment for sexually transmitted diseases?

Health education messages, like 'stick to one partner' and 'use a condom' are important, but more focused approaches need to be developed, especially in those parts of the world where the epidemic is at a much earlier stage, to try to avoid the epidemics that have been experienced in east and central Africa. In order to develop strategies for behaviour change that are more effective and adapted to local circumstances, a clearer understanding is needed, first, of those sexual behaviour patterns that cause a rapid spread of HIV, and second, of the social, economic and cultural context that determines these behaviour patterns. Putting sexual behaviour in its socio-economic and cultural context should offer new opportunities for strategies of behaviour change that will address not only individual responsibilities in risk taking but also economic and political responsibilities.

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