The epidemiology of trichomoniasis in women in four African cities

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Objectives: To describe the epidemiology of *Trichomonas vaginalis* infection and its association with HIV infection, in women in four African cities with different levels of HIV infection.

Design: Cross-sectional study, using standardized methods, including a standardized questionnaire and standardized laboratory tests, in four cities in sub-Saharan Africa: two with a high prevalence of HIV infection (Kisumu, Kenya and Ndola, Zambia), and two with a relatively low prevalence of HIV (Cotonou, Benin and Yaoundé, Cameroon).

Methods: In each city, a random sample of about 2000 adults aged 15–49 years was taken. Consenting men and women were interviewed about their socio-demographic characteristics and their sexual behaviour, and were tested for HIV, syphilis, herpes simplex virus type 2 (HSV-2), gonorrhoea, chlamydial infection, and (women only) *T. vaginalis* infection. Risk factor analyses were carried out for trichomoniasis for each city separately. Multivariate analysis, however, was only possible for Yaoundé, Kisumu and Ndola.

Results: The prevalence of trichomoniasis was significantly higher in the high HIV prevalence cities (29.3% in Kisumu and 34.3% in Ndola) than in Cotonou (3.2%) and Yaoundé (17.6%). Risk of trichomoniasis was increased in women who reported more lifetime sex partners. HIV infection was an independent risk factor for trichomonas infection in Yaoundé [adjusted odds ratio (OR) = 1.8, 95% confidence interval (CI) = 0.9–3.7] and Kisumu (adjusted OR = 1.7, 95% CI = 1.1–2.7), but not in Ndola. A striking finding was the high prevalence (40%) of trichomonas infection in women in Ndola who denied that they had ever had sex.

Conclusion: Trichomoniasis may have played a role in the spread of HIV in sub-Saharan Africa and may be one of the factors explaining the differences in levels of HIV infection between different regions in Africa. The differences in prevalence of trichomoniasis between the four cities remain unexplained, but we lack data on the epidemiology of trichomoniasis in men. More research is required on the interaction between trichomoniasis and HIV infection, the epidemiology of trichomoniasis in men, and trichomonas infections in women who deny sexual activity.

AIDS 2001, **15** (suppl 4):S89–S96

Keywords: Trichomoniasis, HIV, epidemiology, Africa

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Introduction

There is convincing evidence that the most common classical sexually transmitted infections (STIs), gonorrhoea, chlamydial infection and genital ulcer disease, enhance the transmission of HIV during sexual intercourse [1]. However, the role of *Trichomonas vaginalis* infection in the transmission of HIV is less clear. One prospective study among female sex workers in Kinshasa found trichomoniasis to be a risk factor for the acquisition of HIV infection, although the association was of borderline significance [2]. Other prospective studies in women did not find a statistically significant association between *T. vaginalis* infection and HIV acquisition [3,4]. A study in Malawi on genital shedding of HIV in men found some evidence that urethritis due to *T. vaginalis* may enhance the infectiousness of HIV-infected men, whereas a study among female sex workers in Abidjan found no evidence of increased genital shedding of HIV associated with trichomoniasis [5,6].

As part of a multicentre study on factors determining the differential spread of HIV in Africa, we assessed the prevalence of classical sexually transmitted infections in four cities in sub-Saharan Africa: two with a high prevalence of HIV infection, and two with a relatively low and stable prevalence [7]. The cities with high HIV prevalence were Kisumu (Kenya) and Ndola (Zambia), and the cities with relatively low HIV prevalence were Cotonou (Benin) and Yaoundé (Cameroon). This paper describes the prevalence of trichomoniasis in women in the four cities and explores risk factors, including the association with other STIs. The possible role of trichomonas infection in the spread of HIV in the four cities is discussed. The epidemiology of gonorrhoea, chlamydial infection, syphilis and herpes simplex virus type 2 (HSV-2) are described in two other papers in this supplement [8,9].

Methods

The methods of the multicentre study on factors determining the differential spread of HIV are described in detail elsewhere [7]. Briefly, in each of the four cities in which the study took place, a representative sample of consenting men and women aged 15–49 years were interviewed about their socio-demographic characteristics and their sexual behaviour. After the interview, study participants were requested to give a blood sample that was tested for HIV, syphilis and HSV-2, and a urine sample that was tested for gonorrhoea and chlamydial infection. Women were also asked to insert a swab into the vagina to test for *T. vaginalis* infection. Study participants with symptoms and/or signs suggestive of a STI were treated immediately by the study team, following the national guidelines for the syndromic management of STIs. Any participants with positive syphilis serology or with *T. vaginalis* infection were traced back and treated later. It was not possible to treat study participants after they were found to have gonorrhoea or chlamydial infection because the urine samples were tested for these infections several months after the collection of the specimens, at the Institute of Tropical Medicine in Antwerp, Belgium.

The diagnosis of trichomoniasis was established by inoculation of a self-administered vaginal swab into a culture medium for *T. vaginalis* (InPouch™ TV; Biomed Diagnostics, San José, California, USA), which was read according to the manufacturer's instructions after 3 and 5 days. The diagnosis of gonorrhoea and chlamydial infection was made on a urine sample that was first tested with the Amplicor *Chlamydia trachomatis/Neisseria gonorrhoeae* polymerase chain reaction test (Roche Diagnostics, Branchburg, New Jersey, USA). Samples that tested positive were confirmed using the LCx™ *Chlamydia trachomatis* assay or the LCx™ *Neisseria gonorrhoeae* assay (Abbott Laboratories, Abbott Park, Illinois, USA). Only individuals who were positive on both tests were considered infected. Syphilis serology was assessed with the rapid plasma region (RPR) Card test (Becton Dickinson and Company, Cockeysville, Maryland, USA) and with the Serodia®-*Treponema pallidum* particle agglutination (TPPA; Fujirebio Inc., Tokyo, Japan). Individuals testing positive on both the RPR (at any titre) and the TPPA were considered to have recently acquired and/or untreated syphilis, which was the syphilis variable used in the present analyses. Sera were tested for HIV antibodies first with an enzyme-linked immunosorbent assay (ELISA), followed by confirmatory testing with a rapid test or another ELISA [7].

The prevalence of trichomoniasis in all women, whether or not they had reported that they had ever had sexual intercourse, was compared between the four cities. In each city, the following risk factors for trichomoniasis were explored: age, sexual activity, marital status, early age at first sexual intercourse, lifetime number of sex partners, number of non-spousal partners in the past 12 months, sex in exchange for money in the past 12 months, condom use with non-spousal partners, educational attainment, occupation, alcohol use and ethnic group (the latter in Yaoundé and Kisumu only). In addition, the association with HIV infection and other STIs (gonorrhoea, chlamydial infection, syphilis and HSV-2) was explored. Logistic regression was used to calculate both crude and age-adjusted odds ratios (ORs) for the association between trichomoniasis and the variables. Risk factors that were found, after adjusting for age, to be statistically significant at the 0.1 level, were entered in a multiple logistic regression model. First, the socio-demographic and behavioural variables were entered in the model. Thereafter, HIV and/or other STIs were included to explore the effects of these variables on the other factors and to assess their association with *T. vaginalis* infection. All analyses were carried out in SPSS for Windows, version 8.0 (SPSS Inc. 1997, Chicago, Illinois, USA).

Results

Response rates

The proportion of female study participants who were tested for *T. vaginalis* infection was 86% (941/1095) in Cotonou, 64% (717/1116) in Yaoundé, 43% (454/1060) in Kisumu and 56% (569/1010) in Ndola. These low participation rates were mainly due to interruptions in the supply of InPouch kits to the study sites. A comparison was made of the socio-demographic and sexual behaviour characteristics of women who were tested for trichomoniasis and women who were not. In Cotonou, women who were not tested for trichomoniasis were more often not sexually active than women who were tested. Among the sexually active women, those not tested were more often single and more likely to be a housewife than women who were tested. In Yaoundé, women who were not tested were older than women who were tested, they were more likely to be married and more likely to have initiated sexual activity after age 15. They also drank alcohol less often, were more likely to have no schooling and to be a housewife. In Kisumu, women who denied that they had ever had sex were less likely to have been tested for trichomoniasis. Among the sexually active women, single women, women who had their sexual debut after age 15, women with fewer lifetime sex partners, and women with a higher educational attainment were less likely to have been tested. In Ndola, women who were not tested had a lower educational level than women who were tested.

Prevalence of trichomoniasis by city and age

The prevalence of trichomoniasis was significantly higher in the two high HIV prevalence cities than in the two low HIV prevalence cities: it was 29.3% [95% confidence interval (CI) = 25.2–33.8] in Kisumu and 34.3% (30.4–38.4) in Ndola, and 3.2% (2.2–4.6) in Cotonou and 17.6% (14.9–20.6) in Yaoundé (Table 1). The results of the univariate analyses are presented in Table 1. The results of the final logistic regression model for Yaoundé, Kisumu and Ndola are presented in Table 2. In Cotonou, too few women were found with trichomonas infection to permit meaningful multivariate risk factor analysis.

The prevalence of trichomonas infection decreased with increasing age in all cities except Yaoundé. The decrease was most noticeable in Ndola, where prevalence decreased from 52% among those aged 15–19 to 19% among those aged 40–49 ($P < 0.001$ for trend; Table 1). Young age remained an independent risk factor for trichomoniasis in Ndola after adjusting for other factors, although the association was no longer statistically significant (Table 2).

Association of trichomoniasis with socio-demographic and behavioural factors

In Yaoundé and Kisumu, the prevalence of *T. vaginalis* was higher in women who reported that they had had sex than in women who denied sexual activity. In Cotonou the prevalence was similar in both groups of women, and in Ndola it was higher among women who denied sexual activity. However, among women aged 15–19 years, prevalence was higher among sexually active women than among those who denied that they had ever had sex (7.4 versus 3.4% in Cotonou, $P = 0.2$; 59 versus 43% in Ndola, $P = 0.06$).

Women who were married had a lower prevalence of trichomoniasis than single women and women who had been married in the past, in all four cities, but the difference was statistically significant in Cotonou and Ndola only. In multivariate analysis, marital status remained an independent risk factor for trichomoniasis in Ndola.

Other socio-demographic variables associated with trichomoniasis were alcohol consumption in the past month and being of Pahouin ethnic group among women in Yaoundé, and low levels of education and not being in full-time employment among women in Ndola. After adjustment for other factors, ethnic group remained significantly associated with trichomoniasis in Yaoundé, and low levels of education in Ndola.

Sexual debut before age 15 was significantly associated with an increased risk of trichomonas infection in women in Ndola, and this association persisted after adjustment for other factors, although it was of borderline statistical significance only. In all cities, higher lifetime numbers of sex partners and/or higher numbers of non-spousal partners in the past 12 months were associated with an increased prevalence of trichomoniasis. Women who reported that they had received money or gifts in exchange for sex in the past 12 months were more likely to have trichomoniasis but the association was confounded by the number of non-spousal partners in the past 12 months. In the logistic regression model with the socio-demographic and behavioural variables only, lifetime number of sex partners was an independent risk factor for trichomoniasis but the association was not statistically significant in Ndola (data not shown). Number of non-spousal partners in the past 12 months was not an independent risk factor for trichomoniasis in multivariate analysis in any of the cities. After adding STIs to the model, the lifetime number of sex partners was still an independent risk factor for trichomoniasis in each city, with women who reported more than three lifetime sex partners having three to four times the odds of infection compared with those who reported having never been sexually active. However, the associations were no longer statistically significant.

Association of trichomoniasis with other STIs

In each city, *T. vaginalis* infection was more prevalent in women with positive syphilis serology, gonorrhoea, and chlamydial infection, respectively. However, statistically significant associations were only found with gonor-

Table 1. Prevalence of trichomoniasis among all women by socio-demographic and sexual behavioural characteristics

	Cotonou [% (*n*)]	Yaoundé [% (*n*)]	Kisumu [% (*n*)]	Ndola [% (*n*)]
Overall prevalence	3.2% (30/941)	17.6% (126 /717)	29.3% (133/454)	34.3% (195/569)
Age (years)[a]	*P* = 0.2	*P* = 0.3	*P* = 0.07	*P* < 0.001
15–19	5.4 (182)	13.1 (175)	33.7 (89)	51.7 (149)
20–29	3.1 (390)	19.8 (300)	32.8 (186)	31.0 (245)
30–39	1.8 (221)	18.1 (160)	22.9(118)	26.2 (122)
40–49	2.7 (148)	18.1 (83)	24.6 (61)	18.9 (53)
Ever had sex	*P*=0.9	*P*=0.03	*P* = 0.08	*P* = 0.26
No	2.9 (102)	6.9 (58)	7.7 (13)	40.0 (75)
Yes	3.2 (838)	18.5 (660)	29.9 (441)	33.4 (494)
Marital status	*P* = 0.006	*P* = 0.2	*P* = 0.5	*P* < 0.001
Never married	5.4 (334)	17.1 (346)	28.6 (77)	46.9 (177)
Now married	1.5 (519)	16.4 (305)	28.4 (324)	26.9 (312)
Past marriage	4.6 (88)	25.4 (67)	35.9(53)	35.0 (80)
Alcohol in the past month	*P* = 0.8	*P* = 0.03	*P* = 0.5	*P* = 0.4
No	3.3 (609)	14.6 (392)	28.7 (418)	33.4 (449)
Yes	3.0 (330)	20.9 (325)	34.3 (35)	37.5 (120)
Education	*P* = 0.05	*P* = 0.13	*P* = 0.7	*P* = 0.002
No primary	4.0 (586)	14.3 (70)	31.2 (221)	43.1 (160)
Primary complete	1.3 (319)	19.1 (544)	27.1 (166)	34.1 (290)
Secondary/higher	5.9 ((34)	11.5 (104)	28.4 (67)	22.7 (119)
Occupation	*P* = 0.7	*P* = 0.2	*P* = 0.2	*P* = 0.002
Full time	3.2 (591)	21.3 (202)	24.2 165)	27.2 (143)
Student	3.9 (153)	13.2 (197)	18.2 (22)	46.2 (65)
Homemaker	3.7 (110)	17.8 (242)	32.8 (180)	30.6 (242)
Other	1.2 (87)	18.4 (77)	33.8 (80)	45.2 (115)
Ethnic group		*P* = 0.001	*P* = 0.2	
1 (Yaoundé = Pahouin, Kisumu = Luo)		23.0 (354)	30.1 (375)	
2 (Yaoundé = Bamileke, Kisumu = Luya)		12.4 (162)	32.0 (50)	
3 (= other)		12.4 (196)	13.8 (29)	
Age at first sex[b]	*P* = 1.0	*P* = 0.7	*P* = 0.4	*P* = 0.002
No sex/sex after age 15	3.3 (888)	18.3 (631)	28.7 (296)	30.3 (478)
Before age 15	2.0 (51)	20.2 (84)	32.3 (155)	48.2 (85)
Number of lifetime partners	*P* = 0.9	*P* < 0.001	*P* = 0.02	*P* = 0.02
0	2.9 (102)	6.9 (58)	7.7 (13)	40.0 (75)
1	3.8 (261)	7.6 (118)	17.6 (74)	32.3 (201)
2–3	2.8 (427)	16.2 (210)	33.3 (270)	29.8 (228)
> 3	3.4 (149)	24.6 (318)	29.9 (97)	49.2 (63)
Number of non-spousal partners past year	*P* = 0.001	*P* = 0.003	*P* = 0.2	*P* = 0.001
0	2.4 (766)	14.4 (373)	27.5 (374)	31.6 (492)
1	8.1 (149)	17.9 (235)	36.4 (66)	52.9 (70)
> 1	0 (23)	29.1 (108)	42.9 (13)	40.0 (5)
Sex for money in past year	*P* = 0.05	*P* = 0.06	*P*= 0.2	*P* = 0.11
No	3.0 (927)	16.9 (674)	28.6 (422)	33.5 (540)
Yes	18.2 (11)	29.3 (42)	38.7 (31)	48.3 (29)
Used a condom with all non-spousal partners of the past 12 months	*P* = 0.7	*P* = 0.6	*P* = 0.9	*P* = 0.5
Never/Rarely	7.4 (148)	21.8 (285)	36.9 (65)	49.1 (55)
Mostly/Always	5.3 (19)	18.9 (53)	35.7 (14)	57.1 (21)
HSV-2	*P* = 0.3	*P* < 0.001	*P* = 0.4	*P* = 0.5
Negative	3.0 (258)	10.2 (343)	25.4 (110)	35.8 (240)
Positive	4.3 (608)	24.5 (355)	30.1 (299)	32.8 (296)
Syphilis	*P* = 0.5	*P* = 0.2	*P* = 0.4	*P* = 0.2
Negative	3.4 (889)	17.3 (665)	29.0 (403)	33.5 (478)
Positive	0 (19)	25.0 (40)	42.9 (7)	41.3 (63)
Gonorrhoea	*P* = 0.3	*P* = 0.02	*P* = 0.6	*P* = 0.09
Negative	3.2 (899)	16.9 (679)	29.0 (424)	33.8 (550)
Positive	11.1 (9)	40.0 (20)	40.0 (5)	60.0 (10)
Chlamydial infection	*P* = 0.4	*P* = 0.3	*P* = 0.05	*P* = 0.02
Negative	3.2 (896)	17.0 (628)	28.1 (409)	33.5 (544)
Positive	8.3 (12)	22.5 (71)	50.0 (20)	61.1 (18)
HIV	*P* = 0.3	*P* = 0.001	*P* = 0.003	*P* = 1.0
Negative	3.1 (906)	16.3 (659)	24.9 (293)	34.3 (378)
Positive	6.1 (33)	37.5 (48)	39.3 (140)	34.5 (177)

[a] Test for trend. [b] Among sexually active women. HSV-2, herpes simplex virus type 2.

Table 2. Risk factors for trichomoniasis in all women: multivariate analysis

	Yaoundé	Kisumu	Ndola
Age (years)	$P = 0.8$	$P = 0.3$	$P = 0.08$
15–19	1	1	1
20–29	0.7 (0.4–1.4)	0.8 (0.4–1.5)	0.5 (0.3–1.0)
30–39	0.6 (0.3–1.5)	0.5 (0.3–1.1)	0.5 (0.2–1.1)
40–49	0.7 (0.3–1.9)	0.7 (0.3–1.6)	0.3 (0.1–0.8)
Marital status	$P = 0.4$		$P = 0.03$
Never married	1		1
Now married	0.7 (0.3–1.4)		0.4 (0.2–0.8)
Past marriage	1.3 (0.6–2.7)		0.4 (0.2–0.8)
Alcohol in the past month	$P = 0.2$		$P = 0.06$
No	1		1
Yes	1.4 (0.9–2.1)		1.7 (0.97–2.8)
Education			$P = 0.003$
No primary			1
Primary complete			0.6 (0.4–1.0)
Secondary/higher			0.3 (0.2–0.6)
Occupation			$P = 0.6$
Full time			1
Student			1.1 (0.4–2.8)
Homemaker			1.2 (0.7–2.1)
Other			1.5 (0.8–2.9)
Ethnic group	$P = 0.06$		
1 Pahouin	1		
2 Bamileke	0.6 (0.4–1.1)		
3 Other	0.6 (0.3–1.0)		
Age at first sex			$P = 0.07$
After age 15			1
Before age 15			1.7 (0.96–3.0)
Number of lifetime partners	$P = 0.2$	$P = 0.09$	$P = 0.2$
0	1	1	1
1	1.4 (0.4–5.6)	2.2 (0.2–19.0)	1.6 (0.7–3.7)
2–3	2.4 (0.6–9.0)	4.9 (0.6–40.6)	1.5 (0.6–3.7)
> 3	3.1 (0.8–11.9)	4.4 (0.5–38.8)	3.0 (1.0–9.0)
Number of non-spousal partners past year	$P = 0.4$		$P = 0.1$
0	1		1
1	0.7 (0.3–1.4)		1.7 (0.8–3.5)
> 1	0.9 (0.4–2.2)		0.3 (0.03–1.9)
Money in exchange for sex	$P = 0.2$		
No	1		
Yes	1.2 (0.5–2.7)		
HIV	$P = 0.1$	$P = 0.02$	
Negative	1	1	
Positive	1.8 (0.9–3.7)	1.7 (1.1–2.7)	
HSV-2	$P = 0.004$		$P = 0.4$
Negative	1		1
Positive	2.2 (1.3–3.7)		1.2 (0.8–2.0)
Gonorrhoea	$P = 0.05$		$P = 0.2$
Negative	1		1
Positive	3.0 (1.0–8.6)		3.0 (0.7–13.6)
Chlamydial infection		$P = 0.3$	$P = 0.08$
Negative		1	1
Positive		1.7 (0.7–4.6)	2.9 (0.9–9.1)

Values are shown as odds ratios (95% confidence interval). HSV-2, herpes simplex virus type 2.

rhoea in Yaoundé and with chlamydial infection in Kisumu and Ndola. In multivariate analysis, gonorrhoea was an independent risk factor for *T. vaginalis* infection in Yaoundé (OR = 3.0, 95% CI = 1.0–8.6)and Ndola (OR = 3.0, 95% CI = 0.7–13.6), but it was only statistically significant in Yaoundé. Chlamydial infection was an independent risk factor in Kisumu (OR = 1.7, 95% CI = 0.7–4.6) and Ndola (OR = 2.9, 95%

CI = 0.9–9.1), although the associations were not statistically significant.

HSV-2 infection and HIV infection were associated with an increased prevalence of trichomoniasis in each city except Ndola where the prevalence of trichomoniasis was similar in those with and without HIV or HSV-2. The association between trichomoniasis and HIV and HSV-2 in Ndola was in part confounded by age (age-adjusted OR for HIV = 1.2, 95% CI = 0.8–1.8; age-adjusted OR for HSV-2 = 1.5, 95% CI = 0.96–2.2). The association between trichomoniasis and HSV-2 was statistically significant in Yaoundé, where the association persisted in multivariate analysis (OR = 2.2, 95% CI = 1.3–3.7). In univariate analysis, the association between trichomoniasis and HIV was statistically significant in Yaoundé and Kisumu. In multivariate analysis, HIV remained an independent risk factor for trichomoniasis but the association was statistically significant in Kisumu only (OR = 1.7, 95% CI = 1.1–2.7).

Discussion

The objective of this paper was to describe the epidemiology of *T. vaginalis* infection in women in four cities in sub-Saharan Africa with different levels of HIV infection. The prevalence of trichomoniasis in women was significantly higher in the two high HIV prevalence cities (Kisumu and Ndola) than in the two cities with relatively low levels of HIV infection (Cotonou and Yaoundé). A considerable proportion of the women were not tested for *T. vaginalis* infection but we believe that the differences in prevalence of trichomoniasis between the four cities can not be explained by participation bias. There were some differences in socio-demographic characteristics and sexual behaviour between women who were tested and women who were not, but these differences would have tended to underestimate the prevalence of trichomoniasis in all four cities. Moreover, the differences we found in the prevalence of trichomoniasis between Cotonou, Yaoundé and Ndola are in keeping with the findings from other studies. In Cotonou, the prevalence of trichomoniasis among pregnant women was found to be 17% and that among sex workers 9% in 1993; in the late 1970s, the prevalence among pregnant women in Cameroon was found to be 21% and that in Zambia was 39% [10–12].

We explored risk factors for trichomoniasis in order to try and explain the differences in prevalence between the four cities. In Yaoundé, Kisumu and Ndola, where sample sizes permitted multivariate analysis, risk of trichomoniasis was increased in women who reported higher lifetime numbers of sex partners. In Ndola, trichomonas infection was also associated with early sexual debut. Several other studies from different parts of the world have found that high-risk sexual behaviour (i.e., high rates of partner change and/or sex in exchange for money) are risk factors for *T. vaginalis* infection in women [13–16]. In our study, women in the general population who exchanged sex for money were not at a significantly increased risk of trichomoniasis, but the prevalence of *T. vaginalis* infection was higher in sex workers than in women in the general population. The prevalence was 6% in Cotonou, 27% in Yaoundé, 45% in Kisumu and 42% in Ndola [17].

In multivariate analysis, gonorrhoea and/or chlamydial infection were independent risk factors for trichomonas infection. In our study, there was no statistically significant association between syphilis seroreactivity and *T. vaginalis* infection, and HSV-2 infection was a risk factor for trichomoniasis in Yaoundé but not in Kisumu and Ndola. The most likely explanation for the association between trichomoniasis and other STIs, which has also been documented in other studies [14,18], is residual confounding by sexual behaviour [19]. However, our study design does not allow us to exclude the possibility of biological interaction between trichomoniasis and other STIs.

The prevalence of trichomonas infection was higher in HIV-infected women than in HIV-negative women in all four cities except Ndola. In multivariate analysis, trichomoniasis was associated with HIV infection in Yaoundé and Kisumu, but the association was statistically significant in Kisumu only. Several studies have found an association between trichomonas infection and HIV infection [2,20,21], although others did not find such an association after adjusting for confounding [3,4,18,22,23]. Apart from residual confounding by sexual behaviour, this association could be explained by an enhanced susceptibility to HIV infection in women who have trichomoniasis and/or an increased susceptibility to *T. vaginalis* infection in HIV-infected women. So far, only one prospective study has found trichomonas infection in women to increase the risk of acquisition of HIV infection [2]. Other prospective studies could not confirm this finding [3,4]. A study among Amsterdam sex workers, on the other hand, suggested that HIV-infected women may be more susceptible to *T. vaginalis* infection than non-HIV-infected women [24]. If this is true, then the high prevalence of trichomoniasis in the high HIV prevalence cities could be due to the high prevalence of HIV infection. However, this would not explain the high level of trichomoniasis in Ndola. This is because, in this city, no association was found between HIV infection and trichomoniasis, and because a high prevalence of trichomoniasis has been found among pregnant women in Zambia in the late 1970s, well before HIV infection was widespread in the general population [12]. We therefore believe that trichomoniasis has played a role in enhancing the transmission of HIV in the high HIV prevalence cities by increasing the susceptibility of non-HIV-infected indi-

viduals and the infectiousness of HIV-infected individuals.

The epidemiology of trichomonas infection in Ndola appeared to be different from the other cities. The high prevalence of trichomoniasis in girls who denied that they had had sex was very striking. This could not be explained by under-reporting of sexual activity because that would imply that all women aged 15–19 would have had their sexual debut. In addition, in contrast to the other cities, trichomoniasis in Ndola was age related and the risk decreased with increasing age. Ndola was also the only city where HIV-infected women did not have more trichomoniasis than non-HIV-infected women. This leads us to believe that the trichomonas infections that we detected in Ndola are not all acquired through sexual transmission. There are several reports in the literature of trichomonas infection in girls who are not sexually active. In these cases, transmission is thought to occur through contaminated fomites, a reportedly rare occurrence [25]. It is unlikely that the high prevalence of trichomoniasis in women in Ndola who denied any sexual activity is due to transmission by fomites. We therefore believe that the trichomonas infections in virgins could at least in part be due to intestinal trichomonads that are normally present in the large intestine and that are difficult to distinguish from *T. vaginalis* on microscopy [26]. Faecal material could have contaminated the self-administered vaginal swab if genital hygiene was poor and/or if the swab was not carefully inserted into the vagina. Another possibility is that intestinal trichomonads do colonize the vagina via the perineum. In the 1940s, several experiments were conducted to try and inoculate the vagina with *Trichomonas hominis*. These inoculations failed and it was thought that *T. hominis* could not colonize the vagina [27]. However, with the help of DNA amplification techniques and typing, it should now be possible to study directly the different forms of trichomonas that inhabit different sites of the human body.

The question remains why trichomonas infection is more prevalent in Kisumu and Ndola than in Cotonou and Yaoundé. Differences in sexual behaviour do not offer an adequate explanation, as rates of partner change reported by women were highest in Yaoundé, one of the low HIV prevalence cities, and Kisumu, one of the high HIV prevalence cities [28]. A study of the epidemiology and risk factors of *T. vaginalis* infection in men in the four cities could have clarified this question. Unfortunately, we did not collect samples from men for testing for *T. vaginalis*. It is clear that more research is needed on this micro-organism. Research is also needed on the epidemiology of trichomoniasis in men and on the role of trichomonas infection in the transmission of HIV. Novel molecular biological techniques should also allow us to distinguish between different trichomonads and to test the hypothesis that trichomonas infections in women who deny sexual activity may be due to colonization of the vagina by intestinal trichomonads.

References

1. Fleming DT, Wasserheit JN. **From epidemiological synergy to public health policy and practice: the contribution of other sexually transmitted diseases to sexual transmission of HIV infection.** *Sex Transm Infect* 1999, **75**:3–17.
2. Laga M, Manoka A, Kivuvu M, *et al.* **Non-ulcerative sexually transmitted diseases as risk factors for HIV-1 transmission in women: results from a cohort study.** *AIDS* 1993, **7**:95–102.
3. Kapiga S, Lyamuya EF, Lwihula GK, *et al.* **The incidence of HIV infection among women using family planning methods in Dar-es-Salaam, Tanzania.** *AIDS* 1998, **12**:75–84.
4. Taha E, Hoover DR, Dallabetta GA, *et al.* **Bacterial vaginosis and disturbances of the vaginal flora: association with increased acquisition of HIV.** *AIDS* 1998, **12**:1699–1706.
5. Hobbs MM, Kazembe P, Reed AE, *et al.* ***Trichomonas vaginalis* as a cause of urethritis in Malawian men.** *Sex Transm Dis* 1999, **26**:381–387.
6. Ghys PD, Fransen K, Diallo MO, *et al.* **The associations between cervicovaginal HIV shedding, sexually transmitted diseases and immunosuppression in female sex workers in Abidjan, Côte d'Ivoire.** *AIDS* 1997, **11**:F85–F93.
7. Buvé A, Caraël M, Hayes RJ, *et al.* **Multicentre study on factors determining differences in rate of spread of HIV in sub-Saharan Africa: methods and prevalence of HIV infection.** *AIDS* 2001, **15 (suppl 4)**:S5–S14.
8. Buvé A, Weiss HA, Laga M, *et al.* **The epidemiology of gonorrhoea, chlamydial infection and syphilis in four African cities.** *AIDS* 2001, **15 (suppl 4)**:S79–S88.
9. Weiss HA, Buvé A, Robinson NJ, *et al.* **The epidemiology of HSV-2 infection and its association with HIV infection in four urban African populations.** *AIDS* 2001, **15 (suppl 4)**:S97–S108.
10. Lowndes CM, Alary M, Meda H, *et al.* **Role of core and bridging groups in the transmission dynamics of HIV and STIs in Cotonou, Benin, West Africa.** *Sex Transm Infect* 2001, **(suppl)** (in press).
11. Nasah BT, Ngematcha R, Eyong M, Godwin S. **Gonorrhea, trichomonas and candida among gravid and nongravid women in Cameroon.** *Int J Gynaecol Obstet* 1980, **18**:48–52.
12. Hira PR. **Observations on *Trichomonas vaginalis* infections in Zambia.** *J Hygiene Epidemiol Microbiol Immunol* 1977, **21**:215–224.
13. Cotch MF, Pastorek JG, Nugent RP, Yerg DE, Martin DH, Eschenbach DA. **Demographic and behavioral predictors of *Trichomonas vaginalis* infection among pregnant women. The Vaginal Infections and Prematurity Study Group.** *Obstet Gynaecol* 1991, **78**:1087–1092.
14. Gertig DM, Kapiga SH, Shao JF, Hunter DJ. **Risk factors for sexually transmitted diseases among women attending family planning clinics in Dar-es-Salaam, Tanzania.** *Genitourin Med* 1997, **73**:39–43.
15. Passey M, Mgone CS, Lupiwa S, *et al.* **Community based study of sexually transmitted diseases in rural women in the highlands of Papua New Guinea: prevalence and risk factors.** *Sex Transm Infect* 1998, **74**:120–127.
16. Sorvillo F, Kovacs A, Kerndt P, Stek A, Muderspach L, Sanchez-Keeland L. **Risk factors for trichomoniasis among women with human immunodeficiency virus (HIV) infection at public clinic in Los Angeles County, California: implications for HIV prevention.** *Am J Trop Med Hyg* 1998, **58**:495–500.
17. Morison L, Weiss HA, Buvé A, *et al.* **Commercial sex and the spread of HIV in four cities in sub-Saharan Africa.** AIDS 2001, **15 (suppl 4)**:S61–S69.
18. Shuter J, Bell D, Graham D, Holbrook KA, Bellin EY. **Rates and risk factors for trichomoniasis among pregnant inmates in New York City.** *Sex Transm Dis* 1998, **25**:303–307.
19. Mertens TE, Hayes RJ, Smith PG. **Epidemiological methods to study the interaction between HIV infection and other sexually transmitted diseases.** *AIDS* 1990, **4**:57–65.
20. Leroy V, De Clerq A, Ladner J, Bogaerts J, Van de Perre Ph, Dabis F, and The Pregnancy and HIV (EGE) Group. **Should screening of genital infections be part of antenatal care in areas of high HIV prevalence? A prospective cohort study from Kigali, Rwanda, 1992–1993.** *Genitourin Med* 1995, **71**:207–211.

21. Daly CC, Maggwa N, Mati JK, *et al.* **Risk factors for gonorrheoa, syphilis, and trichomonas infections among women attending family planning clinics in Nairobi, Kenya.** *Genitourin Med* 1994, **70**:155–161.
22. Rugnao S, Nagachinta T, Wanapirak C, *et al.* **Gynaecological conditions associated with HIV infection in women who are partners of HIV-positive Thai blood donors.** *Int J STD AIDS* 1998, **9**:677–682.
23. Cu-Uvin S, Hogan JW, Warren D, *et al.* **Prevalence of lower genital tract infections among human immunodeficiency virus (HIV)-seropositive and high-risk HIV-seronegative women.** *Clin Infect Dis* 1999, **29**:1145–1150.
24. Fennema SA, van Ameijden EJC, Coutinho RA, van den Hoek JAR. **HIV, sexually transmitted diseases and gynaecologic disorders in women: increased risk for genital herpes and warts among HIV-infected prostitutes in Amsterdam.** *AIDS* 1995, **9**:1071–1078.
25. Neinstein LS, Goldenring J, Carpenter S. **Nonsexual transmission of sexually transmitted diseases: an infrequent occurrence.** *Pediatrics* 1984, **74**:67–76.
26. Markell EK, John DT, Krotoski WA. *Markell and Voge's Medical Parasitology.* Philadelphia: WB Saunders Company; 1999:63–68.
27. Feo LG, Rakoff AE, Stabler RM. **Inoculations of intestinal and vaginal trichomonads into the human vagina.** *Am J Obstet Gynecol* 1941, **42**:276–280.
28. Ferry B, Caraël M, Buvé A, *et al.* **Comparison of key parameters of sexual behaviour in four African urban populations with different levels of HIV infection.** *AIDS* 2001, **15 (suppl 4)**: S41–S50.