MYCOPLASMA

Mycoplasma genitalium: an organism commonly associated with cervicitis among west African sex workers

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Objectives: To identify the contribution of *Mycoplasma genitalium* to the aetiology of cervicitis in sub-Saharan Africa and its relative importance in the overall burden of sexually transmitted infections among female sex workers (FSW).

Methods: The study population consisted of FSW recruited in Ghana and Bénin during the initial visit of a randomised controlled trial. A questionnaire was administered, a pelvic examination carried out, and cervical samples obtained for detection of *M genitalium, Neisseria gonorrhoeae, Chlamydia trachomatis*, and *Trichomonas vaginalis*. Clinical signs potentially indicating cervicitis were cervical discharge, pus on the cervical swab, bleeding after sampling, and inflammatory cervix.

Results: Among 826 FSW, 26.3% were infected with *M genitalium*. *N gonorrhoeae* was strongly and independently associated with each of the four signs of cervicitis (adjusted odds ratios (AOR): 4.1 to 6.0). The AOR for *C trachomatis* were intermediate (1.3–4.1) and the AOR for *M genitalium* were lower (between 1.6 and 1.8) but statistically significant ($p \leqslant 0.05$) for each sign.

Conclusions: *M genitalium* is weakly associated with signs of cervicitis in west African FSW but is highly prevalent.

During the past decade, *Mycoplasma genitalium* has been identified as a relatively common cause of non-gonococcal urethritis, both in industrialised countries and in the developing world.[1–4] Ongoing investigations to define its pathogenicity in women have yielded somewhat contradictory findings. *M genitalium* was found more frequently in Japanese, American, and Swedish women with cervicitis than among controls, but no such association was found in France.[5–8] In Kenyan women, *M genitalium* infection was associated with acute endometritis[9] but its prevalence was low among women with salpingitis.[10] *M genitalium* was recovered more frequently in samples from British women with pelvic inflammatory disease than in controls.[11] In Guinea-Bissau, *M genitalium* infection was not associated with adverse outcomes of pregnancy.[12] To identify the contribution of *M genitalium* to the aetiology of cervicitis among female sex workers (FSW) in sub-Saharan Africa and its relative importance in the overall burden of sexually transmitted infections (STI), we looked for *M genitalium* in cervical samples of women during cross sectional studies of FSW in Ghana and Bénin.

METHODS

FSW were recruited at FSW/STI clinics in Accra (Ghana), Cotonou and Porto Novo (Bénin) between March 2001 and April 2002, during the initial visit of a longitudinal study whose primary goal was to evaluate the effectiveness of monthly antibiotics on the prevalence of gonococcal and chlamydial infections, the results of which will be reported elsewhere.[13] The population of FSW thus represented a cross sectional sample, and most did not complain of symptoms of genital infection. The study protocol was approved by the national ethical committees of Bénin and Ghana. After informed consent was obtained, a questionnaire gathering demographic and behavioural information was administered. A pelvic examination was immediately carried out by a medical doctor or midwife; the cervix was visualised with a speculum. Clinical signs potentially indicating cervicitis were cervical discharge, pus on the cervical swab ("swab test"), bleeding after cervical sampling, inflammatory cervix (oedema and erythema). The presence of cervical motion tenderness was also recorded. A cervical swab was taken with the Amplicor collection kit according to recommended procedures, kept at 4–8°C, and sent to a central laboratory in Canada. During this initial visit, antibiotics were given when clinically indicated.

The presence of *Neisseria gonorrhoeae* and *Chlamydia trachomatis* was documented using a commercial polymerase chain reaction (PCR) assay (Amplicor, Roche Diagnostics, Branchburg, NJ, USA). All repeatedly *N gonorrhoeae* positive samples were retested using an in-house 16S rRNA PCR assay[14]; samples were considered positive when confirmed by the 16S rRNA PCR assay. In-house PCR were used for detection of *M genitalium* and *Trichomonas vaginalis*, as described elsewhere.[3 4] The laboratory personnel performing these assays was blinded to the previously recorded clinical findings.

Data were entered and verified using Epi-Info 6.04, and analysis was performed with Stata 6.0. Proportions were compared with the χ^2 test using Yates's correction or, when an expected cell value was less than 5, with Fisher's exact test. Logistic regression was used for multivariate analysis.

RESULTS

A total of 382 different FSW were recruited in Ghana and 444 in Bénin. In Ghana, they were all home based; in Bénin, 192 were brothel based, 223 were home based, and 29 usually picked up clients on the street. The prevalence of *M genitalium* (MG) infection was 26.3% (217/826), compared to 16.0% (132/826) for *N gonorrhoeae* (NG), 3.4% (28/826) for *C trachomatis* (CT) and 23.1% (191/826) for *T vaginalis* (TV). Table 1 shows the frequency of co-infections among these women. The majority of women in whose cervical sample MG was found did not harbour any other co-pathogen.

Abbreviations: AOR, adjusted odds ratio; CT, *Chlamydia trachomatis*; FSW, female sex workers; MG, *Mycoplasma genitalium*; NAAT, nucleic acid amplification tests; NG, *Neisseria gonorrhoeae*; PCR, polymerase chain reaction; STI, sexually transmitted infections; TV, *Trichomonas vaginalis*

Table 1 Frequency of co-infections between various pathogens, among 826 sex workers

	N gonorrhoeae	*C trachomatis*	*M genitalium*	*T vaginalis*
N gonorrhoeae (n = 132)	**57 (43%)**	9 (7%)	42 (32%)	46 (35%)
C trachomatis (n = 28)	9 (32%)	**8 (29%)**	7 (25%)	12 (43%)
M genitalium (n = 217)	42 (19%)	7 (3%)	**128 (59%)**	62 (29%)
T vaginalis (n = 191)	46 (24%)	12 (6%)	62 (32%)	**96 (50%)**

Numbers in bold indicate the number and proportion of women infected with a single pathogen.
The total in each row exceeds 100% because some women were infected with more than two pathogens.

Table 2 displays the association between sexually transmitted pathogens, sociodemographic, and behavioural characteristics among the FSW, in univariate analyses. All four pathogens were more prevalent in FSW in Bénin than in Ghana (within Bénin, they were more prevalent in Porto Novo than in Cotonou, except for TV), but this was significantly so only for NG. While the prevalence of CT decreased with age, this was not seen for the other pathogens. MG and TV were significantly less prevalent in women with post-primary education than in their less educated counterparts, and more prevalent in women who were divorced or widowed. NG was less common in FSW who charged more than the average price for each intercourse. The presence of MG was not associated with the average number of clients per week, but was more common among FSW who had five or more clients the previous day, and in women who did not use a condom with all of their clients of the preceding week. NG and TV infections were also more common in women who did not use a condom with all clients of the preceding week. MG or NG infections were two times more frequent among HIV infected FSW than among their seronegative colleagues. Having had sex with a ''boyfriend'' in the previous week was not associated with a higher prevalence of MG, NG, CT, or TV (data not shown). In a logistic regression model, the independent correlates for infection with MG were HIV infection (adjusted odds ratio (AOR) 2.9; 95% confidence interval (CI) 2.0 to 4.3; $p<0.001$), having only primary school (AOR: 2.4, 95% CI: 1.2 to 4.7) or no formal education at all (AOR 2.5; 95% CI 1.2 to 4.9; $p = 0.01$), experience of sex work shorter than 1 year (AOR 1.8; 95% CI 1.2 to 2.8; $p = 0.005$) and working in Porto Novo (AOR 1.7; 95% CI 1.0 to 2.7; $p = 0.04$) or Cotonou (AOR 1.6; 95% CI 1.1 to 2.4; $p = 0.01$) rather than in Accra.

Table 3 compares the frequency of clinical signs among women with or without various pathogens. The presence of vaginal discharge was significantly but weakly associated

Table 2 Risk factors for infection with *Mycoplasma genitalium* (MG), *Neisseria gonorrhoeae* (NG), *Chlamydia trachomatis* (CT), or *Trichomonas vaginalis* (TV) among sex workers in Ghana and Bénin

	MG+/total	p Value	NG+/total	p Value	CT+/total	p Value	TV+/total	p Value
City of work								
Cotonou	84/304 (27.6%)	0.14	51/304 (16.8%)	0.001	11/304 (3.6%)	0.17	78/304 (25.7%)	0.23
Porto Novo	44/140 (31.4%)		36/140 (25.7%)		8/140 (5.7%)		35/140 (25.0%)	
Accra	89/382 (23.3%)		45/382 (11.8%)		9/382 (2.4%)		78/382 (20.4%)	
Age (years)								
18–30	67/263 (25.5%)	0.09	44/263 (16.7%)	0.90	15/263 (5.7%)	0.04	61/263 (23.2%)	0.31
31–40	108/365 (29.6%)		58/365 (15.9%)		9/365 (2.5%)		77/365 (21.1%)	
More than 40	42/198 (21.2%)		30/198 (15.2%)		4/198 (2.0%)		53/198 (26.8%)	
Schooling								
None	72/244 (29.5%)	0.03	46/244 (18.9%)	0.29	6/244 (2.5%)	0.41	76/244 (31.1%)	0.001
Primary	130/488 (26.6%)		70/488 (14.3%)		20/488 (4.1%)		98/488 (20.1%)	
Secondary or more	14/91 (15.4%)		15/91 (16.5%)		2/91 (2.2%)		17/91 (18.7%)	
Marital status								
Never married	59/273 (21.6%)	0.04	31/273 (11.4%)	0.04	15/273 (5.5%)	0.048	50/273 (18.3%)	0.01
Currently married	22/95 (23.2%)		17/95 (17.9%)		1/95 (1.1%)		17/95 (17.9%)	
Widowed/divorced	135/455 (29.7%)		83/455 (18.2%)		12/455 (2.6%)		123/455 (27.0%)	
Price per intercourse*								
⩽500 CFA/5000Ce	179/656 (27.3%)	0.31	119/656(18.1%)	0.001	21/656 (3.2%)	0.55	158/656 (24.1%)	0.09
>500 CFA/5000 Ce	35/153 (22.9%)		11/153 (7.2%)		7/153 (4.6%)		27/153 (17.6%)	
Duration of sex work								
Less than 1 year	91/295 (30.8%)	0.07	48/295 (16.3%)	0.94	15/295 (5.1%)	0.20	67/295 (22.7%)	0.47
1–3 years	66/285 (23.2%)		45/285 (15.8%)		5/285 (1.8%)		62/285 (21.8%)	
More than 3 years	59/243 (24.3%)		39/243 (16.0%)		8/243 (3.3%)		62/243 (25.5%)	
Average number of clients per week								
14 or less	55/232 (23.7%)	0.50	28/232 (12.1%)	0.13	8/232 (3.4%)	0.99	56/232 (24.1%)	0.92
15–28	85/320 (26.6%)		59/320 (18.4%)		11/320 (3.4%)		73/320 (22.8%)	
more than 28	70/246 (28.5%)		39/246 (15.9%)		8/246 (3.3%)		56/246 (22.8%)	
Number of clients last working day								
0–2	55/222 (24.8%)	0.04	30/222 (13.5%)	0.14	6/222 (2.7%)	0.73	49/222 (22.1%)	0.84
3–4	76/329 (23.1%)		48/329 (14.6%)		13/329 (4.0%)		79/329 (24.0%)	
5 or more	84/261 (32.2%)		51/261 (19.5%)		9/261 (3.4%)		63/261 (24.1%)	
Condom use, last week								
Not with all clients	62/188 (33.0%)	0.02	49/188 (26.1%)	<0.001	8/188 (4.3%)	0.65	60/188 (31.9%)	0.003
With all clients	144/592 (24.3%)		77/592 (13.0%)		19/592 (3.2%)		124/592 (20.9%)	
HIV								
Negative	51/308 (16.6%)	<0.001	30/308 (9.7%)	<0.001	14/308 (4.5%)	0.13	68/308 (22.1%)	0.62
Positive (HIV-1 and/or HIV-2)	156/473 (33.0%)		95/473 (20.1%)		11/473 (2.3%)		113/473 (23.9%)	

*500 CFA and 5000 Cedis ≈ US$0.80.

Table 3 Association in univariate analyses between clinical findings and the presence of *Neisseria gonorrhoeae* (NG), *Chlamydia trachomatis* (CT), *Mycoplasma genitalium* (MG) or *Trichomomas vaginalis* (TV) among sex workers in Ghana and Bénin. The baseline category consists of FSW who were negative for NG, CT, MG, and TV

	NG− CT− MG− TV−	NG+	OR (95% CI)	CT+	OR (95% CI)	MG+	OR (95% CI)	TV+	OR (95% CI)
Cervical discharge									
Yes	32 (7.8%)	43 (32.8%)	5.7 (3.3 to 10.0)**	11 (39.3%)	7.6 (3.0 to 19.1)**	38 (17.5%)	2.5 (1.5 to 4.3)**	34 (17.9%)	2.6 (1.5 to 4.5)**
No	376	88		17		179		156	
Pus on cervical swab†									
Yes	28 (7.2%)	41 (34.5%)	6.8 (3.8 to 12.2)**	8 (32.0%)	6.1 (2.2 to 16.9)**	34 (16.5%)	2.6 (1.5 to 4.5)**	30 (16.9%)	2.6 (1.5 to 4.8)**
No	363	78		17		172		147	
Bleeding after sampling									
Yes	13 (3.2%)	29 (22.1%)	8.7 (4.1 to 18.4)**	4 (14.3%)	5.1 (1.3 to 18.8)*	26 (12.0%)	4.2 (2.0 to 8.8)**	24 (12.6%)	4.4 (2.1 to 9.45)**
No	396	102		24		190		166	
Inflammatory cervix									
Yes	36 (8.8%)	41 (31.5%)	4.8 (2.8 to 8.2)**	7 (25.0%)	3.4 (1.2 to 9.4)*	40 (18.6%)	2.4 (1.4 to 4.0)**	33 (17.4%)	2.2 (1.3 to 3.7)*
No	372	89		21		175		157	
Cervical motion tenderness									
Yes	43 (10.5%)	37 (28.2%)	3.4 (2.0 to 5.7)**	7 (25.0%)	2.8 (1.0 to 7.7)*	39 (18.0%)	1.9 (1.1 to 3.1)*	32 (16.8%)	1.7 (1.0 to 2.9)*
No	366	94		21		178		158	
Number of signs above									
0	331 (84.7%)	62 (52.1%)	1.0	14 (56.0%)	1.0	143(69.4%)	1.0	127(71.8%)	1.0
1	14 (3.6%)	6 (5.0%)	2.3 (0.8 to 6.2)	2 (8.0%)	3.4 (0.7 to 16.4)	10 (4.9%)	1.7 (0.7 to 3.8)	10 (5.6%)	1.9 (0.8 to 4.3)
2	16 (4.1%)	10 (8.4%)	3.3 (1.4 to 7.8)*	2 (8.0%)	3.0 (0.6 to 14.2)	20 (9.7%)	2.9 (1.4 to 5.8)*	10 (5.6%)	1.6 (0.7 to 3.7)
3 to 5	30 (7.7%)	41 (34.5%)	7.3(4.1 to 13.1)**	7 (28.0%)	5.5 (2.0 to 15.0)**	33(16.0%)	2.5 (1.5 to 4.4)**	30 (16.9%)	2.6 (1.5 to 4.5)**
Vaginal discharge									
Yes	69 (16.8%)	37 (28.0%)	1.9	10 (35.7%)	2.75 (1.1 to 6.7)*	53 (24.4%)	1.6 (1.0 to 2.45)*	46 (24.1%)	1.6 (1.0 to 2.45)*
No	341	95	(1.2 to 3.1)*	18		164		145	

*p<0.05; **p<0.001.
†Presence of a yellow cervical exudate ("swab test").

Table 4 Association between *Mycoplasma genitalium* and clinical findings, according to whether vaginal discharge had been noted. The baseline category consists of FSW who were negative for NG, CT, MG, and TV

	No vaginal discharge			Vaginal discharge present			p Value, test for interaction
	NG− CT− MG− TV−	MG+	OR (95% CI)	NG− CT− MG− TV−	MG+	OR (95% CI)	
Cervical discharge							
Yes	24 (7.1%)	33 (20.1%)	3.3	8 (11.8%)	5 (9.4%)	0.8	0.03
No	316	131	(1.8 to 6.1)**	60	48	(0.2 to 2.9)	
Pus on cervical swab†							
Yes	20 (6.0%)	29 (18.0%)	3.5	8 (14.5%)	5 (11.1%)	0.7	
No	316	132	(1.8 to 6.7)**	47	40	(0.2 to 2.8)	0.02
Bleeding after sampling							
Yes	8 (2.4%)	18 (11.0%)	5.2	5 (7.2%)	8 (15.1%)	2.3	0.27
No	332	145	(2.0 to 13.4)**	64	45	(0.6 to 8.8)	
Inflammatory cervix							
Yes	23 (6.8%)	31 (19.0%)	3.2	13 (19.1%)	9 (17.3%)	0.9	0.02
No	317	132	(1.7 to 6.0)**	55	43	(0.3 to 2.5)	
Cervical motion tenderness							
Yes	27 (7.9%)	27 (16.5%)	2.3	16 (23.2%)	12 (22.6%)	1.0	0.10
No	313	137	(1.2 to 4.2)*	53	41	(0.4 to 2.5)	

*p<0.05; **p<0.001.
†Presence of a yellow cervical exudate (''swab test'').

with each of these four pathogens. Vulvar inflammation was uncommon and not associated significantly with any pathogen (data not shown). Each of the four signs potentially indicating cervicitis (cervical discharge, pus on the cervical swab, bleeding after sampling, inflammatory cervix) as well as cervical motion tenderness were associated with each of the four pathogens. By and large, the unadjusted odds ratios for signs of cervicitis were higher for NG and CT, and lower for MG and TV. The presence of a genital ulcer on clinical examination was not associated with a positive PCR for MG, NG, CT, or TV (data not shown). However, as shown in table 4, the associations between signs of cervicitis or cervical motion tenderness and the presence of MG were stronger among women in whom no vaginal discharge was present; for three signs, there was a significant interaction.

Logistic regression analyses were carried out for each of the four signs of cervicitis and for cervical motion tenderness as the outcomes, in which the odds ratios for each pathogen were adjusted for the presence of the other three pathogens and, in three of the models, for age (in models for cervical discharge and pus on swab, age did not improve the fit and was not kept). The presence of vaginal discharge did not improve the fit of any of the models and was thus not further considered. When adjusted for the presence of NG, CT, and MG, the presence of TV was no longer significantly associated with any of the five clinical signs and was also removed from the final models. As shown in table 5, NG was strongly and independently associated with each of the four signs of cervicitis as well as with cervical motion tenderness. The adjusted odds ratios for CT were lower than those of NG, and either similar or somewhat higher than those of MG. However, owing to its higher prevalence, the associations between MG and signs of cervicitis were all statistically significant; there was no significant association with cervical motion tenderness.

Table 6 shows the sensitivity, specificity, positive predictive value, and negative predictive values of two clinical scores to identify among FSW the presence of agents of cervicitis, without any laboratory back-up. The score with the highest PPV/prevalence ratio was the one incorporating the five signs and defining as positive any woman in whom at least two of these signs were found. This score had a sensitivity of 43% and a positive predictive value of 36% in identifying FSW with gonococcal infection. When taking into consideration all three pathogens, the positive predictive value jumped to 61% but the sensitivity dropped to 29%.

DISCUSSION

Among 826 FSW seen during a cross sectional survey, associations were found between *M genitalium* and the presence of four signs generally thought to be indicative of cervicitis. As this was a post hoc initiative exploiting data accumulated during the course of another study,[13] we did not obtain Gram stains of cervical secretions which might have given us a more objective definition of cervicitis.[6] However, this point is debatable as the cut off for the presence of mucopurulent cervicitis used by other researchers varies from ⩾10, ⩾20, and ⩾30 polymorphonuclear leucocytes per oil immersion field,[15] underlining that there is no clear cut cytological definition of cervicitis.

Is the association between *M genitalium* and signs of cervicitis causal? Some of the Bradford Hill[16] criteria have been met by studies addressing this issue, including ours:

Table 5 Associations in multivariate analysis between clinical findings of cervicitis and the presence of *N gonorrhoeae*, *C trachomatis*, and *M genitalium* among sex workers in Ghana and Bénin*

	N gonorrhoeae		*C trachomatis*		*M genitalium*	
	AOR (95% CI)	p Value	AOR (95% CI)	p Value	AOR (95% CI)	p Value
Cervical discharge	4.4 (2.8 to 7.0)	<0.001	4.1 (1.8 to 9.3)	0.002	1.6 (1.0 to 2.5)	0.05
Pus on swab	6.0 (3.7 to 9.6)	<0.001	3.3 (1.3 to 8.4)	0.02	1.6 (1.0 to 2.7)	0.047
Bleeding after sampling	5.0 (2.9 to 8.6)	<0.001	1.3 (0.4 to 4.1)	0.69	1.8 (1.0 to 3.1)	0.04
Inflammatory cervix	4.1 (2.6 to 6.4)	<0.001	1.5 (0.6 to 3.8)	0.42	1.6 (1.0 to 2.5)	0.04
Cervical motion tenderness	3.0 (1.9 to 4.7)	<0.001	1.4 (0.5 to 3.5)	0.50	1.3 (0.9 to 2.0)	0.19

AOR, adjusted odds ratio; CI, confidence interval.
*The adjusted odds ratios were obtained after controlling for the presence of the other pathogens, and for age in the models with post-sampling bleeding, inflammatory cervix, cervical motion tenderness. For cervical discharge and pus on swab, age did not enhance the fit of the model and was not kept.

Table 6 Performance of diagnosis of cervical infections based on scores derived from combinations of clinical findings among sex workers

	N gonorrhoeae	*C trachomatis*	*M genitalium*	NG, CT, MG
Score defined as positive if two or more of the following signs are present: cervical discharge, pus on swab, bleeding after sampling, inflammatory cervix, cervical motion tenderness on examination				
Sensitivity	51/119 (43%)	9/25 (36%)	53/206 (26%)	86/298 (29%)
Specificity	567/657 (86%)	619/751 (82%)	482/570 (85%)	423/478 (88%)
PPV	51/141 (36%)	9/141 (6%)	53/141 (38%)	86/141 (61%)
PPV/prevalence	2.26	1.88	1.43	1.58
NPV	567/635 (89%)	619/635 (97%)	482/635 (76%)	423/635 (67%)
Score defined as positive if one or more of the following signs are present: pus on swab, bleeding after sampling, inflammatory cervix, cervical motion tenderness on examination				
Sensitivity	57/119 (48%)	10/25 (40%)	61/206 (30%)	97/298 (33%)
Specificity	545/657 (83%)	592/751 (79%)	462/570 (81%)	406/478 (85%)
PPV	57/169 (34%)	10/169 (6%)	61/169 (36%)	97/169 (57%)
PPV/prevalence	2.11	1.74	1.37	1.48
NPV	545/607 (90%)	592/607 (98%)	462/607 (76%)	406/607 (67%)

PPV, positive predictive value; NPV, negative predictive value.

consistency (an association between *M genitalium* and cervicitis has been found in Japan, the United States, Sweden, and now west Africa[5–7]), biological plausibility (experimental infections in primates[17]), analogy (*M genitalium* is clearly associated with urethritis in men,[1–4] agents of urethritis such as *N gonorrhoeae* and *C trachomatis* cause cervicitis in women, thus it would make sense for *M genitalium* to cause cervicitis as well), and coherence (many women with cervicitis have no known pathogen found[15]). Temporality and dose response have not been addressed by the literature so far, and the strength of the associations (that is, the odds ratio) is rather weak. The only study that did not find an association between *M genitalium* and cervicitis included only women with a vaginal discharge[8]: our findings suggest that, perhaps as a consequence of its modest pathogenicity, the signs of *M genitalium* induced cervicitis are difficult to elicit in women who also have vaginitis. Ultimately, experimental data will provide the definitive answer: does the treatment of women with cervicitis, among whom *M genitalium* but not *N gonorrhoeae* nor *C trachomatis* has been recovered, with a drug active against *M genitalium* lead to the disappearance of cervicitis in a timely manner?

In this population of west African FSW, among whom there was a high frequency of condom use during transactional sex, *M genitalium* was eight times more prevalent than *C trachomatis* and 1.6 times more prevalent than *N gonorrhoeae*. It might be that the natural history of *M genitalium* cervical infection is characterised by a longer duration of infection, and this could be further compounded by the frequent co-infection with HIV. Alternatively, as *M genitalium* is less strongly associated with signs of cervicitis than are the gonococcus and *C trachomatis*, *M genitalium* infected sex workers might seek care and receive antibiotics less often than when they are infected with the other two pathogens.

C trachomatis was remarkably uncommon (3.4%) among this population of FSW, even among those aged 30 years or less (5.7%). Low prevalence of *C trachomatis* among west African FSW has been noted in recent surveys in Cotonou (5.1%),[18] in a multicentre study which included sites in Côte d'Ivoire and Bénin (1.9% in Abidjan and 5.9% in Cotonou)[19] (B Mâsse, personal communication), and in the four cities study which documented a prevalence of 4% among FSW in Cotonou, compared to 8% in Kisumu (Kenya), 9% in Ndola (Zambia), and 18% in Yaoundé (Cameroon)[20] (all of which used nucleic acid amplification tests (NAAT)). This was mirrored at the population level, with a prevalence of *C trachomatis* as low as 1.3% among a random sample of adult women in Cotonou, compared to 4.5% in Kisumu, 2.9% in Ndola, and 9.4% in Yaoundé,[21] perhaps reflecting to some extent the long standing presence in Bénin, Ghana, and Côte d'Ivoire of interventions targeting FSW, with relatively high rates of condom use and reasonable access to specialised clinics where treatment against *C trachomatis* and *N gonorrhoeae* is provided when cervicitis is suspected. The prevalence of gonorrhoea was not appreciably lower in sex workers of Cotonou than in the other three cities[20]: *C trachomatis* being less transmissible than *N gonorrhoeae*,[22] its prevalence might be more readily lowered by a high rate of condom use during transactional sex. Recent studies of FSW from east Africa, also using NAAT, have documented somewhat higher *C trachomatis* prevalences: 7% in Kenya, 12% in Tanzania, 13% in South Africa, and 16–17% in Madagascar.[23–26] Whether populations vary in their intrinsic, biological susceptibility to sexually transmitted pathogens or simply differ in the frequency of condom use during transactional sex deserves further study.

The population attributable fraction of a given pathogen with regard to a given syndrome depends on both the prevalence of the pathogen, and the strength (odds ratio) of the association. In this case, taking as the measure of association the means of the adjusted odds ratios of the four signs of cervicitis shown in table 5 (4.9 for *N gonorrhoeae*, 2.6 for *C trachomatis*, 1.7 for *M genitalium*) and the prevalences that we measured, it is possible to estimate that 38% of cases of clinical cervicitis are caused by *N gonorrhoeae*, 16% by *M genitalium*, and 5% by *C trachomatis*. The gonococcus thus remains the predominant agent of cervicitis in this population of FSW, but *M genitalium* contributes more than *C trachomatis*.

Several independent correlates of *M genitalium* infection among FSW were identified. It was more frequent in women with little or no formal education, which might be related to health seeking behaviour or condom use. *M genitalium* was also more common in FSW who had been involved for less than 1 year in the trade, which might relate to the same factors, or to a lack of acquired immunity to the pathogen. Work in Porto Novo or Cotonou rather than in Accra was a risk factor, which we believe is related to a lower rate of condom use in Bénin as documented in surveys of clients.[27–29] In the current study, adjustment for condom use (as a marker of the number of unprotected intercourses) reported by the FSW did not enhance the fit of the model and was thus not kept in the final model, emphasising that self reports by FSW might be unreliable, leading to the presence of residual confounding. In this context, the rather strong independent association between *M genitalium* and HIV infections, also described in other studies[12 30] should be interpreted cautiously. HIV infection was also associated with the presence of gonococcal cervicitis, which could be interpreted as an additional argument suggesting that there was some residual confounding. Other potential mechanisms, which could not be sorted out because of the cross sectional design, are either that *M genitalium* might facilitate

the transmission of HIV from clients to FSW, that HIV might prolong the duration of untreated *M genitalium* infection, and that HIV might reduce the effectiveness of antibiotics, given for other reasons, against *M genitalium*. Only longitudinal studies could answer these questions.

Where does that lead us with regard to the syndromic management of STI among FSW in developing countries with no access to laboratory back up? For FSW, the administration of a treatment against agents of cervicitis seems warranted when they are found to have two or more of the following signs: cervical discharge, pus on swab, bleeding after sampling, inflammatory cervix, cervical motion tenderness. One could also drop cervical discharge, and consider as having cervicitis any FSW with at least one of the four other signs. Either strategy would lead to the proper treatment of almost half of the cases of gonococcal infections and, if one considers the presence of *N gonorrhoeae*, *C trachomatis*, and *M genitalium*, in the overtreatment of 39–43% of women found to fulfil these criteria. The higher prevalence of sexually transmitted pathogens among sex workers result in a positive predictive value much higher than among women not involved in transactional sex, and these recommendations cannot be extrapolated to other populations. Furthermore, the identification of signs of cervicitis by polyvalent health care providers who carry out speculum examinations infrequently might be less reliable.[31] This argues in favour of organising the care of FSW around specialised nurses or medical officers, working within primary healthcare institutions. The proper control of these infections among the core groups of FSW might be the key to reducing their prevalence in the general adult population.[32]

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CONTRIBUTORS

JP conceived the study; ACL, KN, AD, CAA, and HM supervised the field work at both sites; ACL, SD and EF carried out laboratory analyses; JP, ACL, and MA performed the statistical analyses; JP wrote the first draft of the manuscript and all authors were involved in writing the subsequent versions of the manuscript.

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