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Molecular Detection of Pathogens Involved in Sexually Transmitted Infections in Brazzaville, Congo

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Abstract

The objective of this multicentric study was to assess the prevalence of *Chlamydia trachomatis*, *Neisseria gonorrhoeae*, *Mycoplasma génitalium* and *Trichomonas vaginalis* infections in Brazzaville, in the Republic of Congo, using molecular methods. From January to December 2021, the sexually transmitted disease risk participants were recruited from six centers: The Association of Young HIV-Positive People of Congo, The Congolese Association for Family Welfare, The Association for Support to Vulnerable Groups, Talangaï hospital, Brazzaville university hospital (outpatient service) and the private clinic COGEMO (outpatient service). The real-time multiplex PCR was carried out to detect these pathogens. Each patient had at least one specimen (urine, urethral, anal and/or vaginal samples). The patients were considered infected when one of their samples was positive. 287 participants made of 227 women and 60 men were tested. The general prevalence of these infections was: *Chlamydia trachomatis* 2.79%, *Neisseria gonorrhoeae* 3.14%, *Mycoplasma génitalium* 3.45% and *Trichomonas vaginalis* 2.97. The prevalence rates according

to sex were: *C. trachomatis*, *M. génitalium*, *N. gonorrhea* and *T. vaginalis* were 1.32%, 2.05%, 1.32% and 3.42% in women and 8.33%, 7.02%, 10% and 1.75% in men, respectively. Most infected patients were asymptomatic. Prevalence rates were higher in bisexual individuals, with the exception of *T. vaginalis* which showed higher prevalence in heterosexual patients. The bisexual and homosexual individuals represent a major public health problem in sexually active young adults, particularly among men having sex with men. These sexually transmitted infections are mainly asymptomatic, their diagnosis and management remain difficult in developing countries.

Keywords

Prevalence, *Chlamydia trachomatis*, *Neisseria gonorrhoeae*, *Mycoplasma génitalium*, *Trichomonas vaginalis*

1. Introduction

Sexually transmitted infections (STIs) are among the most widely reported infectious diseases in the world and present high morbidity and mortality [1]. STIs can be caused by many pathogens, including human immunodeficiency viruses (HIV), herpes simplex virus type 2, hepatitis B and C viruses, human papillomavirus, *Treponema pallidum*, *Chlamydia trachomatis*, *Neisseria gonorrhoeae*, *Mycoplasma genitalium* and *Trichomonas vaginalis* [2] [3].

In 2016, Rowley *et al*. has been reported that 376.4 million people worldwide contract STIs caused by *C. trachomatis*, *N. gonorrhoeae*, *M. genitalium. Trichomonas vaginalis* and *Treponema pallidum* [4]. The global prevalence estimates for each STI in women and men were respectively as follows: 3.8% and 2.7% for *C. trachomatis*, 0.9% and 0.7% for *N. gonorrhoeae*, 5.3 and 0.6% for *T. vaginalis*, and 1% - 6.4% and 1% - 4% for *M. genitalium* [4]-[6]. However, their prevalence hugely varies from one continent to another. Bacterial STIs (*Chlamydia Trachomatis* and *Neisseria gonorrhoaea*) and parasitic STIs (*Trichomonas vaginalis*) are the most prevalent in the world, with wide disparities depending on the socio-demographic and economic conditions of each country. The African and American continents are more affected than Europe, with prevalences of 42.8 million, 9.1 million and 8.2 million respectively for *Trichomonas vaginalis*, *Chlamydia trachomatis* and *Neisseria gonorrhoaea* in Africa; 57.8 million, 25.2 million and 3.6 million respectively for *Trichomonas vaginalis*, *Chlamydia trachomatis* and *Neisseria gonorrhoaea* in America; versus 14.3 million, 17.3 million and 1.0 million respectively for *Trichomonas vaginalis*, *Chlamydia trachomatis* and *Neisseria gonorrhoaea* in Europe [7]. The estimated prevalence in women and men were higher in African areas with 5.0% and 4.0% for *Chlamydia trachomatis*, 1.9% and 1.6% for *Neisseria gonorrhoeae*, and 11.7% and 1.2% for *Trichomonas vaginalis*, respectively [4]. *Mycoplasma genitalium* infection ranges from 1% to 3% in the general population worldwide, and increases by 38% in African sex workers [8].

Since the emergence of HIV, STIs prevalence increased in the world, because they are cofactors of those infections, and their adequate treatment reduces the risk of HIV infection. Therefore, the World Health Organization (WHO) promotes the syndromic approach for the effective management of STIs in limited-resources countries, such as the Republic of Congo, where access to laboratory testing is limited. In this context, STI treatment is often empiric and is based on the use of large-spectrum antibiotics and surveillance data, when available. In recent years, STI prevalence has been increasing again worldwide, particularly syphilis, *C. trachomatis* and *gonorrhoeae* infections. Clinically, some STIs are asymptomatic, but a variety of pathologies are possible, including urethritis, cervicitis, salpingitis and chorioamnionitis [9] [10]. Moreover, STIs increase the risk of ectopic pregnancy, miscarriage, premature birth, and infertility. There is a critical lack of recent data m on STI pathogens in Africa due to the lack of the laboratories equipment. Therefore, we propose to realize this study in Brazzaville (CONGO), for the diagnosis and epidemiologic interest, in order to optimize the management of patients with STIs. The aim of this study was to determine the prevalence of the following pathogen implicated in STIs: *C. trachomatis*, *M. genitalium*, *N. gonorrhoeae* and *T. vaginalis*.

2. Materials and Methods

2.1. Contest, Study Population and Specimen Collection

This prospective, descriptive and analytic study was conducted between January and December 2021. which concerned homo and bisexual patients in associations and hospital centers.

The study was carried out in health centres such as the medical department of TALANGAI referral hospital, the COGEMO medical and surgical clinic, the teaching hospital center of Brazzaville (CHU) and community health associations (Association Congolese for Well-Being of Family ACBEF, Association positive young people from Congo AJPC, Association Support for Vulnerable Groups ASGV). It included all consenting individuals aged old 18 years, with or without STI symptom or with STI risk factors. These were people living with HIV followed up in the medical department of the TALANGAI referral hospital, patients coming to the COGEMO and CHU health centres with STI risk factors, and members of the above associations with or without STI risk factors. Individuals were recruited exhaustively durind the study period, our prevalences will therefore be compared with those of other studies using a homogeneity test.

For male subjects, urine, urethral samples and anal swabs were taken. For female subjects, an endocervical, vaginal swab and urine sample were collected, using the appropriate Cobas® sampling kits.

Urine was conditioned in Cobas® PCR Media urine transport kit and urethral, anal and endocervical samples in Cobas® PCR Media Dual Swab Sample Kit, in the Bacteriology-Virology laboratory (CHU of Brazzaville) samples were stored at room temperature and send to Bacteriology department in Arnaud de Villeneuve

(CHU of Montpellier) for PCR analysis.

The analysis took place in the Bacteriology and Virology laboratories of the CHU-B in Brazzaville and the CHU Arnaud de Villeneuve in MONTPELLIER.

The variables studied were: Age, sex, sexual orientation (bisexuality, homosexuality, heterosexuality) and clinical signs.

Patients were recruited from the different centres, interviewed and examined by the centre's doctors, and then sampled in the centres.

2.2. DNA. Extraction and Detection of *Chlamydia trachomatis, Neisseria gonorrhoeae, Mycoplasma genitalium* and *Trichomonas vaginalis*

For *C. trachomatis*, *N. gonorrhoeae*, and *T. vaginalis* DNA extraction and amplification was performed as described previously [11]. In summary, DNA extraction was performed on Cobas X 4800 and LightCycler Z 480 Real Time PCR System respectively (Roche Diagnostics). *C. trachomatis* detection was performed with the COBAS® TaqMan® CT Test, v2.0 kit, while the *N. gonorrhoeae porA* gene and the *M. genitalium* attachment (adhesin) protein (*MgPa*) operon were amplified using homemade PCR protocols adapted from Hjelmevoll *et al.* 2006 and Jensen *et al.*, 2004 respectively [8] [11]-[14]. A participant was considered positive when the DNA pathogen was present in one of different sample.

2.3. Data Analysis

Microsoft Excel 2019 was used to create the database, and the statistical analyses were carried out using R Studio "Mountain Hydrangea" Release with R version 4.2.2. Qualitative variables were expressed using frequencies and percentages. Quantitative variables were described using means and standard deviation when normally distributed, or with medians with the first and third quartile when the normal distribution was not confirmed with the test. Factors associated with the dependent variable (positive PCR result) were identified by logistic regression analysis. The association between each factor and the dependent variable was estimated using odds ratios (OR) and their 95% confidence interval (IC). The dependent variable was coded as "0" for negative samples and "1" for *C. trachomatis*, *N. gonorrhoeae*, *M. genitalium*, and *T. vaginalis* positive samples. Patients with at least one positive specimen were considered as having an STI. The threshold of significance was set at 0.05.

3. Result

In total, in our study, 363 samples were collected during January to December 2021. Samples included 36 anal swabs (12.5%), 57 urethral swabs (19.7%), 105 urine samples (36.6%) and 165 endocervical and vaginal swabs (57.5%).

3.1. Characteristics of Patients

The mean age of two hundred and eighty-seven included patients was 37 years ±

12 (range: 18 to 77 years); 227 (79.1%) were women and 60 (20.9%) were men, corresponding to a female to male sex ratio of 3.7.

3.2. Overall Prevalence

The overall prevalence of *Chlamydia trachomatis* infection was 2.79% (N = 287), with a male prevalence of 8.33% (N = 60) and a female prevalence of 1.32% (N = 227).

The overall prevalence of *N. gonorrhoeae* infection was 3.14% (N = 287), with a male prevalence of 10.0% (N = 60) and a female prevalence of 1.32% (N = 227).

The overall prevalence of *M. genitalium* infection was 3.46% (N = 202), with a male prevalence of 7.02% (N = 57) and a female prevalence of 2.05% (N = 146).

Finally, the overall prevalence of *T. vaginalis* infection was 2.97% (N = 202), with a male prevalence of 1.75% (N = 57) and a female prevalence of 3.42% (N = 146).

3.3. Socio-Demographic Characteristics According to the Different Pathogens

3.3.1. *Chlamydia trachomatis* Infection

The age group most affected by *Chlamydia trachomatis* infection was between 18 to 28 years (n = 5), followed by 29 to 38 years (n = 2). Gender is a risk factor, with a p-value of 0.0102. Male sex increased the risk of infection by 6.38 times. Bisexuality and homosexuality were risk factors with p-values of 0.0096 and 0.0023 respectively. The population treated at the Reference Hospital in Talangaï has a high probability to developing a *C. trachomatis* infection (p = 0.0044), as Table 1 shows.

Table 1. Characteristics according to age, sex sexual orientation health center in people with *Chlamydia trachomatis* infection.

		C. trachomatis			
Variables	**n**	**Negative**	**Positive**	**OR (95% CI)**	**P-value**
Age group					
18 - 28	98	93	5	2.25 (0.70 - 2.59)	0.340
29 - 38	85	83	2		
39 - 48	48	47	1	0.87 (0.66 - 3.44)	0.912
49 - 58	40	40	0	-	-
59 - 68	14	14	0	-	-
69 - 80	2	2	0	-	-
Sex					
Woman	227	224	3	6.38 (1.57 - 29.27)	0.0102
Man	60	55	5		

Continued

Sexual orientation					
Bisexual	30	27	3	8.81 (2.31 - 13.28)	0.0096
Heterosexual	241	238	3		
Homosexual	10	8	2	19.83 (2.66 - 21.01)	0.0023
Sex worker	6	6	0	-	-
Sampling center					
AJPC	61	56	5		
ASGV	7	7	0	-	-
ACBEF	47	47	1	0.23 (0.21 - 3.04)	0.1976
Brazzaville university hospital	4	4	0	-	-
COGEMO clinic	62	61	1	0.18 (0.13 - 3.03)	0.1271
Talangaï hospital	105	104	1	0.10 (0.09 - 0.75)	0.0443

3.3.2. *Neisseria gonorrhoeae* Infection

Table 2 shows that the age group most affected by *Neisseria gonorrhoeae* infection is the 18 to 28 years group, followed by the 39 - 48 years group. Gender is a risk factor for infection. Male sex increases the risk of infection 8.29 times. The bisexual group and the AJPC centre are the most affected by *Neisseria gonorrhoeae* infection.

Table 2. Characteristics according to age, sex sexual orientation health center in people with *Neisseria gonorrhoeae* infection.

		N. gonorrhoeae			
Variables	**n**	**Négative**	**Positive**	**OR (95% CI)**	**P-value**
Age group					
18 - 28	98	90	8	0.23 (0.16 - 2.95)	0.999
29 - 38	85	85	0	-	-
39 - 48	48	47	1		
49 - 58	40	40	0	-	-
59 - 68	14	14	0	-	-
69 - 80	2	2	0	-	-
Sex					
Woman	227	224	3	8.29 (2.01 - 4.23)	0.0034
Man	60	54	6		

Continued

Sexual orientation					
Bisexual	30	25	5		
Heterosexual	241	238	3		
Homosexual	10	9	1		
Sex worker	6	6	0	-	-
Sampling center					
AJPC	61	53	8	7.09 (0.92 - 9.23)	0.0695
ASGV	7	7	0	-	-
ACBEF	48	47	1		
Brazzaville university hospital	4	4	0	-	-
COGEMO clinic	62	62	0	-	-
Talangaï hospital	105	105	0	-	-

3.3.3. *M. genitalium* Infection

The age group most affected by *M. genitalium* infection is between 18 to 28 years. Males, the bisexual group and the AJPC centre are the most affected by *M. genitalium* infection (Table 3).

Table 3. Characteristics according to age, sex sexual orientation health center in people with *Mycoplasma genitalium* infection.

		M. genitalium			
Variables	**n**	**Negative**	**Positive**	**OR (95% CI)**	**P-value**
Age group					
18 - 28	69	65	4	2.87 (0.53 - 3.10)	0.3519
29 - 38	47	46	1	-	-
39 - 48	39	39	0	-	-
49 - 58	35	34	1	1.35 (0.96 - 4.18)	0.8328
59 - 68	10	9	1	5.11 (0.86 - 4.30)	0.2639
69 - 80	2	2	0	-	-
Sex					
Woman	145	142	3	3.57 (0.77 - 16.49)	0.1028
Man	57	53	4		

Continued

Sexual orientation					
Bisexual	30	27	3	4.22 (0.97 - 6.16)	0.0689
Heterosexual	156	152	4		
Homosexual	10	10	0	-	-
Sex worker	6	6	0	-	-
Sampling center					
AJPC	61	58	3	0.31 (0.38 - 3.42)	0.3422
ASGV	7	6	1		
ACBEF	48	47	1	0.12 (0.10 - 4.38)	0.1640
Brazzaville university hospital	3	3	0	-	-
COGEMO clinic	0	0	0	-	-
Talangaï hospital	83	81	2	0.14 (0.12 - 3.65)	0.1406

3.3.4. *Trichomonas vaginalis* Infection

The age group most affected by *Trichomonas vaginalis* infection is between 39 to 48 years, followed by 49 to 58 years. The female sex, the heterosexual group and the Talangaï referral hospital are the most affected by *T. vaginalis* infection, as Table 4 shows.

Table 4. Characteristics according to age, sex sexual orientation health center in people with *Trichomonas vaginalis* infection.

		T. vaginalis			
Variables	**N**	**Negative**	**Positive**	**OR (95% CI)**	**P value**
Age group					
18 - 28	69	68	1		
29 - 38	47	47	0		
39 - 48	39	37	2	3.62 (0.74.54)	0.300
49 - 58	35	33	2	4.05 (0.88 - 6.23)	0.260
59 - 68	10	9	1	7.44 (0.69 - 8.25)	0.169
69 - 80	2	2	0		
Sex					
Woman	145	140	5	0.50 (0.05 - 4.37)	0.5311
Man	57	56	1		

Continued

Sexual orientation					
Bisexual	30	30	0	-	-
Heterosexual	156	150	6		
Homosexual	10	10	0		
Sex worker	6	6	0		
Sampling center					
AJPC	61	60	1		
ASGV	7	7	0		
ACBEF	48	47	1	1.27 (0.94.16)	0.864
Brazzaville university hospital	3	3	0		
COGEMO clinic	0	0	0		
Talangaï hospital	83	79	4	3.03 (0.853.0)	0.326

3.3.5. Distribution of Different Infections According to Clinical Symptomatology

Table 5 shows that the Asymptomatic forms are more frequent in *Chlamydia trachomatis* infection (62.5%) and *T. vaginalis* infection (66.67%).

Table 5. Distribution of patients with STIs according to clinical symptoms.

	C. trachomatis (N = 8)		*N. gonorrhoeae* (N = 9)		*M. genitalium* (N = 7)		*T. vaginalis* (N = 6)	
	n	%	n	%	n	%	n	%
Asymptomatic	5	(62.5)	4	(44.4)	3	(42.8)	4	(66.67)
Anogenital warts	0	(0.00)	0	(0.00)	1	(14.2)	0	(0.00)
Dysuria	2	(25.0)	1	(11.1)	1	(14.2)	0	(0.00)
Urethral discharge + dysuria	0	(0.00)	0	(0.00)	1	(14.2)	0	(0.00)
Leucorrhea	0	(0.00)	1	(11.1)	1	(14.2)	2	(33.33)
Anal pruritus	1	(12.5)	2	(22.2)	0	(0.00)	0	(0.00)
Generalized pruritus	0	(0.00)	1	(11.1)	0	(0.00)	0	(0.00)

4. Discussion

The objective of this study was to estimate the prevalence of *C. trachomatis*, *M. genitalium*, *N. gonorrhoeae* and *T. vaginalis* infections in Brazzaville, the Republic of Congo. This is one of the first studies using real-time multiplex PCR [15]. The overall prevalence rates of STIs due to these four pathogens were 2.79% (*C.*

trachomatis), 3.14% (*M. genitalium*), 3.47% (*N. gonorrhoeae*) and 2.96% (*T. vaginalis*). The prevalences of these results are low in women for *C. trachomatis* and *N. gonorrhoeae*, and high for both pathogens in men, compared with those described by the WHO for African region [7]-[16].

Few studies have simultaneously assessed the prevalence of *C. trachomatis*, *N. gonorrhoeae*, *M. genitalium* and *T. vaginalis* in vaginal, urinary and urethral samples in sub-Saharan African regions. Moreover, data on men in other African countries are lacking due to their low participation rate in STI studies.

The overall prevalence of Chlamydia trachomatis infection is 2.79% (N = 287), with a male prevalence of 8.33% (N = 60) and a female prevalence of 1.32% (N = 227). Hanna Guimarães *et al*. found a prevalence of 7.9% (N = 415) in 2013 in Angola. These results are statistically similar to our overall prevalence (Z = -2.84; with α = 5% margin of error and $Z\alpha$ = 1.96) [17]. Their study took place in association offering anonymous HIV testing. As in our study, the following centres the Talangaï referral hospital, AJPC, ASGV and ACBEF receive people for anonymous HIV testing. These people may be immunocompromised due to HIV, a risk factor identified in some studies [18]. Mohamed Diadhiou found a female prevalence of 4.7% (N = 276) in 2019 in Dakar. This prevalence is comparable to that of our study (with Z = −2.15, considering a risk of error of α = 5% and $Z\alpha$ = 1.96) [19]. The characteristics of the two populations are similar in terms of years, and both countries are developing. Fabrice Compain and al, in Ndjamena, Chad in 2019, found a female prevalence of 1.2% (N = 251). These results are lower than our results (Z = 0.11 with a margin of error of α = 5% and $Z\alpha$ = 1.96) [20]. This may be explained by the fact that, in this study, 80.1% of the women had only one regular sexual partner. Similarly, Heloisa Lopes Lavartori *et al*. in 2015 obtained a prevalence of 8% (N = 112), higher than that observed in our study [21]. This could be due to differences in the size, nature and characteristics of the population studied.

The overall prevalence of *Neisseria gonorrhoeae* infection is 3.14% (N = 287), with a male prevalence of 10.0% (N = 60) and a female prevalence of 1.32% (N = 227). Hanna Guimarães *et al*. found a prevalence of 8.1% (N = 415) in 2013 in Angola. These results are statistically close to our overall prevalence (Z = −2.70; with α = 5% margin of error and $Z\alpha$ = 1.96) [17]. Their study took place in an association offering anonymous HIV testing. As in our study, the following centres the Talangaï referral hospital, AJPC, ASGV and ACBEF receive people for anonymous HIV testing. These people may be immunocompromised as a result of HIV, a risk factor identified in some studies [18]. Safae Karim *et al*. found a female prevalence of 14.2% (N = 809) in Morocco. These results are similar to those obtained in our study (Z = −5.40; with α = 5% margin of error and $Z\alpha$ = 1.96) [2]. Our results differ from those observed in Dakar by Mohamed Diadhiou *et al*. in 2019, and those of Fabrice Compain *et al*. in Ndjamena in Chad in 2019, with a female prevalence of N. gonorrhoeae, *M. genitalium* and T. vaginalis of 1.1% (N = 276) and 1% (N = 251) respectively [19] [20]. This disparity in the

prevalence and distribution of bacterial STIs may be due to the nature of the samples taken, the geographical area, diagnostic techniques, management strategies and cultural factors influencing the management of STIs.

T. vaginalis is the most common non-viral STI in the world. According to the 2012 WHO report, in the African region, the prevalence of T. vaginalis infection among women was 2.2%, or 146.0 per 1,000 population [22]. The prevalence of T. vaginalis obtained in this study is higher than that observed by Mahamed D. *et al*. and S. Pereyre *et al* [8]-[19]. Worldwide, the prevalence of *M. genitalium* varies from 1 to 3%, reaching 38% among sex workers in France [23]. The prevalence observed in our study was 3.47%, similar to that reported in a French multicentre study conducted between September 2014 and January 2015 [8], but lower than that observed in other African countries such as Morocco and Chad (N'Djamena) [2]-[20]. The low prevalence rates of *M. genitalium* and T. vaginalis infections in the at-risk populations in our study in Brazzaville may be the result of several factors, such as STI prevention programmes implemented by the health authorities in particular, syndromic management of patients and self-medication, which may help to reduce the prevalence of *M. genitalium* and T. vaginalis infections.

Concerning risk factors in our study, *C. trachomatis*, *N. gonorrhoeae* and *M. genitalium* infections prevalence rates were higher in men than women. Sexual orientation, including bisexuality and homosexuality, were the main risk factors associated with *C. trachomatis* infection (P values = 0.009, and 0.002). In recent years, sexually active homosexual and bisexual men have seen an increase in risky sexual practices, the trivialization of oral sex and a high frequency of anal sex. They constitute a high-risk group for contracting and transmitting *C. trachomatis*, *N. gonorrhoeae*, *M. genitalium* infections, and are thus a potential vector for HIV. Gender was the main risk factor associated with C. trachomatis and N. gonorrhoeae infections in our study (P values = 0.0034). However, male sex multiplied the risk of contracting C. trachomatis by 6.38 and N. gonorrhoeae by 8.29. The introduction of PrEP as prophylaxis in the management of HIV exposure accidents has been associated with an increase in STIs. This has led to a reduction in condom use and an increase in unsafe sexual practices, resulting in greater transmission of STIs.

Although age is not associated with the occurrence of infections, the age range most affected is between 18 and 28 for *C. trachomatis*, *N. gonorrhoeae* and *M. genitalium* infections. Young adults and adolescents in this age bracket are often the most affected. This is often due to factors such as more frequent sexual activities among young people and a lack of awareness about safe sexual practices such as condom use. *T. vaginalis* was highest in people aged between 39 and 58. Young age is an important predictor of sexually transmitted *C. trachomatis* and *N. gonorrhoaea* infections, because most of these infections are asymptomatic.

In this study, asymptomatic forms were more frequent than symptomatic forms and are not significantly associated with infections, particularly dysuria in men and leucorrhea in women. These results are in accordance with those observed by Holmes KK *et al*. in 2008 [24].

In this study, we observed a large number of positive cases of *C. trachomatis*, *N. gonorrhoeae* and *M. genitalium* infections in the HIV-positive population of the AJPC and Talangaï hospital (26.22% for AJPC and 3.61% for Talangaï). These results corroborate those obtained by Laga and *et al*., in 1993 and Napierela M and *al*, in 2012 [18]-[25]. Developing countries are disproportionately affected by these STIs due to the lack of laboratory infrastructures, the absence of awareness and contraception procedures the level of poverty of the populations, and risk sexual behaviour. STIs represent a considerable risk in the transmission and acquisition of HIV and multiply the risk by five. These STIs induce an inflammatory reaction which leads to increased recruitment of CD4 lymphocytes in the genital tract, resulting in an increase in HIV targets and increased HIV replication [26]. The low prevalence of these STIs in no HIV population observed in our study can also be explained by a self-medication, which has become an emerging phenomenon and an increasing threat to public health in developing countries, as it can lead to therapeutic failure or inappropriate treatment. This practice is accepted insofar as it makes it possible to treat people who are victims of stigmatization in urban areas, MSM, sex workers and transgender people, with diseases or symptoms that are presumed to be benign and known, with the advantages of discretion and saving time and money [27]. Furthermore, STIs are considered as a shameful disease in undevelopped countries, often lead to self-medication with antibiotics.

5. Conclusion and Recommendations

This study has permitted to provide STI prevalences of *C. trachomatis*, *N. gonorrhoeae*, *T. vaginalis* and *M. genitalium* among the population at risk in Brazzaville (Republic of Congo). These prevalences are lower compared with certain regions of the world. Sexually active young adults with risky sexual behaviour and sex workers are most at risk of infection. However, no positive results have been observed in the sex worker population, due to their care and awareness in their respective communities. These STIs are mostly asymptomatic, making diagnosis difficult and underestimated. Prevalence rates vary considerably around the world, and can be influenced by socio-economic, cultural and political factors. Screening and care programs should be implemented to monitor these four STIs and reduce their impact on sexual and reproductive health.

6. Limitations of the study

This study has some limitations. Regarding limited financial resources chlamydia trachomatis serology analyses Neisseria gonorrhoaea and Mycoplasma culture are not realised in this study. The low frequency of the male population, with a sex ratio of 3.7:1, is due to cultural considerations in Africa, particularly in Congo-Brazzaville where female population is higher than male population. Given the lack of technical resources and the high cost of PCR in our sub-Saharan African context, our study benefited from technical support from the CHU of MONTPELLIER in the analysis of samples by PCR. Those limitations may have some

implications in the conclusions of this study.

Data Availability

All data used in this study are available from the corresponding author upon request.

Consent

Informed consent was obtained for each participant or from a parent or guardian for underage participants.

Authors' Contributions

JMSMB and SG took part in the molecular analyses and in the writing of the manuscript in collaboration with NENO. NENO and SG designed the study protocol. TM, HT, AA, BRIO and CI were involved in sample collection. LFK, SSP, CD, GC and GMB were involved in the correction of the manuscript. EN, ESKB and GOS participated in the validation of the results and statistical analyses. All authors have read and approved the manuscript.

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Conflicts of Interest

The authors do not declare any conflict of interest.

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List of Symbols

MSM	Men sexual men
CT	*Chlamydia trachomatis*
STI	Infection sexually transmissible
DNA	Acid deoxyribonuclease
NG	*Neisseria gonorrhoaea*
TV	*Trichomonas Vaginalis*
PCR	Polymerase Chain reaction
HIV	Human virus of immunodeficient
MG	*Mycoplasma genitalium*
CHUB	University hospital B
STI	Infection sexually transmissible
OR	Odds ratios
CI	Confidence interval
PCR	Polymerase chain reaction
M. genitalium	*Mycoplasma genitalium*
C. trachomatis	*Chlamydia trachomatis*
N. gonorrhoeae	*Neisseria gonorrhoeae*
T. vaginalis	*Trichomonas vaginalis*
CD4	*CD4' T cells*