



Chlamydia trachomatis and Neisseria gonorrhoeae among adults attending a Nigerian tertiary hospital: prevalence, symptom status and behavioural correlates using the Xpert CT/NG assay

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Abstract

Original Research

Chlamydia trachomatis and Neisseria gonorrhoeae are the two most common curable bacterial sexually transmitted infections worldwide, yet most Nigerian health facilities still practice syndromic management because nucleic acid testing is rarely available outside research settings. Facility-based estimates using molecular diagnostics are correspondingly scarce, and the proportion of infection that would be missed by syndromic management are not well described in this population.

Methods. We conducted a cross-sectional study at a tertiary hospital in southern Nigeria between April 2020 and April 2022. consenting adults who had not taken antibiotics recently were enrolled; women who were menstruating were excluded. Participants completed an interviewer-administered questionnaire covering demographic characteristics, sexual behavior and genitourinary symptoms. Genital specimens were tested with the Xpert CT/NG assay. Prevalence was estimated with Jeffreys 95% confidence intervals, and correlates of infection were examined using Pearson chi-square tests followed by multivariable logistic regression.

Results. Of 472 participants (243 women, 229 men; mean age 29.8 years, SD 8.2), 212 had C. trachomatis, N. gonorrhoeae or both (44.9%, 95% CI 40.5–49.4). N. gonorrhoeae was detected in 211 participants (44.7%, 95% CI 40.3–49.2) and C. trachomatis in 165 (35.0%, 95% CI 30.8–39.3); 164 participants (34.7%) carried both organisms, and all but one chlamydial infection occurred as a co-infection. Prevalence did not differ by sex (47.2% in men, 42.8% in women; $p = 0.39$). Ninety-two of the 212 infections (43.4%) occurred in participants who reported no genitourinary symptoms. In the adjusted model, infection was associated with self-reported HIV-positive status (aOR 7.05, 95% CI 4.02–12.37), sexual debut between 15 and 20 years (aOR 3.78, 95% CI 1.73–8.25) and before 15 years (aOR 3.10, 95% CI 1.38–6.99), non-use of a condom at the most recent sexual encounter (aOR 2.98, 95% CI 1.49–5.97) and symptomatic presentation (aOR 2.03, 95% CI 1.25–3.30). Sex, age group, marital status, education and employment were not independently associated with infection.

Conclusions. Nearly half of the adults tested carried at least one of the two organisms, and more than two in five infections would have been invisible to syndromic management. The concentration of chlamydial infection within co-infected participants and the strong association with early sexual debut argue for molecular screening of attendees who report HIV-positive status, early debut or condomless sex, rather than testing on the basis of symptoms alone.

Keywords: Chlamydia trachomatis; Neisseria gonorrhoeae; Xpert CT/NG; asymptomatic infection; syndromic management; Nigeria.

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1. Background

Chlamydia trachomatis and *Neisseria gonorrhoeae* account for a large share of the curable sexually transmitted infection burden. The World Health Organization estimated 374 million new infections with one of four curable STIs in 2020, of which roughly 129 million were chlamydial and 82 million gonococcal [1]. Global prevalence among people aged 15 to 49 years was put at 4.0% for women and 2.5% for men for chlamydia [1,2,3]. Sub-Saharan Africa carries the heaviest burden, and a recent meta-regression of 211 studies from 28 countries estimated 2020 chlamydia prevalence in the region at 6.9% among women and 4.2% among men, with gonorrhoea at 1.8% and 1.5% respectively [3,4,5,6,7.]

Those regional figures come mainly from general-population and antenatal samples. Prevalence in people presenting to hospital with genitourinary complaints, or attending clinics for related services, is considerably higher, and the same review noted that estimates for men are drawn from far fewer observations than those for women [3]. Nigeria contributes little to this evidence-based studies of key populations, where prevalence is high: among men who have sex with men and transgender women recruited in Abuja and Lagos, screening for urogenital and anorectal chlamydia and gonorrhoea was performed alongside HIV testing in a cohort with 54.9% HIV prevalence [4].

The major problem is diagnostic. Most Nigerian facilities manage genital complaints syndromically, treating on the basis of discharge, dysuria or pelvic pain. Syndromic algorithms were designed for settings without laboratory capacity and they have a structural weakness that applies with particularly to these two organisms: a large fraction of infections produce no symptoms at all. Asymptomatic carriage has been reported in 50 to 70% of infected women and 10 to 50% of infected men, and symptomatic cases often present vaguely [5]. Screening based on self-reported symptoms and signs performs poorly as a substitute, a Kenyan study using three-site nucleic acid testing found [5], Cartridge-based nucleic acid amplification on the GeneXpert platform has made

molecular testing feasible in district and tertiary laboratories, and the Xpert CT/NG assay has performed well against reference nucleic acid tests in multi-country evaluations, with specificity of 96% or better for both organisms [6,7,8,9,10].

What is not well described for Nigerian tertiary care is how much infection molecular testing would find that current practice misses, and which characteristics identify the people carrying it. We therefore measured *C. trachomatis* and *N. gonorrhoeae* prevalence by Xpert CT/NG among patients attending a tertiary hospital in southern Nigeria, quantified infections occurring without symptoms, and examined demographic and behavioral correlates of infection.

2. Methods

2.1 Study design and setting

This was a cross-sectional study carried out at Irrua Specialist Teaching Hospital, a tertiary referral centre in Edo State, southern Nigeria, between April 2020 and April 2022. The hospital serves a mixed urban and rural catchment and receives referrals from primary and secondary facilities across the state and neighboring states.

2.2 Participants and sampling

Participants were recruited consecutively over the study period. Adults were eligible if they gave written informed consent were sexually active and reported no antibiotic therapy in the period preceding enrolment. Refusal of consent not being sexually active and, in women, active menstruation at the time of specimen collection were exclusion criteria. Both symptomatic and asymptomatic attendees were enrolled, which allowed the contribution of asymptomatic infection to be estimated directly rather than inferred.

No formal sample size calculation was performed in advance; the analyzed sample comprises all participants recruited during the twenty-four-month enrolment window who had a valid Xpert CT/NG result.

2.3 Data collection

A structured interviewer-administered questionnaire was used. It covered age, sex, religion, marital status, family setting, employment and highest educational attainment; sexual history including age at first sexual intercourse, number of partners in the preceding year, more than one partner in the preceding three months, condom use at the most recent encounter with the main partner, and coital frequency; treatment for a sexually transmitted infection or urinary tract infection in the preceding three months; previous history of abortion; knowledge of HIV status; and current use of family planning. Genitourinary symptoms were recorded as vaginal discharge, urethral discharge, lower abdominal pain, testicular pain, vulval or vaginal itching, pain on urination, intermenstrual bleeding and post-coital bleeding. Participants reporting none of these were classified as asymptomatic.

2.4 Specimen collection and laboratory testing

First-void urine was collected from all participants. Men additionally provided a urethral swab; women provided a clinician-collected endocervical swab and, where feasible, a self-collected vaginal swab. Specimens were tested with the Xpert CT/NG assay on the GeneXpert platform according to the manufacturer's instructions. Results were reported separately for *C. trachomatis* and *N. gonorrhoeae*. Participants were classified as infected if either organism was detected.

2.5 Data management and statistical analysis

The questionnaires were examined for completeness and accuracy and subsequently entered, with the laboratory results, into excel data spread sheet. The data was checked and cleaned before analysis, and then imported into SPSS version 25.00 (SPSS Inc. Illinois, USA). Coding was done for non-numerical data. Tables and charts were generated to summarize the variables. Statistical significance was determined at a confidence interval of 95%. For bivariate analysis, exposure and outcome variables were

cross-tabulated to compute prevalence odds ratios and their corresponding 95% confidence intervals. Differences between proportions were evaluated by the chi-square test and chi square analysis for linear trend. Statistical significance was determined with the p-value set at 0.05 for descriptive and inferential statistics.

Mean and standard deviation of the results were calculated, the differences in proportions between the groups were compared using Pearson Chi Square test, while the difference in the means were compared using the student t-test, fishers exact test was used to assess the association between the variables. Logistic regression was used to describe relation between prediction variable, P value < 0.05 were considered statistically significant.

2.6 Ethical approval

The study was approved by the Health Research Ethics Committee of Irrua Specialist Teaching Hospital (reference ISTH/HREC/20200911/125). Written informed consent was obtained from every participant before enrolment. Participants with a positive result were treated according to national guidelines and offered partner notification.

3. Results

3.1 Participant characteristics

Four hundred and seventy-two participants were enrolled and tested. Women made up 243 (51.5%) and men 229 (48.5%). Mean age was 29.8 years (SD 8.2), median 28 years (IQR 25–35), range 15 to 56 years. Christians accounted for 292 participants (61.9%) and Muslims for 180 (38.1%). Single participants were the largest marital group at 193 (40.9%), followed by married at 136 (28.8%) and cohabiting at 93 (19.7%); 24 were divorced and 25 widowed. A degree was the highest qualification for 190 participants (40.3%). Symptomatic and asymptomatic participants were evenly represented, 236 in each group. Table 1 gives the full distribution alongside infection prevalence in each stratum.

Table 1. Participant characteristics and prevalence of *C. trachomatis* or *N. gonorrhoeae* by Xpert CT/NG (N = 472)

Characteristic	n (%)	Infected, n (%)	p
Sex			0.390
Female	243 (51.5)	104 (42.8)	
Male	229 (48.5)	108 (47.2)	
Age group (years)			0.068
≤ 24	115 (24.4)	56 (48.7)	
25–34	229 (48.5)	110 (48.0)	
35–44	102 (21.6)	34 (33.3)	
≥ 45	26 (5.5)	12 (46.2)	
Religion			0.613
Christian	292 (61.9)	128 (43.8)	
Muslim	180 (38.1)	84 (46.7)	
Marital status			0.001
Single	193 (40.9)	85 (44.0)	
Married	136 (28.8)	66 (48.5)	
Cohabiting	93 (19.7)	51 (54.8)	
Divorced	24 (5.1)	3 (12.5)	
Widowed	25 (5.3)	6 (24.0)	
Highest education			0.001
Degree	190 (40.3)	74 (38.9)	
SSCE	149 (31.6)	70 (47.0)	
Diploma	67 (14.2)	44 (65.7)	
FSLC	66 (14.0)	24 (36.4)	

Characteristic	n (%)	Infected, n (%)	p
Employment			0.008
Employed	141 (29.9)	58 (41.1)	
Unemployed	142 (30.1)	64 (45.1)	
Self-employed	103 (21.8)	38 (36.9)	
Student	86 (18.2)	52 (60.5)	
Symptom status			0.013
Asymptomatic	236 (50.0)	92 (39.0)	
Symptomatic	236 (50.0)	120 (50.8)	

SSCE, Senior Secondary Certificate of Education; FSLC, First School Leaving Certificate. Percentages in the second column are of the total sample; percentages in the third column are of the row stratum. p-values are from Pearson's chi-square test across all levels of the characteristic. Marital status has one missing value.

3.2 Prevalence of infection

Two hundred and twelve participants had *C. trachomatis*, *N. gonorrhoeae* or both, a prevalence of 44.9% (95% CI 40.5–49.4). *N. gonorrhoeae* was the dominant organism, detected in 211 participants (44.7%, 95% CI 40.3–49.2), while *C. trachomatis* was detected in 165 (35.0%, 95% CI 30.8–39.3). The

two organisms occurred together in 164 participants (34.7%), so that 164 of the 165 chlamydial infections were gonococcal co-infections and only one participant carried *C. trachomatis* alone. Gonococcal mono-infection accounted for the remaining 47 cases (10.0%). Prevalence was similar in men and women (47.2% versus 42.8%, $p = 0.39$), and this held for each organism separately (Table 2).

Table 2. Prevalence of *C. trachomatis* and *N. gonorrhoeae* overall and by sex

Result	Overall (N = 472)	Men (n = 229)	Women (n = 243)	p
Either organism	212 (44.9; 40.5–49.4)	108 (47.2; 40.8–53.6)	104 (42.8; 36.7–49.1)	0.390
<i>N. gonorrhoeae</i>	211 (44.7; 40.3–49.2)	108 (47.2; 40.8–53.6)	103 (42.4; 36.3–48.7)	0.325
<i>C. trachomatis</i>	165 (35.0; 30.8–39.3)	79 (34.5; 28.6–40.8)	86 (35.4; 29.6–41.5)	0.919

Result	Overall (N = 472)	Men (n = 229)	Women (n = 243)	p
Both organisms	164 (34.7; 30.6–39.1)	79 (34.5; 28.6–40.8)	85 (35.0; 29.2–41.1)	–
N. gonorrhoeae only	47 (10.0; 7.5–12.9)	29 (12.7)	18 (7.4)	–
C. trachomatis only	1 (0.2; 0.0–1.0)	0 (0.0)	1 (0.4)	–

Values are n (% ; Jeffreys 95% confidence interval). p-values compare men and women by Pearson's chi-square test.

3.3 Infection in the absence of symptoms

Of the 212 infections detected, 92 (43.4%) occurred in participants who reported none of the eight genitourinary symptoms. Put the other way, 39.0% of asymptomatic participants were infected, against 50.8% of symptomatic participants ($p = 0.013$). Symptoms therefore carried information about infection, but the difference in prevalence between the two groups was under twelve percentage points, and a symptom-triggered testing policy applied to this sample would have identified 120 of 212 infections while testing half the attendees.

Individual symptoms varied widely in their association with infection. Urethral discharge was reported by 73 participants, of whom 74.0% were infected ($p < 0.001$); pain on urination by 111, of whom 64.9% were infected ($p < 0.001$); and testicular pain by 55, of whom 67.3% were infected ($p = 0.006$). Lower abdominal pain was weakly associated (53.4% infected among 133 reporting it, $p = 0.026$). Vaginal discharge, reported by 64 participants, showed no association with infection at all (37.5% infected, $p = 0.577$), nor did vaginal itching ($p = 0.280$), intermenstrual bleeding ($p = 1.000$) or post-coital bleeding ($p = 0.340$).

3.4 Correlates of infection

In unadjusted analysis, infection was associated with

age at sexual debut, condom non-use, recent treatment for a sexually transmitted infection, knowledge of HIV status, marital status, education, employment and symptom status. Sex, religion, family setting, number of partners in the preceding year, more than one partner in the preceding three months, recent urinary tract infection treatment and coital frequency showed no association.

The multivariable model included 469 participants with complete data on all covariates, of whom 210 were infected. Five variables retained independent associations (Table 3). Reported HIV-positive status carried the largest effect (aOR 7.05, 95% CI 4.02–12.37). Sexual debut between 15 and 20 years was associated with a near four-fold increase in odds relative to debut after 20 years (aOR 3.78, 95% CI 1.73–8.25), and debut before 15 years with a three-fold increase (aOR 3.10, 95% CI 1.38–6.99). Not using a condom at the most recent encounter with the main partner tripled the odds of infection (aOR 2.98, 95% CI 1.49–5.97), and symptomatic presentation doubled them (aOR 2.03, 95% CI 1.25–3.30). Sex, age group, marital status, education and employment lost significance on adjustment, as did recent treatment for a sexually transmitted infection. The model gave a McFadden pseudo R-squared of 0.204 with an overall likelihood ratio $p < 0.001$, and the Hosmer–Lemeshow test gave no evidence of poor calibration ($\chi^2 = 6.33$, $df = 8$, $p = 0.610$).

Table 3. Multivariable logistic regression for *C. trachomatis* or *N. gonorrhoeae* infection (n = 469; 210 infections)

Variable	aOR	95% CI	p
Male sex (ref. female)	1.30	0.83–2.02	0.255
Age 25–34 (ref. ≤ 24)	1.62	0.76–3.47	0.215
Age 35–44	1.10	0.40–3.01	0.859
Age ≥ 45	1.49	0.42–5.37	0.540
Married (ref. single)	1.27	0.57–2.81	0.554
Cohabiting	1.11	0.49–2.53	0.807
Divorced	0.69	0.13–3.64	0.662
Widowed	0.89	0.21–3.70	0.872
Diploma (ref. degree)	1.62	0.81–3.24	0.176
SSCE	1.51	0.75–3.04	0.252
FSLC	0.48	0.15–1.50	0.204
Unemployed (ref. employed)	0.62	0.27–1.46	0.276
Self-employed	0.60	0.32–1.16	0.127
Student	1.53	0.53–4.36	0.430
Sexual debut 15–20 y (ref. > 20 y)	3.78	1.73–8.25	0.001
Sexual debut < 15 y	3.10	1.38–6.99	0.006
No condom at last encounter (ref. condom)	2.98	1.49–5.97	0.002
STI treated in past 3 months (ref. no)	1.35	0.79–2.33	0.276
Reported HIV-positive status (ref. no)	7.05	4.02–12.37	< 0.001
Symptomatic (ref. asymptomatic)	2.03	1.25–3.30	0.004

aOR, adjusted odds ratio. Model: McFadden pseudo $R^2 = 0.204$; likelihood ratio $p < 0.001$; Hosmer–Lemeshow $\chi^2 = 6.33$, $df = 8$, $p = 0.610$. Complete-case analysis.

4. Discussion

Nearly half of the adults tested at this tertiary hospital carried *C. trachomatis*, *N. gonorrhoeae* or both. That figure sits far above the sub-Saharan African general-population estimates of 6.9% for chlamydia in women and 1.8% for gonorrhoea reported by the recent regional meta-regression [3], and above the global estimates of 4.0% and 2.5% for chlamydia [2]. The comparison is not like for like: a consecutive series of tertiary hospital attendees is enriched for people seeking care for genital complaints and for people referred with reproductive health problems, so a prevalence several times the community figure is expected. What the comparison does establish is the size of the diagnostic gap in a setting where none of these participants would ordinarily have been tested by nucleic acid amplification.

Two features of the organism distribution deserve comment. First, gonorrhoea rather than chlamydia dominated, which inverts the usual pattern: regional estimates put chlamydia prevalence roughly three to four times gonorrhoea prevalence in both sexes [3]. Second, chlamydial infection was almost entirely confined to participants who also had gonorrhoea, with a single chlamydia-only case in 472 participants. Co-infection is common in high-prevalence settings, and in Curaçao every gonococcal infection in a preterm delivery cohort was accompanied by chlamydia [14], but the near-complete absence of chlamydia monoinfection here is unusual enough that we treat it cautiously. It could reflect a genuine epidemiological pattern in this catchment, in which case gonococcal infection is the driver and chlamydial infection is largely secondary to it. It could equally reflect how the composite result was recorded, since the result field distinguished chlamydia-negative from chlamydia-positive states in combination with gonococcal status rather than reporting the two targets fully independently. Confirmation from a series in which both targets are recorded separately at source would settle this, and until then the chlamydia-specific estimate should be read as provisional.

The asymptomatic fraction is the finding with the clearest operational consequence. More than two in five infections occurred in participants reporting no

genitourinary symptoms. This is consistent with the 50 to 70% asymptomatic proportion described in women and 10 to 50% in men [5], and with the Kenyan finding that self-reported behavior predicted infection poorly [5]. Under a strictly syndromic policy, 92 infected people in this sample would have left the facility untreated, and would have remained infectious and at risk of pelvic inflammatory disease, tubal infertility and enhanced HIV transmission [15]. The symptom-level results sharpen the point. Urethral discharge, dysuria and testicular pain all identified groups in which around two-thirds or more were infected, so the male syndromic algorithm performed reasonably. Vaginal discharge did not discriminate at all, with infection prevalence among women reporting it no different from the sample as a whole. Vaginal discharge in this population is more likely to reflect bacterial vaginosis or candidiasis than gonococcal or chlamydial infection, and treating it as a proxy for either organism will produce both overtreatment and missed cases.(11,12.)

Among behavioral correlates, age at sexual debut showed the most consistent gradient, with both early-debut categories carrying three- to four-fold adjusted odds relative to debut after 20 years. Debut between 15 and 20 years carried a slightly higher point estimate than debut before 15, and the confidence intervals overlap substantially, so the two should be read as a single early-debut effect rather than as a graded dose response. Condom non-use at the most recent encounter tripled the adjusted odds, which is the expected direction and gives internal support to the behavioral data. The strongest single association was with reported HIV-positive status, and the direction is consistent with the established bidirectional relationship between gonococcal or chlamydial infection and HIV acquisition and transmission [1]. Because HIV status here was self-reported at interview rather than confirmed serologically in this study, the estimate is vulnerable to reporting error in both directions, and we present it as an association rather than as a causal quantity.

Number of sexual partners in the preceding year and multiple partnership in the preceding three months showed no association with infection, unadjusted or adjusted. This is worth stating plainly because

partner number is one of the variables most often used to select people for screening. In a population where 44.9% are already infected, partner-count-based selection adds little, and the Kenyan three-site study reached a similar conclusion about behavioral screening criteria [5]. Marital status, education and employment associations present in the crude analysis disappeared on adjustment, indicating that they were operating through age at debut, condom use and reported HIV status rather than independently.

4.1 Implications

The practical inference is not that every attendee should be tested by nucleic acid amplification, which the cartridge cost will not support in most Nigerian facilities. It is that the current reason for testing is the wrong one. Symptom status alone would find 57% of infections; adding reported HIV-positive status, early sexual debut and condomless last encounter as testing indications would capture a substantially larger share for the same testing volume. A prospective evaluation of such a rule against universal testing in the same setting would establish whether the gain is large enough to justify the cost of the cartridge or molecular testing [13].

5. Strengths and limitations

5.1 Strengths

Consecutive enrolment of both symptomatic and asymptomatic attendees over a full twenty four-month period allowed the asymptomatic fraction to be measured directly rather than inferred from a symptomatic series. Molecular testing on a platform already deployed for tuberculosis diagnosis in Nigerian tertiary laboratories means the approach evaluated here is implementable without new capital equipment. Men and women were enrolled in near-equal numbers, which addresses the shortage of male observations noted in the regional evidence base [3].

5.2 Design limitations

The cross-sectional design establishes association, not sequence: whether early sexual debut and

condom non-use preceded infection cannot be determined from these data, although the temporal logic for debut age is one-directional. Enrolment at a single tertiary centre limits generalizability to Nigerian hospital attendees of similar profile, and the prevalence reported here should not be transferred to community populations.

5.3 Measurement limitations

Sexual behaviour, symptoms and HIV status were self-reported to an interviewer, and social desirability bias will have attenuated reporting of condomless sex, multiple partnership and early debut, most probably biasing the corresponding odds ratios toward the null. HIV status was not confirmed serologically within the study, and the questionnaire recorded knowledge of status in a form that conflates knowing one's status with being positive; the estimate for this variable should therefore be treated as the most fragile in the model. No formal sample size calculation preceded recruitment. Anatomical sites other than the genital tract were not sampled, so pharyngeal and rectal infections, which the Kenyan study found common and clinically silent [5], were not counted, and true prevalence of infection at any site is higher than reported here.

6. Conclusions

Among 472 consecutive adult attendees at a Nigerian tertiary hospital, 44.9% carried *C. trachomatis*, *N. gonorrhoeae* or both by Xpert CT/NG, with gonococcal infection predominating and chlamydial infection occurring almost entirely as co-infection. Forty-three per cent of infections were in participants with no genitourinary symptoms, and vaginal discharge — the symptom that drives syndromic treatment in women — carried no information about infection status. Reported HIV-positive status, sexual debut before the age of 21 and condomless sex at the last encounter identified the participants most likely to be infected, while partner number did not. Testing criteria built on those characteristics would find more infection per cartridge than the symptom-based approach currently in use.

Declarations

Ethics approval and consent to participate.

Approved by the Health Research Ethics Committee, Irrua Specialist Teaching Hospital (ISTH/HREC/20200911/125). Written informed consent was obtained from all participants. participants that were under 18 at enrolment assent and parental or guardian consent were obtained.

Consent for publication. Not applicable.

Availability of data and materials. The dataset analyzed during the current study is available from the corresponding author on reasonable request.

Competing interests. The authors declare that they have no competing interests.

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Authors' contributions. The research topic was conceived by corresponding author other authors assisted in sample collection, data collection and proof reading the manuscript.

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