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Prevalence and Risk Factors of Penicillinase-Type *β*-Lactamase Producing *Neisseria gonorrhoeae* Isolated from Patients Attending Health-Facilities in Yaounde, Cameroon

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Abstract

Background and Objectives: Mitigation of antibiotic resistant *Neisseria gonorrhoeae* has become a priority due to considerable health and economical disabilities it generates. In order to tackle the emergence of resistant *Neisseria gonorrhoeae*, this study aimed to determine the prevalence and risk factors of penicillinase type *β*-lactamase-producing *Neisseria gonorrheae* among patients consulting for genital infectious disorders in two health-facilities in Yaounde, Cameroon. **Materials and Method:** A cross-sectional descriptive and analytical study was conducted over a 3-month period, from July 2nd to October 2nd, 2022. Vaginal and urethral secretions were collected. Biochemical identification tests were performed on colonies grown on chocolate agar + polyvitex using the Api NH gallery. The detection of penicillinases was equally performed using the API NH gallery and confirmed using the antimicrobial susceptibility testing. The Minimum Inhibitory Concentrations of some antibiotics were determined using the E-Test. **Results:** The results showed that out of the 198 patients sampled, 16 (8.08%) were positive for *Neisseria gonorrhoeae*, among which 13/16 (81.25%) were penicillinase-type *β*-lactamase producers. Antimicrobial susceptibility testing results showed high co-resistances

to antibiotics, mainly ciprofloxacin (100%), nalidixic acid (92.31%) and azithromycin (84.62%). Moreover, high Minimum Inhibitory Concentrations of ceftriaxone (ranging from 6 to 24 mg/L) was observed toward *Neisseria gonorrhoeae* isolates. The risk factors of the carriage of penicillinase-type *β*-lactamase producing *Neisseria gonorrhoeae* identified were: a history of Sexually Transmitted infections (p = 0.01) and unprotected sexual intercourse (p = 0.01). **Conclusion:** The emergence of penicillinase-type *β*-lactamase producing *Neisseria gonorrhoeae* is increasing and the situation is becoming worrisome. The identified risk factors can constitute a basic outlook to tackle resistant *Neisseria gonorrhoeae*, and therefore sustain antibiotic stewardship.

Keywords

Neisseria gonorrhoeae, Antimicrobial Resistance, *β*-Lactamase, Penicillinase, Cameroon

1. Introduction

Sexually transmitted infections (STIs) represent a public health problem, due to the morbidity of acute infections and the risk of serious sequelae [1]. The World Health Organization estimated that 450 million people are victims of STI per year worldwide, among which the number of patients suffering from gonorrhea accounts for more than 78 million [1]. Gonorrhoea is the second most common bacterial STIs in the world [2]. The causative agent: *Neisseria gonorrhoeae* is an obligate human pathogen which infects the mucosa of the lower genital tract [2]. 75 million gonorrhea cases are recorded each year worldwide, concerning 19 per 1000 females and 24 per 1000 males [3]. In England, gonorrhea is the second most common bacterial STI after chlamydia [3]. In 2014, 34,958 cases of gonorrhea were reported through routine surveillance by public Health England (PHE) [4]. The burden is heavier in Africa and it is continuously evolving [3] [5]. A study conducted in Cameroon by Chanyi *et al.* from 2010 to 2015 in the southwest region showed that the prevalence of gonorrhoea was increasing over the years till 12.9% in 2015 [6].

Gonorrhoeae is more often asymptomatic especially in women (approximately 50% of cases), thereby leading to undiagnosed and untreated gonorrhoea [7]. Less biased studies' findings revealed that 70% to 90% of women, carrying *Neisseria gonorrhoeae*, are asymptomatic [8] [9]. However, when it is symptomatic, signs such as cervicitis with purulent leucorrhoea, or even vulvar irritation are frequently observed [10]. In men, symptoms often include painful urination, abnormal urethral discharge, and swelling of the testicles [10]. Untreated gonorrhoea can progress to disseminated gonococcal infection, pelvic inflammatory disease with long-term sequelae such as chronic pelvic pain, tissue scarring, ectopic pregnancy and infertility [11]. In addition, it can be transmitted from mother to newborn during delivery, causing conjunctivitis in the newborn, and even blind-

ness if the infection is not detected and treated promptly and accordingly [11].

Gonorrhoea has become a public health priority due to the emergence of strains resistant to ceftriaxone/cefixime, penicillin and azithromycin worldwide between 2007 and 2018 [12]. In 2020, the WHO included gonococcus resistant to third-generation cephalosporins and fluoroquinolones on the list of priority bacteria to be monitored. To escape the toxicity of these antibiotics, *Neisseria gonorrhoeae* has developed several resistance mechanisms such as chromosomal mutations and the production of some enzymes (β-lactamases) [13]. Thus, the emergence of resistant phenotypes within this bacterium can have many consequences on human health, such as therapeutic failures, which contribute to increase morbidity and mortality rates, as well as high expenditure [14].

A recent study in France showed that the proportions of *N. gonorrhoeae* isolates resistant to penicillin, tetracycline and ciprofloxacin were respectively 13%, 56% and 42% [15]. Another study carried out in China from 2014 to 2015 showed that the proportions of *N. gonorrhoeae* isolates resistant to tetracycline, ciprofloxacin and penicillin were respectively 81.7%, 100% and 73.3%. This latter study also showed that the proportion of penicillinase producing *N. gonorrhoeae* was 39.7% [16]. More recently, isolates of *Neisseria gonorrhoeae* resistant to several antibiotics have been identified and included penicillin, azithromycin, ciprofloxacine and extended spectrum cephalosporins, such as ceftriaxone and cefixime [17]. Moreover, another study conducted in Cameroon from 2012 to 2018 showed high proportions of resistant *N. gonorrhoeae* to ciprofloxacin (64.4%) [18]. The resistance to ciprofloxacin in this latter study had increased significantly from 15% in 2012 to 79.5% in 2018 [18].

For long time, penicillinase-type β-lactamase producing *Neisseria gonorrhoeae* has been evolving. It has been recently found related to co-resistance, concerning various classes of antibiotics. Moreover, genes encoding for penicillinases being plasmid mediated, have readily spread throughout the world, thereby by challenging the global public health [3]. In 1984, a study realized in Central African Republic on 460 males showed that the prevalence of penicillinase-type β-lactamase producing *Neisseria gonorrhoeae* was 1.5% [3]. More recently, a study conducted in South Africa showed a prevalence of 60% [5]. In Cameroon, a study showed that the period prevalence (2012-2018) was 81% [18]. However, penicillinase-type β-lactamase producing *Neisseria gonorrhoeae* remains insufficiently described in Cameroon. This current research hence aimed to describe the epidemiology of penicillinase-type β-lactamase producing *Neisseria gonorrhoeae* in patients presenting with genital disorders in two health-facilities in Yaounde, Cameroon.

2. Material and Method

2.1. Study Design

A cross-sectional descriptive and analytical study was carried out from the 2nd May 2022 to the 2nd October 2022 in two hospital laboratories of Yaounde:

namely Gyneco-Obstetrics and Pediatric Hospital of Yaounde's (HGOPY) laboratory and the Saint Martin of Porres Dominican Hospital's laboratory.

2.2. Sampling Population and Data Collection

This study included patients of both male and female gender who came to the laboratories of the concerned health facilities for cervical-vaginal/urethral samples and who consented. The minimum sample size was calculated using the Lorentz formula, including the prevalence of *N. gonorrhoeae* infection in Africa (5%) [3] as follows:

$$N = P\frac{(1-P)z^2}{d^2} = 0.05\frac{(1-0.05)1.96^2}{0.05^2} = 73$$

Cervical-vaginal/urethral secretions consecutively collected from them were subjected to *N. gonorrhoeae* screening. Data relative to demographics and potential risk factors to penicillinase-type β-lactamase producing *Neisseria gonorrhoeae* carriage were collected using a questionnaire designed in the two national languages (English and French). The questionnaire was constituted of closed ended questions and was pretested prior to the study, toward patients consulting the laboratories of a healthfacility in Bangangte ("Clinique Universitaire des Montagnes") for cervical-vaginal/urethral samples (**Appendix**).

2.3. Sample Analysis

The samples were inoculated on Chocolate agar [prepared from Columbia agar (Titan Biotech Ltd., India) and sheep blood] + polyvitex (LiofilchemSrl, Italy) for urethral samples, and on Chocolate agar + polyvitex + VCN (LiofilchemSrl, Italy) for cervical & vaginal samples. After inoculation, the media were placed together with a CO_2 DC-100 device in a jar ([CO_2]: 5% - 10%), and incubated at 37˚C for 24 to 48 h. Identification of isolates and detection of penicillinases were carried out using the API NH micro gallery (Biomerieux, France) and subsequently tested for antimicrobial susceptibility.

2.4. Antimicrobial Susceptibility Testing

The antimicrobial susceptibility testing was carried out using the Kirby Bauer disk diffusion method [19] on Chocolate agar + polyvitex. The following antibiotics (Rapid Labs, England): amoxicillin (30 µg), amoxicillin + clavulanic acid (20 - 10 µg), cefixime (30 µg), penicillin G (10 µg), ceftriaxone (30 µg), tetracycline (30 µg), nalixidic acid (30 µg), ciprofloxacin (5 µg), azithromycin (15 µg), gentamycin (10 µg), spectinomycin (100 µg) [20]; were tested. The incubation was done at 37˚C with 5% - 10% of CO_2. This assay was performed according to the 2022 recommendations of the European Committee on Antimicrobial Susceptibility Testing (EUCAST 2022) [20].

The confirmation of penicillinase production was carried out using thedouble disk synergy testing according to the EUCAST recommendations [20]. The production of penicillinase was shown when the inhibition zone around penicil-

lin antibiotic disk was enhanced on the side of the clavulanate-containing disk, resulting in a characteristically shaped zone referred to as a "champagne cork" on one hand, and a reduction in the inhibition diameters around tetracycline and ciprofloxacin disks on the other hand.

The Minimal Inhibitory Concentrations (MIC) of Azithromycin, Ceftriaxone, Ciprofloxacin, and Penicillin G toward penicillinase type β-lactamase producing *Neisseria gonorrhoeae* isolates were determined using E-Test strips (Biomerieux, France).

2.5. Statistical Analysis

Statistical analysis was carried out using Epi-Info 7 software. The confidence interval was calculated when necessary. Fisher-Exact test helped to compare proportions and logistic regression helped to identify the predictive factors of participants' carriage of penicillinase type β-lactamase producing *Neisseria gonorrhoeae*. $p \leq 0.05$ was considered statistically significant.

2.6. Ethical Consideration

The study was approved by the Institutional Ethics Committee of *Université des Montagnes* (N˚2022/173/UdM/PR/CEAQ) and the Institutional Committee for Research on Human Health of HGOPY (Authorization N˚350/CIERSG/DM/2022). Informed consent was obtained from all participants.

3. Results

3.1. Socio-Demographics of Participants

Table 1 presents the distribution of participants according to their socio-demographic characteristics.

Table 1. Socio-demographic characteristics of participants.

Characteristcs	Categories	Number (N = 198)	Percentage (%)
Age (years)	<30	100	50.51
	[30 - 49]	89	44.95
	≥50	9	4.55
Gender	Female	130	65.66
	Male	68	34.34
Marital Status	Single	93	46.97
	Married	105	53.03
School level	Primary	3	1.52
	Secondary	63	31.82
	Superior (university)	132	66.67
Occupation	Teachers	46	23.23
	Students	56	28.28
	Merchants	47	23.74
	Other	49	24.75

Table 1 shows that, out of the 198 participants sampled, 100 (51.51%) were <30 years old, 130 (65.66%) were females, 108 were married (53.03%), 132 had a superior level of education (66.67%) and 56 were students (28.28%).

3.2. Prevalence of *Neisseria gonorrhoeae* Carriage

Table 2 shows that the prevalence of *Neisseria gonorrhoeae* carriage among participants was 8.08%. The prevalence of *Neisseria gonorrhoeae* carriage among participants of the male gender (14.71%) was significantly higher as compared to the prevalence among participants of the female gender (4.62%).

3.3. Prevalence of Penicillinase Type *β*-Lactamases Producing *Neisseria gonorrhoeae*

Figure 1 shows that the prevalence of penicillinase-like *β*-lactamases producing *Neisseria gonorrhoeae* isolates was 81.25%.

Table 2. Distribution of *Neisseria gonorrhoeae* infection according to socio-demographic characteristics.

Characteristics		N	Isolates		Carriage	p-value
			n	%	%	
Total		**198**	**16**	**100**	**8.08**	-
Age	<30	100	5	31.25	5.00	0.14
	[30 - 49]	89	11	68.75	12.36	
	≥50	9	0	0.00	0.00	
Gender	Female	130	6	37.50	4.62	**0.01**
	Male	68	10	62.50	14.71	
School level	Primary	3	0	0.00	0.00	0.15
	Secondary	63	9	56.25	14.29	
	Higher	132	7	43.75	5.38	
Marital Status	Single	93	7	43.75	7.53	0.79
	Married	105	9	56.25	8.57	
Occupation	Teachers	46	2	12.50	4.35	0.26
	Students	56	3	18.75	5.36	
	Vendors	47	7	43.75	14.89	
	Other	49	4	25.00	8.16	

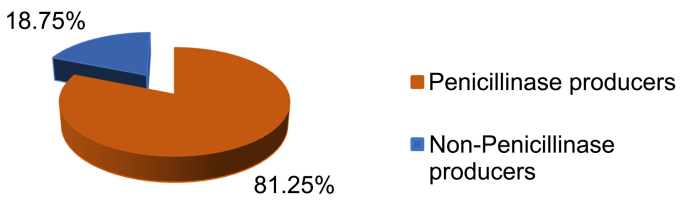

Figure 1. Prevalence of penicillinase-like *β*-lactamases producing *Neisseria gonorrhoeae* isolates.

3.4. Resistance Prevalence of Penicillinase-Like *β*-Lactamases Producing *Neisseria gonorrhoeae* Isolates to Tested Antibiotics

Figure 2 illustrates the co-resistance levels of penicillinase-like *β*-lactamases producing *Neisseria gonorrhoeae* isolates to Macrolides, Aminoside, Cycline, and Quinolones.

Penicillinase-like *β*-lactamases producing *Neisseria gonorrhoeae* isolates showed 100% co-resistance to ciprofloxacin, 92.31% to nalidixic acid and 84.62% to azithromycin (Figure 2).

3.5. Minimum Inhibitory Concentrations of 4 Antibiotics Tested on Penicillinase-Like *β*-Lactamases Producing *Neisseria gonorrhoeae* Isolates

Figure 3 shows that 2 mg/L, 6 mg/L, 2 mg/L, and 0.094 mg/L were respectively the MICs of azithromycin, ciprofloxacin, penicillin G and ceftriaxone for respectively 25%, 18.75%,18.75%, and 18.75% of penicillinase-like *β*-lactamases producing *Neisseria gonorrhoeae* isolates.

3.6. Analysis of Risk Factors Related to Penicillinase-Like *β*-Lactamases Producing *Neisseria gonorrhoeae*

Table 3 shows that a history of STIs (OR = 5.00; p = 0.00), unprotected sexual practices (OR = 4.98; p = 0.00) and hospitalization within the past 3 months (OR = 4.62; p = 0.05) were statistically associated to carriage of penicillinase-type *β*-lactamases producing *Neisseria gonorrhoeae*.

Furthermore, Table 4 shows that the adjustment of these risk factors highlighted both history of STIs (adjusted OR = 5.18; p = 0.01) and unprotected sexual practices (adjusted OR = 4.72; p = 0.01) as significant risk factors to penicillinase-type *β*-lactamases producing *Neisseria gonorrhoeae* carriage. Obviously, the odds of having a history of STI among participants was 5.18 folds higher

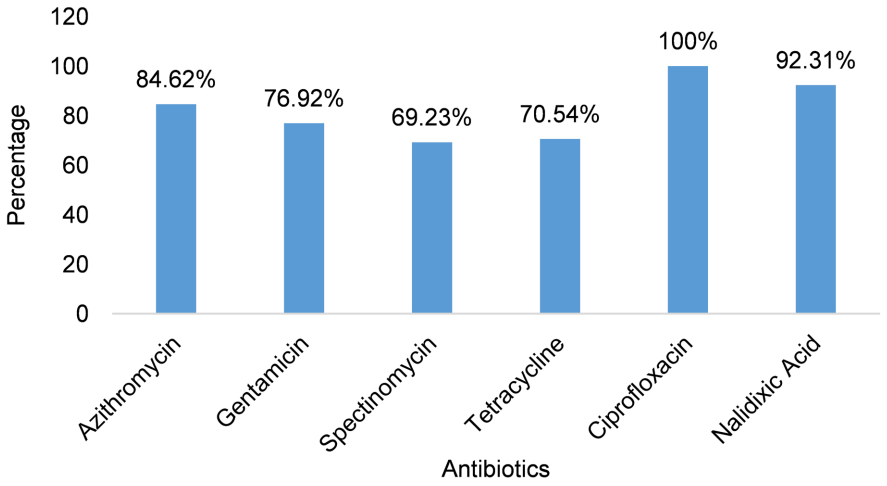

Figure 2. Co-resistance prevalence of penicillinase-like *β*-lactamases producing *Neisseria gonorrhoeae* isolates to non-*β*-lactam antibiotics.

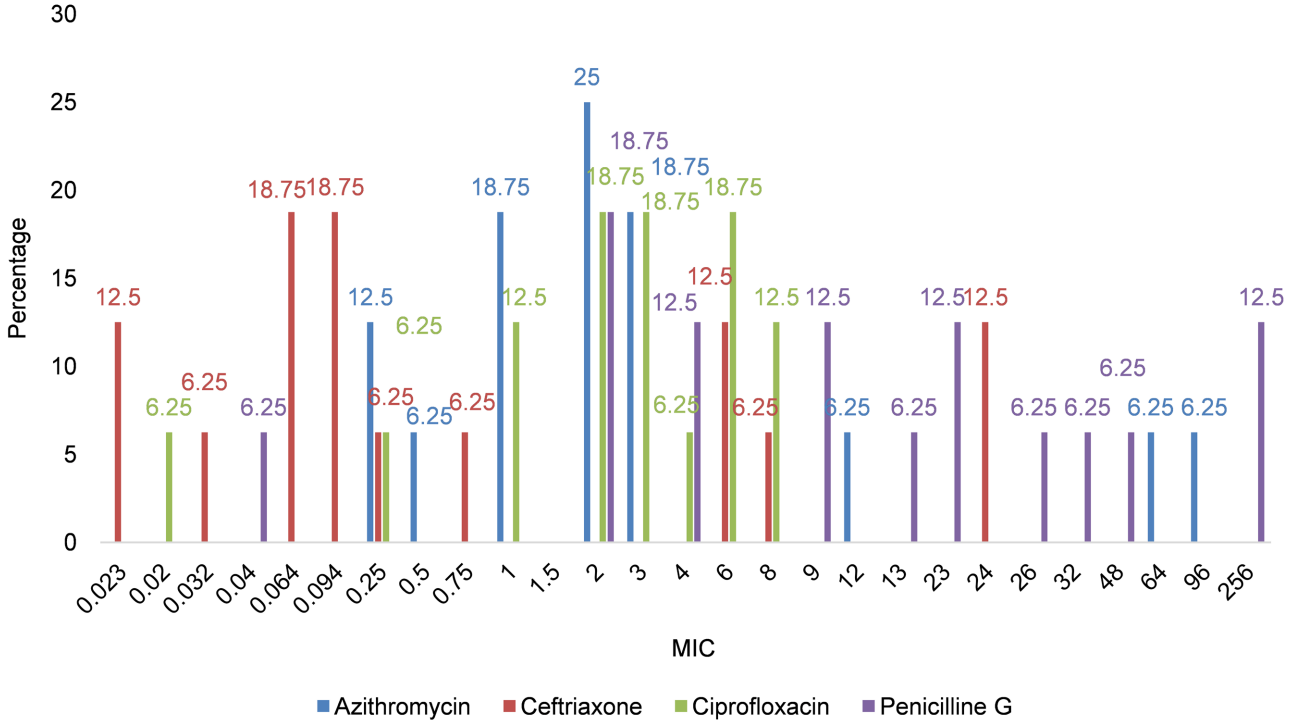

Figure 3. Frequencies of minimum inhibitory concentrations of azithromycin, ceftriaxone, ciprofloxacin and penicillin G tested on penicillinase-like *β*-lactamases producing *Neisseria gonorrhoeae* isolates.

Table 3. Univariate analysis of risk factors related to penicillinase-type *β*-lactamases producing *Neisseria gonorrhoeae* carriage.

Variables	Categories	Penicillinase producing *N. gonorrhoeae* n (%)	OR (95% CI)	p-value
History of STI	No	6 (3.85)	1	Ref
	Yes	7 (16.67)	5.00 (1.58 - 15.80)	**0.00**
Hospitalised for the past 3 months	No	11 (5.82)	1	Ref
	Yes	2 (22.22)	4.62 (0.86 - 24.94)	**0.05**
Self-medication	No	10 (6.02)	1	Ref
	Yes	3 (9.38)	1.61 (0.42 - 6.22)	0.45
Unprotected Sex	No	5 (3.45)	1	Ref
	Yes	8 (15.09)	4.98 (1.55 - 15.99)	**0.00**
Number of sexual partners			0.84 (0.46 - 1.53)	0.56

OR. Odds Ratio, CI. Confidence Interval.

Table 4. Multivariate analysis of risk factors related to penicillinase-type *β*-lactamases producing *Neisseria gonorrhoeae* carriage.

Variables	Categories	Ajusted-OR (95% CI)	p-value
History of STI	No	1	Ref
	Yes	5.18 (1.56 - 17.19)	**0.01**
Unprotected Sex	No	1	Ref
	Yes	4.72 (1.36 - 16.38)	**0.01**
Hospitalised for the past 3 months	No	1	Ref
	Yes	2.08 (0.33 - 13.30)	0.44

for those contaminated with penicillinase-type *β*-lactamases producing *Neisseria gonorrhoeae* as compared to non-contaminated ones. Likewise, the odds of practicing unprotected sex were 4.72 folds higher for participants contaminated with penicillinase-type *β*-lactamases producing *Neisseria gonorrhoeae* as compared to non-contaminated participants.

4. Discussion

The objective of this study was to determine the prevalence and risk factors of penicillinase type *β*-lactamase-producing *Neisseria gonorrheae* among patients consulting for genital infections in two health-facilities in Yaounde.

The most represented age group was that of <30 years with a proportion of 50.51%, thereby highlighting the fact that younger people were more frequently visiting the concerned health facilities for gynecological consultations during the study period. Regarding gender, women were approximately twice as represented (65.66%) as men did (34.34%). This is because cervico-vaginal tests were more requested by prescribers for diagnosis of various diseases, whereas men's urethral sample tests were requested only for suspicious gonorrhoea cases.

The *Neisseria gonorrhoeae* genital carriage was quite prevalent: 8.08%. This finding is lower than that of Chuan *et al* who obtained a prevalence of 40% in China [21]. This difference can be explained by the therapeutic routes in the Cameroonian context, where most infected patients rely firstly on traditional or self-treatments in communities before consulting health facilities after the persistence of the infections [22] [23].

The distribution of *Neisseria gonorrhoeae* infection according to socio-demographic characteristics showed that the percentage of *Neisseria gonorrhoeae* contamination was significantly higher in men (14.71%) than in women (4.62%). This can be explained by the fact that in men, the incubation period of this bacterium is shorter (2 to 6 days). Thus, after the third day of infection, men will begin to present symptoms, and will therefore seek for care, whereas in women, the infection is asymptomatic in more than 50% of cases, and the diagnosis is therefore delayed [7].

A high prevalence of penicillinases producing *Neisseria gonorrhoeae* (81.25%) was obtained during this study. This result is higher than that of Teke *et al.* who reported a prevalence of 65% of penicillinases producing *Neisseria gonorrhoeae* [24]. This is an evidence of the emergence of penicillinases producing *Neisseria gonorrhoeae* upon time which can be attributed to the fact that penicillin has been used as a first-line drug for gonorrhea treatment [18]. Penicillin usage has probably induced the selection of penicillinases producing *Neisseria gonorrhoeae* strains through adaptation [25].

The qualitative antimicrobial susceptibility testing on penicillinases producing *Neisseria gonorrhoeae* showed high co-resistance rates to ciprofloxacin (100%), nalidixic acid (92.31%) and azithromycin (84.62%). These findings are similar to those of Mabonga et *al*, who also obtained high levels of co-resistance toward these antibiotics [25]. Indeed, ciprofloxacin and azithromycin have been used earlier as first-line treatment for gonorrheaand are readily sold in streets and thus, accessible to the community at affordable prices [22]. Additionally, the findings of Kularatne *et al.* have shown a considerable increase in the co-resistance prevalence of *Neisseria gonorrhoeae* to ciprofloxacin, from 25% in 2008 to 69% in 2017 in South Africa. This illustrates the overuse, misuse or non-standard use of ciprofloxacin [26]. It was on this basis that quinolones have been excluded from the list of antibiotics recommended for gonorrhea therapy [23].

This study showed a high MICs for azithromycin (2 mg/L, 25%), ciprofloxacin (6 mg/L, 18.75%), and penicillin G (2 mg/L, 18.75%), toward penicillinase type β-lactamase producing *Neisseria gonorrhoeae* isolates. This further highlights the co-resistance suspicion of penicillinases producing *Neisseria gonorrhoeae* strains to these antibiotics. Similarly, high MICs have been observed for ceftriaxone (6 mg/L, 12.5%; 8 mg/L, 6.25%; 24 mg/L, 12.5%). These findings are in line with those of Crucitti *et al.*, who also observed high MICs for ceftriaxone (1 and 1.5 mg/L) [18]. This raises the concern that ceftriaxone has to be sparingly monitored in order to mitigate *Neisseria gonorrhoeae* strains resistant to this antibiotic.

Multivariate logistic regression analysis showed that, having a history of STIs and practicing unprotected sexual intercourse are risk factors to the carriage of penicillinase-type β-lactamases producing *Neisseria gonorrhoeae*. This can be explained by the fact that persistent gonorrhea (due to its resistant nature) significantly increases the risk of transmission of other STIs such as HIV, because of its invasive nature, leading to lesions and thereby promoting or facilitating the transmission of other sexually transmissible pathogens [27]. Also, unprotected sexual practices due to the absence of a physical barrier procured by condoms, increase the chances of transmission of penicillinase-type β-lactamases producing *Neisseria gonorrhoeae*. Accordingly, these findings highlight the fact that the presence of history of STIs and the practice of unprotected sex among patients consulting for genital disorders, independently exacerbate the chances of being contaminated with penicillinase-type β-lactamases producing *Neisseria gonorr-*

hoeae. This can serve as basis for decision making, thereby constituting a tool to mitigate this phenomenon.

This study had nevertheless two main limitations. The first one is the detection of penicillinase production through classical bacteriological techniques, which have relatively lower sensitivity and specificity as compared to molecular techniques. This can hence contribute to an over-estimation or under-estimation of our principal measurement, *i.e.* prevalence of penicillinase-type β-lactamases producing *Neisseria gonorrhoeae*. The second one is the non-representative population included in this study and likely represented by patients of low socio-economic level and visiting only two health facilities. This calls for more researches to study accurately and globally penicillinase-type β-lactamases producing *Neisseria gonorrhoeae*, in order to guide effective preventive actions.

5. Conclusion

This present study revealed a high prevalence of penicillinase-type β-lactamases producing *Neisseria gonorrhoeae*. This latter eventually showed high proportions of co-resistance, mainly to quinolones and macrolides. The factors identified to increase the risk of contamination with penicillinase-type β-lactamases producing *Neisseria gonorrhoeae* were unprotected sexual intercourse practices and having a history of Sexually Transmitted infections. Ultimately, this research indicates a worrisome emergency of resistant *Neisseria gonorrhoeae*. Hence, identified risk factors can constitute a basic outlook to tackle resistant *Neisseria gonorrhoeae*, and therefore sustain antibiotic stewardship.

Consent for Publication

All authors consented for publication.

Availability of Data and Material

All data are available upon request.

Authors' Contributions

Conceptualization: CID; Project administration: CID and BDPT; Resources: CID, LND, and BDPT; Methodology: CID, CSN, CT, BDPT and LND, Funding acquisition: CID, LND, and BDPT; Investigation: LND, CSN, JMT, BKM, FW, GFN, TVKK and HKT; Software: CID and CSN; Formal analysis: CSN and WYD; Visualization: CID, LND, CSN, FW, WYD and BDTP; Writing-original draft: LND; Writing-review & editing: CID, CSN, FW, and BDTP; Validation: BDTP, NAM and CID; Supervision: BDTP and NAM; Data curation: CID.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

[1] La ruche, G., Goulet, V., Bouyssou, A., Sednaoui, P., De Barbeyrac, B., Dupin, N., *et al.* (2013) Current Epidemiology of Bacterial Sexually Transmitted Infections in France. *Presse Médicale*, **42**, 432-439. https://doi.org/10.1016/j.lpm.2012.09.022

[2] Newman, L., Rowley, J., Vander Hoorn, S., Wijesooriya, N.S., Unemo, M., Low, N., *et al.* (2015) Global Estimates of the Prevalence and Incidence of Four Curable Sexually Transmitted Infections in 2012 Based on Systemic Review and Global Reporting. *PLOS ONE*, **10**, e0143304. https://doi.org/10.1371/journal.pone.0143304

[3] Yakobi, S. and Pooe, O. (2022) Antimicrobial Resistance of *Neisseria gonorrhoeae* in Sub-Saharan Populations. *Bacteria*, **1**, 96-111. https://doi.org/10.3390/bacteria1020009

[4] Public Health England (2015) Sexually Transmitted Infections and Chlamydia Screening in England. *Health Protection Report*, **8**, 9-22.

[5] Rambaran, S., Naidoo, K., Dookie, N., Moodley, P. and Sturm, A.W. (2019) Resistance Profile of *Neisseria gonorrhoeae* in KwaZulu-Natal, South Africa Questioning the Effect of the Currently Advocated Dual Therapy. *Sexually Transmitted Diseases*, **46**, 266-270. https://doi.org/10.1097/OLQ.0000000000000961

[6] Chanyi, L., Nkenyi, R. and Esum, M. (2019) Prevalence and Risk Factors of Sexually Transmitted Infections in Selected Health Facilities in Southwest Region of Cameroun. *International Journal of Tropical Disease and Health*, **37**, 1-9. https://doi.org/10.9734/ijtdh/2019/v37i130155

[7] Jayne, M. (2015) Extended-Spectrum *β*-Lactamases and *Neisseria gonorrhoeae*: Pre-Empting a Mechanism That Could Abolish Cephalosporins for the Treatment of Gonorrhoea. Doctoral Thesis, University of Portsmouth, Portsmouth.

[8] Unemo, M., Seifert, H.S., Hook, E.W., Hawkes, S., Ndowa, F. and Dillon, J.-A.R. (2019) Gonorrhoea. *Nature Reviews*, *Disease Primers*, **5**, Article No. 79. https://doi.org/10.1038/s41572-019-0128-6

[9] Schaughnessy, J., Ram, S. and Rice, P.A. (2019) Biology of the Gonococcus: Disease and Pathogenesis. In: Christodoulides, M., Ed., *Neisseria gonorrhoeae*: *Methods and Protocols*, *Methods in Molecular Biology*, Vol. 1997, Springer, Berlin, 1-27. https://doi.org/10.1007/978-1-4939-9496-0_1

[10] Quillin, S.J. and Seifert, H.S. (2018) *Neisseria gonorrhoeae* Host Adaptation and Pathogenesis. *Nature Reviews Microbiology*, **16**, 226-240. https://doi.org/10.1038/nrmicro.2017.169

[11] Costa-Lourenco, A.P.R., Su, X., Le, W., Yang, Z., Patts, G.J., Massari, P., *et al.* (2021) Epidemiological and Clinical Observations of Gonococcal Infections in Women and Prevention Strategies. *Vaccines*, **9**, Article No. 327. https://doi.org/10.3390/vaccines9040327

[12] Chen, S.C., Yin, Y.P., Di, X.Q., Unemo, M. and Chen, X.S. (2016) First Nationwide Study Regarding Ceftriaxone Resistance and Molecular Epidemiology of *Neisseria*

gonorrhoeae in China. *Journal of Antimicrobial Chemotherapy*, **71**, 92-99. https://doi.org/10.1093/jac/dkv321

[13] Unemo, M., Del Rio, C. and Shafer, W.M. (2016) Antimicrobial Resistance Expressed by *Neisseria gonorrhoeae*: A Major Global Public Health Problem in the 21st Century. *Microbiology Spectrum*, **4**, 1-32. https://doi.org/10.1128/microbiolspec.EI10-0009-2015

[14] Cole, M.J., Spiteri, G., Jacobsson, S., Woodford, N., Tripodo, F., Amato-Gauci, A.J., *et al.* (2017) Overall Low Extended-Spectrum Cephalosporin Resistance but High Azithromycin Resistance in *Neisseria gonorrhoeae* in 24 European Countries, 2015. *BMC Infectious Diseases*, **17**, Article No. 617. https://doi.org/10.1186/s12879-017-2707-z

[15] La Ruche, G., Goubard, A., Bercot, B., Cabeau, E., Semaille, E. and Sednaoui, P. (2014) Evolution of Gonococcal Resistance to Antibiotics in France from 2001 to 2012. *Bulletin Epidemiologique Hebdomadaire*, **5**, 93-103.

[16] Jiang, F., Lan, Q., Le, W. and Su, X. (2017) Antimicrobial Susceptibility of *Neisseria gonorrhoeae* Isolates from Hefei (2014-2015): Genetic Characteristics of Antimicrobial Resistance. *BCM Infectious Diseases*, **17**, Article No. 366. https://doi.org/10.1186/s12879-017-2472-z

[17] Mlynarcczyk-Bonikowska, B., Majewska, A., Malejczyk, M., Mlynarczyk, G. and Majeswski, S. (2020) Multiresistant *Neisseria gonorrhoeae*: A New Threat in Second Decade of the XXI Century. *Medical Microbiology and Immunology*, **209**, 95-108. https://doi.org/10.1007/s00430-019-00651-4

[18] Crucitti, T., Belinga, S., Fonkoua, M.C., Abanda, M., Mbanzouen, W. and Sokeng, E. (2020) Sharp Increase in Ciprofloxacin Resistance of *Neisseria gonorrhoeae* in Yaounde, Cameroun: Analyses of a Laboratory Database Period 2012-2018. *International Journal of STD and AIDS*, **31**, 579-586. https://doi.org/10.1177/0956462419897227

[19] Hudzicki, J. (2009) Kirby-Bauer Disk Diffusion Susceptibility Test Protocol. American Society for Microbiology, Washington DC, 55-63.

[20] (2022) EUCAST: Recommendations 2022. Société Française de Microbiologie, Paris. https://www.sfm-microbiologie.org/boutique/comite-de-lantibiograme-de-la-sfm-casfm

[21] Wan, C., *et al.* (2018) Increasing Resistance to Azithromycin in *Neisseria gonorrhoeae* in Eastern Chinese Cities: Resistance Mechanisms and Genetic Diversity among Isolates from Nanjing. *Antimicrobial Agents and Chemotherapy*, **62**, e02499-17.

[22] Djuikoue, I.C., Nana, S.D., Ngouambe, N.A., Ekeu, N.D., Wanda, G. and Guegang, G.C. (2022) Prescribers, Dispensers and Users Knowledge, Attitudes and Practices Relative to Antimicrobial Resistance in Douala, Cameroun. *World Journal of Public Health*, **7**, 111-118. https://doi.org/10.1128/AAC.02499-17

[23] (2022) Diagnosis and Treatment of Gonorrhea. VIDAL, Issy-les-Moulineaux. https://www.vidal.fr/sexualite-contraception/gonorrhée-blennorragie/traitements.html

[24] Apalata, T., Zimba, T., Sturm, W. and Moodley, P. (2009) Antimicrobial Susceptibility Profile of *Neisseria gonorrhoeae* Isolated from Patients Attending a STD Facility in Maputo, Mozambique. *Sexually Transmitted Diseases*, **36**, 341-343. https://doi.org/10.1097/OLQ.0b013e3181982e3c

[25] Mabonga, E., Parkes-Ratanshi, R. and Riedel, S. (2019) Complete Ciprofloxacin Resistance in Gonococcal Isolates in an Urban Ugandan Clinic: Findings from a Cross-Sectional Study. *International Journal of STD and AIDS*, **30**, 256-263.

https://doi.org/10.1177/0956462418799017

[26] Kularante, R., Maseko, V. and Gumede, L. (2018) Trends in *Neisseria gonorrhoeae* Antimicrobial Resistance over a Ten-Year Surveillance Period, Johannesburg, South Africa? 2008-2017. *Antibiotics*, **7**, 58-69. https://doi.org/10.3390/antibiotics7030058

[27] HAS (2010) Dépistage et prise en charge de l'infection à *Neisseria gonorrhoeae*: État des lieux et propositions. [Screening and Management of *Neisseria gonorrhoeae* Infection: Current Situation and Proposals]. *Haute Autorité de Santé*, **10**, 120-144.

Appendix

Questionnaire

What is your age? What is your sex? What was your highest educational level? What is your marital status? What is your actual occupation? Do you always protect yourselves during sexual intercourse? Have you got a sexually transmissible infection in the past? Have you been hospitalized for the past three months? Do you always rely on a health professional to buy drugs when you are ill? Do you sometimes take personal initiatives in the choice of drugs you consume when you feel ill? If yes, are antibiotics included in some of those drugs? Have you taken other treatments before coming to the health facility?