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# Epidemiological profile of vulvovaginal candidiasis and antifungal susceptibility of *Candida* isolates using two susceptibility testing methods in a resource-limited setting: Study from Bouake, Côte d'Ivoire

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## ABSTRACT

Vulvovaginal candidiasis (VVC) is a common fungal infection in women, and the emergence of non-*albicans Candida* species with variable antifungal susceptibility may complicate treatment, particularly where access to mycological diagnosis and standardized susceptibility testing is limited. This study described the epidemiological profile of VVC and the antifungal susceptibility patterns of *Candida* isolates among symptomatic women attending the University Hospital of Bouaké, Côte d'Ivoire. A prospective cross-sectional study was conducted among 400 women from April 2022 to March 2023. Vaginal specimens were examined microscopically and cultured on Sabouraud agar supplemented with chloramphenicol. Isolates were identified using morphological and biochemical methods, and antifungal susceptibility was assessed using ATB Fungus 3 and agar diffusion. VVC was confirmed in 159 women, giving a prevalence of 39.75%. *Candida albicans* accounted for 86.79% of isolates, while non-*albicans Candida* species represented 13.21%. Pregnancy was significantly associated with VVC ($p$= 0.04). With ATB Fungus 3, susceptibility was highest to voriconazole (95.88%), fluconazole (93.81%), and 5-flucytosine (91.75%). Among non-*albicans Candida* isolates tested by this method, resistance was observed in 30% to fluconazole and 40% to itraconazole. Agar diffusion showed high susceptibility to amphotericin B (98.98%) and nystatin (97.96%), with greater variability for the other antifungals tested. *C. albicans* remains the predominant cause of VVC in this setting, while the variable susceptibility of non-*albicans Candida* highlights the importance of species-level identification and appropriately standardized antifungal susceptibility testing to support effective management.

**Keywords:** Vulvovaginal candidiasis, *Candida albicans*, Non-*albicans Candida*, Antifungal susceptibility, Azole resistance

## INTRODUCTION

Vulvovaginal candidiasis (VVC) is a common fungal infection of the vulva and vagina caused by yeasts of the genus *Candida*. It is among the most frequent causes of vulvovaginal symptoms and is generally considered the second most common vaginal infection after bacterial vaginosis (Rosati *et al.*, 2020; Anderson *et al.*, 2004).

Approximately 70–75% of women experience at least one episode of VVC during their lifetime, particularly during the reproductive years (Sobel *et al.*, 2016; Workowski *et al.*, 2015). Among affected women, nearly half may experience a subsequent episode, while approximately 5–10% develop recurrent vulvovaginal candidiasis (RVVC) (Sobel, 2007; Denning *et al.*, 2018). The burden of VVC varies considerably across geographical regions and study populations. In Africa, prevalence rates exceeding 30% have been reported in several settings (Fanou *et al.*, 2022; Kechia *et al.*, 2015; Sylla *et al.*, 2017). In Côte d'Ivoire, a recent study reported a prevalence of 53.6%, higher than that documented in some earlier investigations (Konate *et al.*, 2014; Konate-Toure *et al.*, 2024). Nevertheless, the true burden of VVC may remain underestimated, particularly where laboratory investigation is limited and diagnosis is based primarily on clinical presentation.

Although several *Candida* species can cause VVC, *C. albicans* remains the predominant species in most populations. Other species commonly associated with the infection include *C. glabrata*, *C. tropicalis*, *C. parapsilosis*, and *C. krusei* (Gonçalves *et al.*, 2016). In recent years, however, increasing attention has been given to non-*albicans Candida* (NAC) species because of their growing contribution to vulvovaginal infections in some populations (Shokoohi *et al.*, 2021). Their emergence is clinically relevant because antifungal susceptibility differs among *Candida* species, and some NAC species exhibit reduced susceptibility or intrinsic resistance to commonly used antifungal agents, particularly azoles (Pappas *et al.*, 2016). Accurate identification beyond the genus level is therefore increasingly important, especially in persistent or recurrent infections.

Management of VVC relies largely on antifungal therapy, with azole compounds such as fluconazole, itraconazole, clotrimazole, and miconazole commonly used (Peyton *et al.*, 2015; Dovnik *et al.*, 2015). Azoles interfere with ergosterol synthesis and consequently disrupt fungal cell membrane structure and function (Lalla *et al.*, 2014). However, repeated or inappropriate exposure to antifungal agents can contribute to the selection of less susceptible or resistant isolates, potentially complicating the management of infection. Monitoring antifungal susceptibility is therefore important for understanding local resistance patterns and supporting appropriate antifungal use.

Standardized antifungal susceptibility testing is primarily based on reference procedures such as the CLSI and EUCAST broth microdilution methods (EUCAST, 2025). These methods require standardized reagents, appropriate laboratory infrastructure, trained personnel, and rigorous quality control. Such requirements can restrict their routine application in laboratories with limited resources. More accessible approaches, including commercial systems such as ATB Fungus 3 and agar-based susceptibility testing, may therefore be used in routine laboratory practice where reference methods are not readily available. However, results generated by alternative methods need to be considered within the methodological characteristics and limitations of each testing system.

Despite the clinical importance of VVC, current information on its epidemiology, species distribution, and antifungal susceptibility patterns remains limited in many parts of sub-Saharan Africa (Bogomin *et al.*, 2017). In Côte d'Ivoire, available studies have largely originated from Abidjan, while recent data from Bouaké are scarce. In particular, little is known about the distribution of *Candida* species causing VVC among symptomatic women attending the University Hospital of Bouaké or about their susceptibility to antifungal agents used in clinical practice. In addition, limited access to routine fungal culture, species-level identification, and antifungal susceptibility testing may

encourage empirical treatment and restrict local surveillance of antifungal resistance. Evidence on the performance and practical application of locally available susceptibility-testing approaches under these resource constraints is also limited.

Against this background, this study aimed to describe the epidemiological and mycological profile of vulvovaginal candidiasis among symptomatic women attending the University Hospital of Bouaké, Côte d'Ivoire, and to characterize the antifungal susceptibility patterns of the *Candida* isolates recovered. Specifically, the study sought to determine the prevalence of laboratory-confirmed VVC, describe the distribution of *Candida* species, assess factors associated with VVC, and characterize the susceptibility profiles of the isolates using two antifungal susceptibility-testing approaches available within the study setting: ATB Fungus 3 and agar diffusion.

## MATERIALS AND METHODS

### Study design and setting

A prospective cross-sectional study with descriptive and analytical components was conducted over a 12-month period, from April 2022 to March 2023, at the University Hospital of Bouaké (CHU de Bouaké), Côte d'Ivoire. Participant recruitment and clinical assessment were carried out in the Department of Gynaecology and Obstetrics, while mycological investigations were performed in the hospital's Parasitology and Mycology laboratory. The University Hospital of Bouaké is a tertiary-level public referral hospital serving Bouaké and surrounding areas.

### Study population and sample size

The minimum sample size was estimated using Schwartz's formula:

$$N = Z^2 p(1 - p)/d^2$$

where $N$ is the minimum required sample size, $Z$ is the standard normal deviate corresponding to a 95% confidence level (1.96), $p$ is the expected prevalence, and $d$ is the desired precision. In the absence of a prevalence estimate selected specifically for the sample-size calculation, a prevalence of 50% was used to provide the maximum sample size, with a precision of 5%. The resulting minimum sample size was 384 participants. To allow for potential exclusions or incomplete data, 400 women were ultimately enrolled.

Women attending the Department of Gynaecology and Obstetrics during the study period were recruited consecutively if they presented with at least one symptom suggestive of vulvovaginal candidiasis (VVC), such as abnormal vaginal discharge, vulvar or vaginal pruritus, burning sensation, dysuria, or other compatible vulvovaginal symptoms. Participants were required to have abstained from sexual intercourse and intravaginal cleansing for 24–48 h before specimen collection and to be non-menstruating at the time of sampling. Women receiving antifungal treatment at the time of recruitment were excluded. Written informed consent was obtained before enrolment.

### Clinical and epidemiological data collection

Sociodemographic characteristics, relevant medical history, lifestyle and hygiene practices, reproductive characteristics, and potential factors associated with VVC were collected using an anonymous structured questionnaire. Each participant underwent a medical interview and clinical examination before specimen collection. Clinical information included the characteristics of vaginal discharge and the presence of associated symptoms or signs, including vulvar pruritus, vaginal burning, pelvic pain, dyspareunia, vaginitis, cervicitis, vulvitis, and vulvovaginitis.

Information on potential associated factors, including pregnancy, gestational period, diabetes, HIV infection, oral contraceptive use, vaginal cleansing practices, type of underwear, and educational level, was also recorded for subsequent statistical analysis.

### Vaginal specimen collection

Vaginal specimens were collected during gynaecological examination using an unlubricated

sterile speculum. Samples were obtained by swabbing the vaginal fornix and cervical area. Two sterile swabs were collected from each participant: one was used for direct microscopic examination and the second for fungal culture.

**Direct microscopic examination and fungal culture**

For direct examination, material from the first swab was suspended in a drop of sterile physiological saline on a glass slide, covered with a coverslip, and examined by light microscopy at ×400 magnification. The preparation was examined for yeast cells, budding yeasts, pseudohyphae, and hyphal elements.

The second swab was inoculated onto Sabouraud agar supplemented with chloramphenicol. Cultures were incubated at 37°C for 24–48 h and examined for yeast growth. Suspected yeast colonies were evaluated macroscopically according to their colony morphology, including appearance, size, shape, and colour, and were subsequently subjected to microscopic and biochemical identification.

**Identification of yeast isolates**

Yeast isolates were identified using a combination of morphological and biochemical methods. Initial identification included microscopic examination and a germ-tube test. Isolates requiring further differentiation were investigated using the Bichro-Dubli latex agglutination test (Fumouze Diagnostics, Levallois-Perret, France) and the ID 32 C identification system (bioMérieux, Marcy-l'Étoile, France).

**Germ-tube test**

A yeast suspension was prepared in human serum and incubated at 37°C for 3 h. The preparation was then examined by light microscopy using a ×40 objective. The presence of germ tubes without constriction at their point of origin from the yeast cell was considered a positive germ-tube reaction and was used for presumptive identification of isolates belonging to the *C. albicans/C. dubliniensis* group.

**Differentiation of *Candida albicans* and *Candida dubliniensis***

Germ-tube-positive isolates were further examined using the Bichro-Dubli latex agglutination test (Fumouze Diagnostics) according to the manufacturer's instructions. This test was used to differentiate *C. dubliniensis* from *C. albicans*. Visible blue agglutinates against a pink background were interpreted as a positive reaction for *C. dubliniensis*, whereas the absence of agglutination was interpreted as a negative reaction. The Bichro-Dubli test has previously been shown to provide rapid phenotypic differentiation of *C. dubliniensis* from closely related yeasts.

**Biochemical identification**

When the initial morphological tests did not provide definitive species identification, isolates were further characterised using the ID 32 C system (bioMérieux) according to the manufacturer's instructions. The system differentiates yeasts on the basis of their biochemical assimilation profiles, including assimilation of multiple carbon sources, growth in the presence of cycloheximide (actidione), and an esculin reaction. The resulting biochemical profiles were used for species-level identification.

**Antifungal susceptibility testing**

Antifungal susceptibility was assessed using two locally available methods: the ATB Fungus 3 system (bioMérieux, Marcy-l'Étoile, France) and an agar disk-diffusion method. Because of logistical constraints, particularly reagent availability and the viability of stored isolates at the time of testing, not all culture-positive isolates could be tested, and the same number of isolates was not available for both methods. Consequently, 97 isolates were tested using ATB Fungus 3 and 98 using agar diffusion. The two approaches were analysed as separate susceptibility-testing procedures rather than as a formal method-comparison or validation study.

**ATB Fungus 3 susceptibility testing**

The ATB Fungus 3 system was used to assess susceptibility to five systemic antifungal agents: 5-

flucytosine, amphotericin B, itraconazole, voriconazole, and fluconazole.

Testing was performed according to the manufacturer's procedure. Briefly, several colonies from a fresh yeast culture were suspended in sterile 0.85% NaCl solution and adjusted to a turbidity equivalent to a 2 McFarland standard. A 20-µL aliquot of this suspension was transferred to the ATB Fungus medium and thoroughly homogenised. Each cupule was then inoculated with 135 µL of the resulting suspension. The strips were incubated at approximately 36 ± 1°C for 24–48 h.

Growth was assessed visually against a dark background. Growth in antifungal-containing wells was compared with that in the growth-control wells and scored according to the manufacturer's growth scale: 4, no reduction in growth; 3, slight reduction; 2, marked reduction; 1, very weak growth; and 0, absence of visible growth. The susceptibility category assigned to each isolate was recorded for subsequent analysis.

**Agar diffusion susceptibility testing**

Agar diffusion testing was performed on Casitone and semi-synthetic media using commercially prepared antifungal disks (MAST Group Ltd., Bootle, Merseyside, United Kingdom). The yeast inoculum was applied to the agar surface by flooding or swabbing, after which antifungal disks were placed on the inoculated plates. Plates were incubated at 35–37°C for 24–48 h.

Seven antifungal agents were evaluated: amphotericin B (20 µg/disc), 5-flucytosine (1 µg/disc), nystatin, miconazole (10 µg/disc), econazole (10 µg/disc), clotrimazole (10 µg/disc), and ketoconazole (10 µg/disc). Following incubation, the diameter of the growth-inhibition zone surrounding each disk was measured, and isolates were classified as susceptible, intermediate, or resistant according to the interpretive criteria applied in the laboratory.

Because the antifungal panel and media used in this study do not correspond completely to the currently standardized CLSI M44 disk-diffusion procedure for *Candida* spp., the results of this assay were considered findings from the locally applied agar diffusion method rather than results obtained by the CLSI reference disk-diffusion method.

**Statistical analysis**

Data were entered and analysed using Epi Info 7 (version 7.2.2.6) and R statistical software. Categorical variables were summarized as frequencies and percentages, whereas quantitative variables were summarized using appropriate measures of central tendency and dispersion.

Associations between VVC and potential epidemiological or clinical factors were assessed using Pearson's chi-square test or Fisher's exact test, as appropriate. Statistical significance was defined as $p < 0.05$.

**Ethical considerations**

The study was conducted after authorization from the medical and scientific administration of the University Hospital of Bouaké (reference no. 163/MSHP/CHU-B/DG/DMS/ONAR/22). All participants were informed about the study procedures and provided consent before enrolment. Data were collected anonymously and handled confidentially.

**Methodological limitations**

Antifungal susceptibility testing could not be performed on all 159 *Candida* isolates recovered during the study. ATB Fungus 3 was performed on 97 isolates and agar diffusion on 98 isolates because of limitations in reagent availability and isolate viability. Moreover, the isolates tested by the two methods were not necessarily identical in all cases. Direct agreement between the two methods should therefore be interpreted cautiously.

In addition, neither susceptibility procedure was compared directly with a reference broth microdilution method during the study. The agar diffusion procedure used locally also differed from the standardized CLSI M44 method in terms of the media and antifungal agents tested. The susceptibility results should therefore

be interpreted primarily as descriptive findings obtained with the two methods available under the study conditions rather than as a formal validation or head-to-head performance comparison of the methods.

## RESULTS

### Sociodemographic characteristics of the participants

A total of 400 women were included in the study. Women aged 21–30 years constituted the largest age group, accounting for 197 (49.25%) participants, followed by those aged 31–40 years with 135 (33.75%). Women aged ≤20 years and ≥41 years represented 35 (8.75%) and 33 (8.25%) participants, respectively. Regarding marital status, 241 (60.25%) were widowed, 137 (34.25%) were single, and 22 (5.50%) were married. A total of 167 (41.75%) participants had no formal education, while 104 (26.00%) had higher education, 73 (18.25%) secondary education, and 56 (14.00%) primary education (Table 1).

**Table 1.** Socio-demographic characteristics of the patients who took part in the study (n=400)

| Variables | Frequency | Percentage |
|---|---|---|
| Age group | | |
| ]20] | 35 | 8.75 |
| [21-30] | 197 | 49.25 |
| [31-40] | 135 | 33.75 |
| [41[ | 33 | 8.25 |
| Marital status | | |
| Widow | 241 | 60.25 |
| Single | 137 | 34.25 |
| Married | 22 | 5.5 |
| Level of study | | |
| None | 167 | 41.75 |
| Higher education | 104 | 26 |
| Secondary education | 73 | 18.25 |
| Primary education | 56 | 14 |
| Pregnancy | | |
| No | 237 | 59.25 |
| Yes | 163 | 40.75 |
| Gestational period | | |
| 3rd Trimester | 84 | 51.53 |
| 2ndTrimester | 59 | 36.20 |
| 1stTrimester | 20 | 12.27 |
| Occupation | | |
| Housewives | 139 | 34.75 |
| Students | 91 | 22.75 |
| Saleswomen | 80 | 20 |
| Craftwomen* | 35 | 8.75 |
| Healthcare worker | 21 | 5.25 |
| Teacher | 12 | 3 |
| Office worker | 12 | 3 |
| Farmer | 10 | 2.5 |
| Total | 400 | 100 |

Pregnant women accounted for 163 (40.75%) of the study population. Among them, 84 (51.53%) were in the third trimester, 59 (36.20%) in the second trimester, and 20 (12.27%) in the first trimester. Housewives were the largest occupational group, comprising 139 (34.75%) participants, followed by students, 91 (22.75%); saleswomen, 80 (20.00%); craftswomen, 35 (8.75%); healthcare workers, 21 (5.25%); teachers, 12 (3.00%); office workers, 12 (3.00%); and farmers, 10 (2.50%) (Table 1).

### Clinical characteristics

The clinical characteristics of the participants are presented in Table 2. Creamy vaginal discharge was recorded in 263 (65.75%) women, followed by curdled discharge in 120 (30.00%), fluid discharge in 16 (4.00%), and sparkling discharge in 1 (0.25%). The discharge was predominantly whitish in 260 (65.00%) participants, followed by yellowish in 97 (24.25%), greenish in 35 (8.75%), greyish in 6 (1.50%), and clear in 2 (0.50%).

**Table 2.** Clinical symptoms reported by the patients included in the study

| Parameters | | Frequency n=400 | Percentage (%) |
|---|---|---|---|
| | Leucorrhea characteristics | | |
| Appearance | Creamy | 263 | 65.75 |
| | Curdled | 120 | 30 |
| | Fluid | 16 | 4 |
| | Sparkling | 1 | 0.25 |
| Color | Whitish | 260 | 65 |
| | Yellowish | 97 | 24.25 |
| | Greenish | 35 | 8.75 |
| | Greyish | 6 | 1.5 |
| | Clear | 2 | 0.5 |
| Abundance | Average | 277 | 69.25 |
| | Large | 89 | 8.5 |
| | Minimal | 34 | 22.25 |
| smell | Blend | 196 | 49 |
| | Foul | 157 | 39.25 |
| | Absence | 46 | 11.50 |
| | Rotten fish | 1 | 0.25 |
| Associated signs | Vulvar pruritus | 314 | 78.50 |
| | Vaginal burning | 173 | 43.25 |

| | | | |
|---|---|---|---|
| | Pelvic pain | 101 | 25.25 |
| | Dyspareunia | 90 | 22.5 |
| Vulvovaginal inflammation | | | |
| Macroscopic appearance | Healthy | 356 | 89 |
| | Vaginitis | 29 | 7.25 |
| | Cervicitis | 12 | 3 |
| | Vulvitis | 2 | 0.5 |
| | Vulvovaginitis | 1 | 0.25 |

Regarding the abundance of vaginal discharge, 277 (69.25%) women had a moderate amount, 89 (22.25%) had a large amount, and 34 (8.50%) had a minimal amount. The discharge had a bland odour in 196 (49.00%) participants and a foul odour in 157 (39.25%), while 46 (11.50%) reported no odour and 1 (0.25%) had a rotten-fish odour (Table 2).

Among the associated clinical signs, vulvar pruritus was recorded in 314 (78.50%) women, vaginal burning in 173 (43.25%), pelvic pain in 101 (25.25%), and dyspareunia in 90 (22.50%). On macroscopic examination, 356 (89.00%) participants had a healthy appearance, while vaginitis was observed in 29 (7.25%), cervicitis in 12 (3.00%), vulvitis in 2 (0.50%), and vulvovaginitis in 1 (0.25%) (Table 2).

**Prevalence of vulvovaginal candidiasis and distribution of *Candida* species**

Vulvovaginal candidiasis was laboratory-confirmed in 159 of the 400 participants, corresponding to a prevalence of 39.75%. *Candida albicans* accounted for 138 (86.79%) of the 159 isolates, whereas non-*albicans Candida* species collectively represented 21 (13.21%) isolates (Table 3).

**Table 3.** Frequency of species isolated in cases of vulvovaginal candidiasis

| Candida species | Frequency | Percentage (%) |
|---|---|---|
| Candida albicans | 138 | 86.79 |
| Candida glabrata | 6 | 3.77 |
| Candida humicola | 6 | 3.77 |
| Candida krusei | 4 | 2.52 |
| Candida famata | 2 | 1.26 |
| Candida intermidia | 2 | 1.26 |
| Candida catenulata | 1 | 0.63 |
| Total | 159 | 100 |

Among the non-*albicans Candida* species, *C. glabrata* and *C. humicola* were each identified in 6 (3.77%) cases, followed by *C. krusei* in 4 (2.52%), *C. famata* in 2 (1.26%), *C. intermidia* in 2 (1.26%), and *C. catenulata* in 1 (0.63%) (Table 3).

**Factors associated with vulvovaginal candidiasis**

The distribution of VVC according to the assessed factors is shown in Table 4. Among the 324 women who reported daily vaginal washing, 127 had VVC and 197 did not, compared with 32 positive and 44 negative cases among the 76 women who did not report daily vaginal washing ($p$ = 0.74). Among the 158 participants for whom the pH of the antiseptic used was recorded, VVC was identified in 36 of 87 women who did not know the pH, 19 of 50 using neutral products, 5 of 9 using acidic products, and 2 of 12 using basic products ($p$ = 0.29).

For underwear type, VVC was recorded in 111 of 301 women with no specific preference, 32 of 59 wearing loose-fitting cotton underwear, 7 of 19 wearing tight-woven cotton underwear, 6 of 13 wearing tight synthetic underwear, and 2 of 8 wearing loose-fitting synthetic underwear ($p$ = 0.12). VVC was identified in 98 of 243 educated women and 61 of 157 women without formal education ($p$ = 0.85) (Table 4).

Among participants with the medical histories reported in Table 4, VVC was present in 7 women with diabetes and 5 women living with HIV ($p$ = 0.82). Nineteen of the 64 women taking oral contraceptives had VVC, compared with 140 of the 336 who were not taking oral contraceptives ($p$ = 0.09). According to marital status, VVC was detected in 91 widowed, 60 single, and 8 married women ($p$ = 0.50) (Table 4).

Among the 163 pregnant women, 75 (46.01%) had VVC, compared with 84 (35.44%) of the 237 non-pregnant women ($p$ = 0.04). Among pregnant women, VVC was detected in 11 of 20 women in the first trimester, 30 of 59 in the second trimester, and 34 of 84 in the third trimester ($p$ = 0.31) (Table 4).

**Table 4.** Analysis of associated factors with vulvovaginal candidiasis among gynecology and obstetrics patients

| Parameters | | Vulvovaginal candidiasis | | *p*-value |
|---|---|---|---|---|
| | | Oui | Non | |
| Daily vaginal wash (n=400) | Yes | 127 | 197 | 0.74 |
| | No | 32 | 44 | |
| pH of the antiseptic used (n=158) | Unknown | 36 | 51 | 0.29 |
| | Neutral | 19 | 31 | |
| | Acid | 5 | 4 | |
| | Basic | 2 | 10 | |
| Type of underwear n=400 | No preference | 111 | 190 | 0.12 |
| | Loose-fitting cotton | 32 | 27 | |
| | Tight-woven cotton | 7 | 12 | |
| | Tight synthetic | 6 | 7 | |
| | Synthetic, loose-fitting | 2 | 6 | |
| Instruction level (n=400) | Educated | 98 | 145 | 0.85 |
| | Uneducated | 61 | 96 | |
| Medical history (n=29) | Diabetes | 7 | 8 | 0.82 |
| | HIV | 5 | 9 | |
| Taking oral contraceptives (n=400) | Yes | 19 | 45 | 0.09 |
| | No | 140 | 196 | |
| Marital status n=400 | Widow | 91 | 151 | 0.50 |
| | Single | 60 | 77 | |
| | Married | 8 | 13 | |
| Pregnancy n=400 | Yes | 75 | 88 | 0.04 |
| | No | 84 | 153 | |
| Gestational period n=163 | Trimester 1 | 11 | 9 | 0.31 |
| | Trimester 2 | 30 | 29 | |
| | Trimester 3 | 34 | 50 | |

**Table 5.** Susceptibility profile of *Candida* species to the antifungals tested on solid media

| Yeasts tested | AMB | | 5 FC | | | ECN | | | MCL | | | NYS | | CTM | | | KET | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | S | R | S | I | R | S | I | R | S | I | R | S | R | S | I | R | S | I | R | |
| *C. albicans* | 80 | 0 | 50 | 9 | 21 | 44 | 25 | 11 | 43 | 24 | 13 | 79 | 1 | 59 | 18 | 3 | 47 | 18 | 15 | 80 |
| *C.* non *albicans* | 17 | 1 | 14 | 1 | 3 | 12 | 3 | 3 | 11 | 5 | 2 | 17 | 1 | 15 | 1 | 2 | 15 | 0 | 3 | 18 |
| *C. catenulata* | 1 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 |
| *C. famata* | 2 | 0 | 2 | 0 | 0 | 2 | 0 | 0 | 2 | 0 | 0 | 2 | 0 | 2 | 0 | 0 | 2 | 0 | 0 | 2 |
| *C. glabrata* | 6 | 0 | 6 | 0 | 0 | 5 | 0 | 1 | 5 | 1 | 0 | 6 | 0 | 5 | 1 | 0 | 5 | 0 | 1 | 6 |
| *C. humicola* | 4 | 0 | 2 | 1 | 1 | 3 | 1 | 0 | 2 | 2 | 0 | 4 | 0 | 4 | 0 | 0 | 4 | 0 | 0 | 4 |
| *C. krusei* | 3 | 1 | 3 | 0 | 1 | 0 | 2 | 2 | 0 | 2 | 2 | 3 | 1 | 2 | 0 | 2 | 2 | 0 | 2 | 4 |
| *C. intermidia* | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 |
| Total | 97 | 1 | 64 | 10 | 24 | 56 | 28 | 14 | 59 | 29 | 15 | 96 | 2 | 74 | 19 | 5 | 62 | 18 | 18 | 98 |

AMB:amphotéricine B, 5FC:5 flucytosine, ECN:econazole, MCL:miconazole, NYS:nystatine, CTM:cotrimoxazole, KET:ketoconazole

**Antifungal susceptibility by agar diffusion**

A total of 98 *Candida* isolates were evaluated using the agar diffusion method. The susceptibility profiles according to species and antifungal agent are presented in Table 5. For amphotericin B, 97 (98.98%) isolates were susceptible and 1 (1.02%) was resistant. For 5-flucytosine, 64 (65.31%) isolates were susceptible, 10 (10.20%) intermediate, and 24 (24.49%) resistant. Susceptibility to econazole was recorded in 56 (57.14%) isolates, while 28 (28.57%) were intermediate and 14 (14.29%) resistant. For miconazole, 59 (60.20%) isolates were susceptible, 24 (24.49%) intermediate, and 15 (15.31%) resistant. Nystatin susceptibility was observed in 96 (97.96%) isolates, with 2 (2.04%) resistant isolates. Clotrimazole showed susceptibility in 74 (75.51%) isolates, intermediate susceptibility in 19 (19.39%), and resistance in 5 (5.10%). For ketoconazole, 62 (63.27%) isolates were susceptible, 18 (18.37%) intermediate, and 18 (18.37%) resistant (Table 5).

Among the 80 *C. albicans* isolates tested by agar diffusion, all 80 were susceptible to amphotericin B,

while 79 were susceptible and 1 resistant to nystatin. For 5-flucytosine, 50 were susceptible, 9 intermediate, and 21 resistant. Econazole susceptibility was recorded in 44 isolates, with 25 intermediate and 11 resistant. For miconazole, 43 isolates were susceptible, 24 intermediate, and 13 resistant. Clotrimazole showed susceptibility in 59 isolates, intermediate susceptibility in 18, and resistance in 3, whereas ketoconazole showed 47 susceptible, 18 intermediate, and 15 resistant isolates (Table 5).

**Table 6.** Susceptibility profile of *Candida* species to antifungal agents tested with ATB Fungus 3

| Yeasts tested | AMB | | | 5FC | | | ITR | | | VRC | | | FLU | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | S | I | R | S | I | R | S | I | R | S | I | R | S | I | R | |
| *C. albicans* | 77 | 8 | 2 | 82 | 3 | 2 | 82 | 3 | 2 | 86 | 1 | 0 | 86 | 0 | 1 | 87 |
| *C.* non *albicans* | 4 | 2 | 4 | 7 | 3 | 0 | 3 | 3 | 4 | 7 | 2 | 1 | 5 | 2 | 3 | 10 |
| *C. glabrata* | 2 | 0 | 0 | 2 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 2 | 0 | 0 | 2 |
| *C. humicola* | 1 | 1 | 3 | 4 | 1 | 0 | 2 | 2 | 1 | 3 | 1 | 1 | 2 | 1 | 2 | 5 |
| *C. intermidia* | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 |
| *C. krusei* | 0 | 1 | 1 | 0 | 2 | 0 | 0 | 0 | 2 | 2 | 0 | 0 | 0 | 1 | 1 | 2 |
| Total | 81 | 10 | 6 | 89 | 6 | 2 | 85 | 6 | 6 | 93 | 3 | 1 | 91 | 2 | 4 | 97 |

AMB:amphotéricin B, 5FC:5 flucytosine, ITR:itraconazole, VRC:voriconazole, FLU:fluconazole

**Table 7.** Summary table of antifungal susceptibility testing in semi-solid and solid media

| | Antifungal | Sensitive | Intermediate | Resistant | Total |
|---|---|---|---|---|---|
| ATB fungus 3 | Voriconazole | 93 (95.88%) | 3 (3.09%) | 1 (1.03%) | 97 (100%) |
| | Itraconazole | 85 (87.63%) | 6 (6.19%) | 6 (6.19%) | |
| | Fluconazole | 91 (93.81%) | 2 (2.06%) | 4 (4.12%) | |
| | AmphotericineB | 81 (83.51%) | 12 (12.37%) | 4 (4.12%) | |
| | 5 Flucytosine | 89 (91.75%) | 6 (6.19%) | 2 (2.06%) | |
| Casitone and semi-synthetic media | Clotrimazole | 74 (75.51%) | 19 (19.39%) | 5 (5.10%) | 98 (100%) |
| | Miconazole | 55 (56.12%) | 28 (28.57%) | 15 (15.31%) | |
| | Ketoconazole | 62 (63.27%) | 18 (18.37%) | 18 (18.37%) | |
| | AmphotéricineB | 97 (98.98%) | 0 | 1 (1.02%) | |
| | 5 Flucytosine | 64 (65.31%) | 10 (10.20%) | 24 (24.49%) | |
| | Econazole | 56 (57.14%) | 28 (28.57%) | 14 (14.29%) | |
| | Nystatine | 96 (97.96%) | 0 | 2 (2.04%) | |

Among the 18 non-*albicans Candida* isolates tested, 17 were susceptible and 1 resistant to amphotericin B. Fourteen were susceptible, 1 intermediate, and 3 resistant to 5-flucytosine. For econazole, 12 were susceptible, 3 intermediate, and 3 resistant, while miconazole showed 11 susceptible, 5 intermediate, and 2 resistant isolates. Seventeen isolates were susceptible and 1 resistant to nystatin. Clotrimazole showed 15 susceptible, 1 intermediate, and 2 resistant isolates, while ketoconazole showed 15 susceptible and 3 resistant isolates (Table 5).

**Antifungal susceptibility determined using ATB Fungus 3**

Antifungal susceptibility was assessed in 97 isolates using ATB Fungus 3 (Table 6). For amphotericin B, 81 (83.51%) isolates were susceptible, 10 (10.31%) intermediate, and 6 (6.19%) resistant. For 5-flucytosine, 89 (91.75%) were susceptible, 6 (6.19%) intermediate, and 2 (2.06%) resistant. Itraconazole susceptibility was recorded in 85 (87.63%) isolates, while 6 (6.19%) were intermediate and 6 (6.19%) resistant. Voriconazole showed 93 (95.88%) susceptible, 3 (3.09%) intermediate, and 1 (1.03%) resistant isolate. For fluconazole, 91 (93.81%) isolates were susceptible, 2 (2.06%) intermediate, and 4 (4.12%) resistant (Table 6).

Among the 87 *C. albicans* isolates tested with ATB Fungus 3, amphotericin B showed 77 susceptible, 8 intermediate, and 2 resistant isolates. For 5-flucytosine, 82 were susceptible, 3 intermediate, and 2 resistant. Itraconazole showed 82 susceptible, 3 intermediate, and 2 resistant isolates. For voriconazole,

86 were susceptible and 1 intermediate, with no resistant isolate, while fluconazole showed 86 susceptible and 1 resistant isolate (Table 6).

Among the 10 non-*albicans* *Candida* isolates, amphotericin B showed 4 susceptible, 2 intermediate, and 4 resistant isolates. Seven were susceptible and 3 intermediate to 5-flucytosine. For itraconazole, 3 isolates were susceptible, 3 intermediate, and 4 resistant. Voriconazole showed 7 susceptible, 2 intermediate, and 1 resistant isolate, whereas fluconazole showed 5 susceptible, 2 intermediate, and 3 resistant isolates (Table 6).

**Overall antifungal susceptibility profile**

The overall susceptibility findings obtained with the two testing approaches are summarized in Table 7. With ATB Fungus 3, susceptibility was recorded in 93 (95.88%) isolates for voriconazole, 91 (93.81%) for fluconazole, 89 (91.75%) for 5-flucytosine, 85 (87.63%) for itraconazole, and 81 (83.51%) for amphotericin B. Resistance was recorded in 1 (1.03%) isolate for voriconazole, 4 (4.12%) for fluconazole, 2 (2.06%) for 5-flucytosine, and 6 (6.19%) for itraconazole (Table 7).

For antifungals evaluated on solid media, susceptibility was recorded in 97 (98.98%) isolates for amphotericin B, 96 (97.96%) for nystatin, 74 (75.51%) for clotrimazole, 64 (65.31%) for 5-flucytosine, 62 (63.27%) for ketoconazole, 56 (57.14%) for econazole, and 55 (56.12%) for miconazole, as reported in the summary table. The corresponding resistant isolates were 1 (1.02%) for amphotericin B, 2 (2.04%) for nystatin, 5 (5.10%) for clotrimazole, 24 (24.49%) for 5-flucytosine, 18 (18.37%) for ketoconazole, 14 (14.29%) for econazole, and 15 (15.31%) for miconazole (Table 7).

**DISCUSSION**

This study provides epidemiological and mycological data on vulvovaginal candidiasis (VVC) among symptomatic women attending the University Hospital of Bouaké and describes the antifungal susceptibility patterns of the *Candida* isolates recovered. The study population was predominantly composed of women of reproductive age, with almost half of the participants (49.25%) aged 21–30 years and a further 33.75% aged 31–40 years. This age distribution is consistent with previous reports showing that VVC occurs predominantly during the reproductive years (Gonçalves *et al.*, 2016). A study conducted in Abidjan similarly reported a mean age of 31.65 years among affected women (Djohan *et al.*, 2019). Comparable age distributions have also been reported in Mali (Doumbo *et al.*, 2022), Cameroon (Bouba *et al.*, 2023), Ghana (Waikhom *et al.*, 2020; Aboagye *et al.*, 2025), and Benin (Fanou *et al.*, 2022).

The predominance of VVC among women of reproductive age is likely related to the hormonal and physiological environment of the vagina during this period. Oestrogen promotes glycogen accumulation in the vaginal epithelium and creates conditions that can favour *Candida* colonisation and proliferation. Pregnancy and other hormonal changes may further alter the vaginal environment and host response, thereby influencing susceptibility to symptomatic infection (Kamath *et al.*, 2013).

Laboratory-confirmed VVC was found in 159 of the 400 symptomatic women, giving a prevalence of 39.75%. This finding falls within the range previously reported in Côte d'Ivoire, where prevalence estimates have varied from 23.50% to 53.60% (Djohan *et al.*, 2019; Konate-Toure *et al.*, 2024). Differences in prevalence between studies are not unexpected, given variations in the populations investigated, recruitment settings, clinical characteristics, diagnostic procedures, and geographical context. Considerable variation has likewise been reported elsewhere in Africa, including a prevalence of approximately 20.7% in Cameroon (Nicoline *et al.*, 2024) and substantially higher rates in Mali (Doumbo *et al.*, 2022).

Among the factors examined, pregnancy was significantly associated with VVC ($p$ = 0.04). VVC was detected in 46.01% of pregnant women compared with 35.44% of non-pregnant women. This association is consistent with previous studies in which pregnancy

was identified as an important factor associated with vaginal candidiasis (Babic *et al.*, 2010; Nelson *et al.*, 2013; Waikhom *et al.*, 2020). Pregnancy is accompanied by increased oestrogen levels, changes in vaginal epithelial glycogen content, and alterations in the local vaginal environment that may favour *Candida* proliferation. Within the pregnant subgroup, however, the distribution of VVC did not differ significantly according to trimester ($p$ = 0.31). None of the other factors evaluated in this study, including daily vaginal washing, type of underwear, educational status, oral contraceptive use, marital status, or the reported medical conditions, showed a statistically significant association with VVC.

The clinical findings also illustrate the difficulty of diagnosing VVC on symptoms alone. Vulvar pruritus was the most frequently reported associated symptom (78.50%), followed by vaginal burning (43.25%), pelvic pain (25.25%), and dyspareunia (22.50%). Vaginal discharge was predominantly creamy and whitish. Similar clinical presentations have been described in Côte d'Ivoire and Morocco (Konate *et al.*, 2014; Djohan *et al.*, 2019; Benchellal *et al.*, 2011). Pruritus, vulvovaginal burning, soreness, erythema, and abnormal discharge are well-recognised manifestations of VVC (Amouri *et al.*, 2010; Sobel, 2005; Qin *et al.*, 2018; Brown *et al.*, 2020; Mohammed *et al.*, 2021; Neal *et al.*, 2022). Nevertheless, these manifestations are not specific to candidiasis and may occur in other causes of vulvovaginitis. The fact that only 39.75% of the symptomatic women in the present study had laboratory-confirmed VVC further illustrates the limited specificity of clinical presentation alone. This observation supports recommendations that symptomatic VVC should, whenever feasible, be supported by appropriate mycological investigation, particularly in persistent, recurrent, or clinically uncertain cases (Farr *et al.*, 2021).

*C. albicans* remained the predominant species, accounting for 86.79% of all isolates, while non-*albicans Candida* (NAC) species represented 13.21%. The predominance of *C. albicans* agrees with the general epidemiological pattern reported for VVC and with findings from several African studies (Gonçalves *et al.*, 2016; Waikhom *et al.*, 2020). However, the relative contribution of NAC species varies considerably between populations, and some studies have reported a much greater proportion of these species (Fanou *et al.*, 2022).

The NAC isolates recovered in the present study comprised *C. glabrata*, *C. humicola*, *C. krusei*, *C. famata*, *C. intermidia*, and *C. catenulata*. *C. glabrata* and *C. humicola* were the most frequently identified NAC species, each accounting for 3.77% of all isolates, followed by *C. krusei* at 2.52%. Although NAC species represented a relatively small proportion of the isolates, their identification remains clinically relevant because antifungal susceptibility varies among *Candida* species, and some NAC species show reduced susceptibility to commonly used azoles (Tsega *et al.*, 2019; Pappas *et al.*, 2016; Whaley *et al.*, 2017). Species-level identification therefore becomes particularly important when infection persists or recurs despite antifungal therapy.

The antifungal susceptibility findings varied according to the antifungal agent, species group, and testing method. Among the 97 isolates evaluated using ATB Fungus 3, susceptibility was highest for voriconazole (95.88%), followed by fluconazole (93.81%), 5-flucytosine (91.75%), itraconazole (87.63%), and amphotericin B (83.51%). Resistance was comparatively uncommon overall, although it was detected for all five agents tested. These findings indicate that most isolates tested with this system remained susceptible to the systemic azoles evaluated. The high fluconazole susceptibility observed in the present study differs from the much lower susceptibility reported in some African settings. For example, Waikhom *et al.* (2020) reported lower susceptibility to fluconazole and voriconazole among vaginal *Candida* isolates in Ghana, in a population with a different distribution of *Candida* species.

The species-specific findings provide additional information that is not apparent from the overall susceptibility percentages. Among the 87 *C. albicans* isolates evaluated using ATB Fungus 3, 86 were susceptible to fluconazole and only one was resistant. Similarly, 82 isolates were susceptible to itraconazole and 86 to voriconazole, with no *C. albicans* isolate classified as resistant to voriconazole. These results are broadly consistent with the generally favourable azole susceptibility of vaginal *C. albicans* reported in earlier studies, although geographical variation in resistance has been documented (Djohan *et al.*, 2012; Kouadio-Yapo *et al.*, 2020; Whaley *et al.*, 2017).

A different pattern was observed among the 10 NAC isolates tested with ATB Fungus 3. Only five were susceptible to fluconazole, while three were resistant, and only three were susceptible to itraconazole, with four resistant isolates. Amphotericin B resistance was also recorded in four of these isolates. These results should be interpreted cautiously because of the small number of NAC isolates tested, but they nevertheless demonstrate greater heterogeneity in susceptibility within this group. This is particularly relevant for species such as *C. krusei*, which has intrinsic resistance to fluconazole, and *C. glabrata*, for which reduced azole susceptibility and acquired resistance are well recognised (Pappas *et al.*, 2016; Whaley *et al.*, 2017). The findings are also consistent with the broader concern regarding fluconazole resistance among NAC species (Li *et al.*, 2026).

The agar diffusion results showed a different susceptibility profile. Among the 98 isolates tested, amphotericin B and nystatin retained the highest activity, with susceptibility rates of 98.98% and 97.96%, respectively. In contrast, susceptibility was lower for miconazole (60.20%), econazole (57.14%), ketoconazole (63.27%), and clotrimazole (75.51%). Resistance was particularly evident for 5-flucytosine (24.49%), ketoconazole (18.37%), miconazole (15.31%), and econazole (14.29%). Previous work in Abidjan has also documented variability in the susceptibility of vaginal *Candida* isolates to antifungal agents (Djohan *et al.*, 2012; Kouadio-Yapo *et al.*, 2020). More recently, higher susceptibility rates to several commonly used antifungals were reported among pregnant women at Angré University Hospital in Abidjan (Angora *et al.*, 2025). Differences between studies may reflect variation in species distribution, antifungal exposure, study populations, laboratory procedures, and interpretive criteria.

Among *C. albicans* isolates tested by agar diffusion, resistance was most frequent with 5-flucytosine, ketoconazole, miconazole, and econazole, whereas all isolates were susceptible to amphotericin B and only one was resistant to nystatin. The NAC group also showed variable susceptibility across the antifungal panel. Given the small number of isolates within individual NAC species, however, species-specific resistance percentages should be interpreted with caution. Larger studies would be required to establish reliable susceptibility patterns for the less frequently isolated species.

An important feature of the present study is the difference in susceptibility patterns obtained with ATB Fungus 3 and agar diffusion. These findings should not be interpreted as direct evidence that one method systematically detects more resistance than the other. The two methods were applied to slightly different numbers of isolates (97 and 98, respectively), the same isolates were not necessarily tested by both methods, and the antifungal panels were substantially different. Fluconazole, itraconazole, and voriconazole were evaluated with ATB Fungus 3, whereas the agar diffusion panel included topical azoles such as econazole, miconazole, clotrimazole, and ketoconazole. A direct comparison of overall resistance percentages between the two approaches is therefore limited.

Methodological characteristics may also influence susceptibility classification. ATB Fungus 3 is a commercial dilution-based system for determining the susceptibility of yeasts to several antifungal agents, but its performance depends on how

endpoints are read and interpreted. In a comparison with CLSI broth microdilution, Zhang *et al.* (2014) found high overall essential agreement when ATB Fungus 3 results were read visually, whereas automated readings showed lower agreement for several azoles. Such findings emphasise that results obtained using commercial or alternative susceptibility methods should be interpreted within the context of the specific testing procedure and should not automatically be considered interchangeable with those generated by a reference method.

The findings from the agar diffusion assay require similar caution. The method used in the present study involved Casitone and semi-synthetic media and a panel of seven antifungal agents. Because the procedure and antifungal panel do not fully correspond to the standardized reference disk-diffusion methodology for all of the drugs evaluated, the susceptibility categories should be considered within the context of the locally applied procedure. In addition, the absence of direct comparison with a reference broth microdilution method limits conclusions regarding agreement or diagnostic performance between the two susceptibility approaches.

Taken together, the findings show that *C. albicans* remains the predominant species associated with VVC in this population, while NAC species constitute a smaller but clinically relevant group with more heterogeneous susceptibility profiles. The generally high susceptibility of *C. albicans* to systemic azoles in the ATB Fungus 3 assay contrasts with the lower susceptibility observed for several antifungals evaluated by agar diffusion. However, differences in the isolates tested, antifungal panels, and methodological characteristics prevent direct equivalence between these results. Future studies using the same isolates across susceptibility methods and including a recognized reference broth microdilution method would provide a stronger basis for evaluating agreement between testing approaches. Correlating laboratory susceptibility findings with treatment exposure and clinical outcomes would also help clarify the clinical relevance of in vitro resistance patterns in women with VVC in this setting.

## CONCLUSION

Vulvovaginal candidiasis was confirmed in 39.75% of symptomatic women attending the University Hospital of Bouaké, with *Candida albicans* remaining the predominant species. Although non-*albicans Candida* species accounted for a smaller proportion of isolates, they showed more variable antifungal susceptibility profiles, particularly to azole antifungals. Pregnancy was the only factor significantly associated with VVC among the variables examined.

Most isolates tested with ATB Fungus 3 remained susceptible to the systemic antifungals evaluated, particularly voriconazole, fluconazole, and 5-flucytosine. The agar diffusion assay showed high susceptibility to amphotericin B and nystatin but greater variability with the other antifungal agents tested. These findings should be interpreted within the methodological context of each assay, as the two methods involved different antifungal panels, slightly different numbers of isolates, and were not compared against a reference broth microdilution method.

The findings reinforce the importance of laboratory confirmation of suspected VVC, together with species-level identification of *Candida* isolates, particularly in persistent or recurrent infections. Strengthening access to mycological diagnosis and appropriately standardized antifungal susceptibility testing in resource-limited settings could support more informed antifungal use. Further studies using the same isolates across susceptibility methods, incorporating a reference method and linking laboratory findings with treatment response, are needed to clarify the clinical significance of the observed susceptibility patterns and to inform the management of VVC in this setting.

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