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# Association of Biofilm Formation with Fluconazole Susceptibility in Candida Urinary Isolates

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**ABSTRACT**

**Introduction.** This study aims to investigate the association between biofilm formation by *Candida* spp. and in vitro fluconazole susceptibility in urinary isolates from intensive care unit (ICU) patients with indwelling urinary catheters, while characterising species distribution, biofilm formation, and susceptibility patterns. **Methods.** This cross-sectional study included 44 *Candida* spp. isolates recovered from urine samples of ICU patients catheterised for more than 48 hours. Species identification and fluconazole susceptibility testing were performed using the VITEK 2 system, and biofilm formation was assessed using a microtiter plate assay. Demographic characteristics, comorbidities, and catheterisation duration were obtained from medical records. **Results.** *Candida albicans* was the most frequent species (40.9%), followed by *Candida tropicalis* (25.0%), *Candida glabrata* (20.5%), and *Candida parapsilosis* (13.6%). Half of the isolates (22/44) formed biofilms, predominantly weak, with only a small proportion demonstrating moderate biofilm formation. Fluconazole susceptibility was observed in 16 of 22 (72.7%) biofilm-forming isolates and 17 of 22 (77.3%) non-biofilm-forming isolates, while resistance was identified in 6 of 22 (27.3%) and 5 of 22 (22.7%), respectively. No significant association was found between biofilm formation and fluconazole susceptibility ($\chi^2$ = 0.121; p = 0.728). **Conclusion.** In this single-centre ICU cohort, biofilm formation among urinary *Candida* isolates was common but predominantly weak and was not significantly associated with in vitro fluconazole susceptibility. These findings should be interpreted cautiously, given the cross-sectional design and in vitro nature of the study. Larger multicentre studies are warranted to clarify the clinical relevance of *Candida* biofilm formation in candiduria.

## 1. Introduction

Healthcare-Associated Infections (HAIs) are an important cause of morbidity and mortality, especially for hospitalized patients, and are more common in intensive care units (ICUs).[1] A large percentage of HAIs are Catheter-Associated Urinary Tract Infections (CAUTIs), and fungi, particularly *Candida spp.,* are becoming more widely acknowledged as important pathogens. In Intensive Care Units, *Candida spp*. are the second most common cause of CAUTI after *Escherichia coli,* with an incidence rate of 17.8%.[2] Nosocomial infection rates have been linked to the presence of *Candida spp.* in silicone or latex urinary catheters, especially during the first 10–14 days after catheterization.[3] Extracellular polymeric materials with proteins or polysaccharides make up biofilms, which shield embedded bacteria from harsh environmental factors such as osmolarity shifts, pH swings, food shortages, and exposure to antimicrobial agents.[4]

Recently, urinary tract infections caused by opportunistic *Candida spp.* have increased and now occur in about 10 to 15% of all urinary tract infection cases. *Candida spp*. are the most common fungal cause of urinary tract infection and colonize the gastrointestinal tract, reproductive tract (particularly in women), and the skin.[5] Immunocompromised conditions such as diabetes mellitus, HIV infection, malignancy, chemotherapy, broad-spectrum antibiotic use, long-term corticosteroid therapy, and prolonged urinary catheterization are important risk factors for invasive candidiasis and Candida urinary tract infection.[2] *Candida albicans* is the most common pathogen, responsible for approximately 50 to 70% of candiduria cases, whereas about 20% are caused by *Candida glabrata*; in neonates, *Candida parapsilosis* is a frequent cause of candiduria.[5,6]

Fungal persistence and resistance to antifungal medications like fluconazole and amphotericin B are increased when *Candida spp.* biofilms grow on urinary catheters.[7,8] Several clinical and experimental studies have suggested an association between Candida biofilm formation and decreased fluconazole susceptibility.[7–11] Nevertheless, findings remain inconsistent, and data specifically focusing on urinary Candida isolates from catheterized ICU patients are still limited, particularly in Indonesia. Moreover, most available studies have evaluated mixed clinical specimens or non-ICU populations, making the relationship between biofilm formation and

fluconazole susceptibility in ICU-associated candiduria insufficiently characterized.[7–11] However, local data on whether biofilm-forming urinary Candida isolates from catheterized ICU patients show reduced fluconazole susceptibility remain limited.[7-9] This study aimed to evaluate the association between biofilm formation and in vitro fluconazole susceptibility among *Candida spp.* urinary isolates from intensive care unit patients at Dr. Saiful Anwar General Hospital, Malang.

## 2. Methods

This observational analytic cross-sectional study was conducted in the Clinical Microbiology Laboratory, Faculty of Medicine, Universitas Brawijaya, and in the intensive care unit (ICU) of Dr. Saiful Anwar General Hospital, Malang, Indonesia, from August to September 2024. Urine samples from ICU patients using indwelling urinary catheters were prospectively cultured, and all isolates from one isolate per patient obtained during the study period were eligible for inclusion. Isolates were included if they were obtained from patients who had a urinary catheter in place for more than 48 hours. Candiduria was defined as the presence of *Candida* spp. growth in urine culture with a colony count $\geq 10^5$ CFU/mL. The study protocol was approved by the Health Research Ethics Committee of Dr. Saiful Anwar General Hospital, Malang, Indonesia (ethical approval no. 400/212/K.3/102.7/2024; 18 July 2024).

Patients with comorbid conditions associated with increased risk of candiduria or invasive candidiasis, including diabetes mellitus, pneumonia, malignancy, and HIV infection, were not excluded from the study. Total sampling was applied, and all isolates meeting the inclusion criteria during the study period were enrolled. Isolates from patients with incomplete medical record data were excluded from the analysis.

Yeast colonies grown on *Sabouraud dextrose agar* were identified to the species level and tested for fluconazole susceptibility using the VITEK 2 compact system (bioMérieux, Marcy-l'Étoile, France), following the manufacturer's instructions and European Committee on Antimicrobial Susceptibility Testing (EUCAST) recommendations. Fluconazole minimum inhibitory concentrations were interpreted according to EUCAST clinical breakpoints, and isolates were categorised as susceptible or resistant.

Biofilm formation by *Candida spp*. was assessed using a quantitative microtiter plate assay. Briefly, isolates grown on Sabouraud dextrose agar were inoculated into Sabouraud dextrose broth supplemented with 1% glucose and adjusted to a 0.5 McFarland standard, then incubated at 37 °C for 24 hours. The suspension was diluted 1 to 20 to obtain a final inoculum of approximately $5 \times 10^6$ colony-forming units per millilitre. For each isolate, 180 microlitres of glucose-supplemented Sabouraud dextrose broth and 20 microlitres of the standardised yeast suspension were dispensed into sterile, flat-bottom 96-well polystyrene microplates. The plates were incubated at 37 °C for 24 to 48 hours, after which the wells were gently washed twice with phosphate-buffered saline (pH 7.3) and air-dried for 1 hour. Biofilms were fixed with 150 microlitres of methanol for 20 minutes, stained with 0.1% crystal violet for 10 to 15 minutes, and the excess stain was removed. The bound dye was then solubilised with 150 microlitres of 95% ethanol, and the optical density (OD) of each well was measured at 570 nanometres using a Spectrostar Nano microplate reader. Uninoculated wells containing only broth served as negative controls. No reference biofilm-producing control strain was included in the assay because the study focused on comparative evaluation among clinical urinary isolates obtained during the study period. All assays were performed under identical experimental conditions to minimize inter-assay variability.

The cut-off OD (ODc) was defined as the mean OD of the negative control plus three times the standard deviation of the negative control. Based on the optical density (OD) values, the isolates were categorized according to their biofilm-forming ability. Isolates with OD values < ODc were classified as non-biofilm producers, those with OD values > ODc but < 2 × ODc were classified as weak biofilm producers, isolates with OD values > 2 × ODc but < 4 × ODc were categorized as moderate biofilm producers, and isolates with OD values > 4 × ODc were classified as strong biofilm producers. All assays were performed in triplicate, and the mean optical density (OD) value for each isolate was used for analysis.

Biofilm formation was initially classified into four categories based on optical density values: no biofilm formation, weak, moderate, and strong biofilm formation. Due to the limited number of isolates in the moderate and strong biofilm groups, biofilm status was subsequently dichotomized into biofilm-forming and non-biofilm-forming isolates for inferential statistical analysis to ensure adequate cell counts and test validity. Descriptive analysis of the original biofilm categories was nevertheless retained to preserve information regarding the distribution of biofilm intensity among isolates.

All biofilm assays were performed in triplicate, and the mean optical density value for each isolate was used for analysis. The association between biofilm formation and fluconazole susceptibility was evaluated using the chi-square test. Fisher's exact test was applied when chi-square assumptions were not fulfilled, particularly when expected cell counts were less than five. A p-value <0.05 was considered statistically significant. Statistical analyses were performed using SPSS version 29.0.2.0 for Windows.

## 3. Results

### Sample Characteristics

Urine specimens from intensive care unit patients

collected between August and September 2024 yielded 44 *Candida spp.* isolates. Most isolates were obtained from female patients (30/44; 68.2%), and the majority were from patients older than 50 years (36/44; 81.8%). Only four isolates (9.1%) were from patients aged 35–50 years, and four isolates (9.1%) were from patients younger than 35 years. With respect to catheterisation duration, 13 isolates (29.5%) were from patients catheterised for <7 days, 14 isolates (31.8%) for 7–14 days, and 17 isolates (38.6%) for >14 days. Diabetes mellitus was the most frequent comorbid condition (21/44; 47.7%), followed by pneumonia (community-acquired or ventilator-associated) in 15 isolates (34.1%) and malignancy in 8 isolates (18.2%).

**Profile of *Candida spp.***

The distribution of *Candida* species isolated from urine specimens of ICU patients is presented in Table 1. *Candida albicans* was the most frequently identified species (40.9%), followed by *Candida tropicalis* (25.0%), *Candida glabrata* (20.5%), and *Candida parapsilosis* (13.6%) (Table 2).

**Fluconazole Susceptibility Profiles of *Candida* Species**

Fluconazole susceptibility profiles according to *Candida* species are presented in Table 3. Overall, 33 of 44 isolates (75.0%) were susceptible to fluconazole, whereas 11 isolates (25.0%) were resistant. *Candida albicans* and *Candida tropicalis* demonstrated the highest susceptibility rates (65.9%), while *Candida glabrata* showed the highest proportion of fluconazole resistance (20.5%).

**Table 1. Distribution of study samples**

| Variable | Frequency | Percentage (%) |
|---|---|---|
| **Gender** | | |
| Male | 14 | 31.8% |
| Female | 30 | 68.2% |
| **Age** | | |
| <18 years | 2 | 4.54% |
| 18–35 years | 2 | 4.54% |
| 35–50 years | 4 | 9.09% |
| >50 years | 36 | 81.8% |
| **Catheterization Duration** | | |
| <7 days | 13 | 29.5% |
| 7–14 days | 14 | 31.8% |
| >14 days | 17 | 38.6% |
| **Comorbid Conditions** | | |
| Diabetes Mellitus | 21 | 47.7% |
| Pneumonia (CAP, VAP) | 15 | 34.1% |
| Malignancy | 8 | 18.2% |

**Table 2. Distribution of *Candida* species isolated from urine specimens of ICU patients**

| *Candida* species | Number of isolates (n) | Percentage (%) |
|---|---|---|
| *Candida albicans* | 18 | 40.9 |
| *Candida tropicalis* | 11 | 25.0 |
| *Candida glabrata* | 9 | 20.5 |
| *Candida parapsilosis* | 6 | 13.6 |
| Total | 44 | 100 |

**Table 3. Fluconazole susceptibility profiles of *Candida* species**

| *Candida* species | Susceptible n (%) | Resistant n (%) | Total |
|---|---|---|---|
| *Candida albicans* | 18 (40.9) | - | 18 |
| *Candida tropicalis* | 11 (25.0) | - | 11 |
| *Candida glabrata* | - | 9 (20.5) | 9 |
| *Candida parapsilosis* | 4 (9.1) | 2 (4.5) | 6 |
| Total | 33 (75) | 11 (25) | 44 |

**Table 4. Biofilm formation profile of *Candida spp.***

| Species | Biofilm-Negative (%) | Weak Biofilm (%) | Moderate Biofilm (%) |
|---|---|---|---|
| *Candida albicans* | 11 (25) | 7 (15.9) | - |
| *Candida tropicalis* | 3 (6.8) | 7 (15.9) | 1 (2.3%) |
| *Candida glabrata* | 4 (9.1) | 4 (9.1) | 1 (2.3%) |
| *Candida parapsilosis* | 4 (9.1) | 2 (4.5) | - |

**Table 5. Relationship between biofilm formation and fluconazole susceptibility**

| Biofilm Formation | Susceptible n (%) | Resistant n (%) | Total n (%) | *p-value* |
|---|---|---|---|---|
| *Biofilm-forming (ODc > 0.414)* | 16 (72.7) | 6 (27.3) | 22 (50.0) | |
| *Non-biofilm-forming (ODc < 0.414)* | 17 (77.3) | 5 (22.7) | 22 (50.0) | 0.728 |
| Total | 33 (75) | 11 (25.0) | 44 (100) | |

**Biofilm Formation Profile of *Candida spp.***

Quantitative microtiter plate assays showed that 22/44 isolates (50.0%) did not form biofilm, 20/44 isolates (45.5%) exhibited weak biofilm formation, and 2/44 isolates (4.5%) exhibited moderate biofilm formation. None of the isolates showed strong biofilm formation. Weak biofilm production was most frequent among Candida tropicalis and Candida albicans, each contributing 7/44 isolates (15.9%), whereas moderate biofilm formation was observed in one isolate of Candida tropicalis and one isolate of Candida glabrata. Candida albicans accounted for the highest proportion of isolates without biofilm formation (11/44; 25.0%) (Table 4).

**Relationship between biofilm formation and fluconazole susceptibility**

Overall, fluconazole susceptibility was comparable between biofilm-forming and non-biofilm-forming isolates. Among biofilm-forming isolates, 16/22 (72.7%) were susceptible to fluconazole, whereas 6/22 (27.3%) were resistant. Similarly, among non-biofilm-forming isolates, 17/22 (77.3%) were susceptible, and 5/22 (22.7%) were resistant. Statistical analysis demonstrated no significant association between biofilm formation and fluconazole susceptibility (chi-square = 0.121; p = 0.728).

## 4. Discussion

The present study evaluated the biofilm formation of *Candida spp.* isolated from urine specimens of intensive care unit patients with indwelling urinary catheters and analysed its association with fluconazole susceptibility. A total of 44 Candida isolates were obtained, most of which originated from patients older than 50 years with at least one comorbid condition and from patients who had been catheterised for more than 14 days. *Candida albicans* was the predominant species, followed by *Candida tropicalis*, *Candida glabrata,* and *Candida parapsilosis.* Half of the isolates did not form biofilm, whereas most biofilm-forming isolates produced only weak biofilms, and none produced strong biofilms. Fluconazole susceptibility was comparable between biofilm-forming and non-biofilm-forming isolates, and there was no statistically significant association between biofilm formation and fluconazole susceptibility (p = 0.728).

The sample characteristics in this study are consistent with recognised risk profiles for catheter-associated urinary tract infection in intensive care settings. Older age, prolonged catheterisation, and the presence of comorbid conditions such as diabetes mellitus, pneumonia, malignancy, and HIV infection are well-known risk factors for candiduria and invasive candidiasis.[12] Singh et al. (2022) identified catheter duration as a major risk factor for biofilm formation by *Candida spp.* on urinary catheters in intensive care patients, with longer catheter use associated with higher rates of catheter-associated urinary tract infection.[3] In the present cohort, more than one-third of isolates were obtained from patients catheterised for more than 14 days, which is in line with the concept that extended catheterisation facilitates colonisation and biofilm formation on catheter surfaces. However, this study did not specifically analyse the statistical relationship between individual risk factors and biofilm formation.

The distribution of Candida species observed here is broadly similar to that reported in previous investigations of catheter-associated candiduria. *Candida albicans* accounted for 40.9% of isolates, with non-albicans Candida species, particularly *Candida tropicalis* and *Candida glabrata*, comprising the remainder. Zafar et al. (2020) likewise reported *Candida albicans* as the most common species in complicated urinary tract infection, followed by non-albicans Candida species.[10] In contrast, Ismail et al. (2020) described *Candida tropicalis* as the leading cause of catheter-associated candiduria, followed by *Candida albicans* and *Candida glabrata*,[7] whereas Singh et al. (2022) found that *Candida albicans* and *non-albicans Candida* contributed almost equally to the burden of catheter-associated urinary tract infection.[3] Variations in ICU patient characteristics, length of catheterization, antibiotic exposure, antifungal prescribing policies, and local hospital epidemiology could all have an impact on the variation in species distribution among studies. Invasive devices and broad-spectrum antibiotics are common in critically ill patients, and both can promote the colonization of non-albicans Candida species. Additionally, variations in infection management and antifungal stewardship methods, as well as geographic variance, may influence changes in species predominance between institutions. The relatively high proportion of non-albicans Candida isolates observed in this study is clinically important because several of these species, particularly Candida glabrata, are known to exhibit reduced susceptibility to azole antifungals. Nevertheless, *Candida albicans*' ongoing dominance and the rise in non-albicans Candida species emphasize the significance of

ongoing local surveillance and the changing epidemiology of candiduria in catheterized ICU patients.[13,14]

In terms of biofilm production, this study showed that 50.0% of isolates did not form biofilm under the assay conditions, 45.5% produced weak biofilm, and only 4.5% produced moderate biofilm, with no strong biofilm producers. Weak biofilm formation was most frequently observed in *Candida tropicalis* and *Candida albicans*, while moderate biofilm formation was limited to single isolates of *Candida tropicalis* and *Candida glabrata*. Chandak et al. (2018) also reported *Candida tropicalis* as a frequent biofilm producer among urinary Candida isolates causing chronic candiduria.[15] Patel et al. (2021) suggested that *Candida spp*. are not always the predominant biofilm-forming organisms on urinary catheters and emphasised the contribution of bacterial uropathogens to catheter-associated biofilms.[16] The relatively low proportion of moderate biofilm producers in the present study may indicate that many urinary Candida isolates in this ICU setting act as colonisers with limited biofilm-forming capacity rather than forming mature, highly structured biofilms.

Several biological and environmental factors may underlie the variability in biofilm formation among Candida species. Genetic differences in adhesin and cell-wall-associated genes, as well as differences in gene expression in response to environmental conditions such as pH, temperature, nutrient availability, and the nature of the device substrate, can influence the initial adhesion phase and subsequent biofilm maturation.[4,17] Cavalheiro and Teixeira (2018) highlighted that hydrophobic materials, including polystyrene and other plastics commonly used in medical devices, promote the development of complex exopolysaccharide matrices and water channels within Candida biofilms, facilitating nutrient diffusion and waste removal.[17] The majority of weak biofilm formation in this study may also be due to variations in local clinical procedures, such as antibiotic exposure and catheter maintenance, which were not thoroughly examined in the current analysis. Inconsistent results in the literature may also be caused by methodological variations among research, such as variations in biofilm quantification methods, cut-off definitions, incubation times, and reference strains. These factors emphasize the complexity of Candida biofilm production and the requirement for standardized methods in subsequent research.

In the present study, no significant association was found between biofilm formation and fluconazole susceptibility. These findings are in line with the observations of Singh et al. (2022), who reported that fluconazole and other azole agents remained active against most Candida isolates in catheter-associated urinary tract infection[3], and with the study of Patel et al. (2021), which showed that Candida biofilm formation on urinary catheters did not consistently confer resistance to fluconazole.[16] Kamini et al. (2022) also demonstrated that fluconazole retained activity against biofilm-producing *Candida albicans*, *Candida tropicalis,* and *Candida glabrata* isolated from catheterised patients with urinary tract infection.[8] The prevalence of weak biofilm-producing isolates in our investigation, whereas moderate and high biofilm formation were rare, may account for the absence of correlation. Weak biofilms might not generate enough extracellular matrix to significantly reduce the activity or penetration of fluconazole. Furthermore, species-related variables, efflux pump activity, metabolic adaptation, and prior antifungal exposure all have an impact on biofilm-associated resistance in addition to biofilm biomass.[17-19] Several factors may contribute to the absence of a statistically significant association in the current study, variability in *Candida* species distribution, local antifungal use, ICU patient characteristics, and methodological variations in biofilm measurement and susceptibility testing may further account for variations between the current findings and publications reporting higher biofilm-associated resistance.[9,18,19] Additionally, the statistical power to identify subtle relationships may have been constrained by the relatively small sample size.

The complex interplay between biofilm formation and antifungal susceptibility in *Candida spp*. is further illustrated by studies on quorum-sensing molecules. Kovács and Majoros (2020) described the role of farnesol, a quorum-sensing molecule produced during sterol synthesis, in modulating Candida morphology, biofilm formation, drug efflux pump expression, apoptosis, and phagocytic responses. Farnesol can inhibit the yeast-to-hyphae transition and thus limit biofilm maturation and may have synergistic effects with antifungal agents.[17,18] These mechanisms support the notion that biofilm formation does not uniformly result in reduced fluconazole susceptibility and that additional regulatory pathways influence the antifungal response of *Candida* within biofilms.

On the other hand, several investigations have reported a stronger association between Candida biofilms and azole resistance than was observed in our cohort. Kamini et al. (2022) found that moderate and strong biofilm-producing isolates of *Candida albicans* and *Candida tropicalis* showed higher rates of fluconazole resistance.[8] Marzucco et al. (2024) reported that all *Candida tropicalis* isolates with moderate biofilm production and most *Candida albicans* and *Candida glabrata* isolates with moderate or strong biofilms were resistant to fluconazole.[19] The current study did not show a significant correlation between biofilm production and fluconazole susceptibility, in contrast to previous studies that found a considerable correlation between Candida biofilm formation and azole resistance. The fact that the majority of the isolates in this investigation that

produced biofilms only showed weak biofilm production, whereas there were few intermediate biofilm producers and no robust biofilm producers, is a significant explanation. Weak biofilms might not produce enough extracellular matrix or structural complexity to significantly lower fluconazole activity, which could account for our isolates' comparatively intact susceptibility.[17,19] Furthermore, the statistical power to identify minor relationships between biofilm formation and antifungal susceptibility may have been restricted by the very small sample size (44 isolates). The conflicting results described in the literature may also be caused by variations in patient characteristics, species distribution, and methodological techniques among studies.

The present study showed that biofilm formation was frequently observed among urinary Candida isolates obtained from catheterized ICU patients, although most isolates demonstrated only weak biofilm-producing capacity, and no significant association with decreased fluconazole susceptibility was identified. Nevertheless, these results should be interpreted with caution. The susceptibility testing used in this study assessed planktonic fungal cells and therefore may not accurately represent antifungal activity against mature biofilms, in which extracellular matrix production and biofilm-related metabolic adaptations can reduce the effectiveness of azole antifungals.[17,19] Furthermore, the overall correlation between biofilm formation and fluconazole resistance may be influenced by variations in Candida species' intrinsic azole susceptibility and ability to create biofilms.[17,19,20] Therefore, species-specific patterns may have been hidden by a combined study of all species, especially among isolates of Candida that are not albicans, like Candida glabrata.[19,20] An additional consideration is that the detection of *Candida* spp. in urine specimens from catheterized patients does not always reflect a true catheter-associated urinary tract infection, since candiduria in critically ill patients may also result from colonization or specimen contamination. Therefore, the clinical significance of biofilm formation and fluconazole susceptibility among urinary *Candida* isolates should be evaluated alongside the patient's overall clinical condition.[2,20] Future multicentre investigations incorporating species-specific evaluation and biofilm-oriented antifungal susceptibility testing are warranted to clarify the clinical impact of *Candida* biofilms in catheter-associated urinary tract infection.

There are various limitations to this study. First, there was a small sample size because data gathering was limited to the August–September 2024 period of time, which could have contributed to data unpredictability. The lack of information on past antibiotic use is another study disadvantage. This missing information may affect the interpretation of the results, because exposure to antibiotics is known to be a risk factor for the production of biofilms. Another disadvantage of this study is that the biofilm development time for *Candida spp.* was not evaluated. Furthermore, the relatively limited number of isolates, especially those with moderate or strong biofilm formation, may have reduced the statistical power of the analysis and affected the ability to identify significant associations. Another limitation is that antifungal susceptibility was evaluated using conventional planktonic testing methods without biofilm-targeted susceptibility assessment, which may not fully represent antifungal activity against mature biofilm-associated cells. Lastly, other laboratory data, such as urinalysis results, which could have offered more proof of urinary tract infections linked to catheterisation, were not available for all patients.

## 5. Conclusion

Biofilm formation among urinary Candida isolates from catheterized ICU patients was common but predominantly weak, and no significant association was observed between biofilm formation and in vitro fluconazole susceptibility. These findings suggest that biofilm formation alone may not predict reduced fluconazole susceptibility in urinary Candida isolates. Within the limitations of this single-centre study, fluconazole therefore remains an acceptable therapeutic option for catheter-associated candiduria in this ICU population, provided that local susceptibility patterns are monitored and individual patient risk factors are carefully considered. Further multicentre studies with larger sample sizes and biofilm-specific antifungal susceptibility testing are needed to better clarify the clinical significance of Candida biofilms in catheter-associated urinary tract infection.

## 6. Author Contribution

RAP. Conceptualization, methodology, and writing original draft preparation, data collection. NAS. Writing, review, and editing. DR. Writing, review, and editing. All authors have read and approved the final manuscript.


## 7. Acknowledgements

Nil.


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