International Journal of Current Research and Applied Studies, (IJCRAS)

ISSN: 2583-6781

available at https://ijcras.com/

Volume 4 Issue 3 May-June 2025, Page 17-36

To cite this article: Martha kangyang Gyang, John Danjuma Mawak and Grace Mebi Ayanbimpe (2025). THERMOTOLERANT NON-ALBICANS CANDIDA ISOLATES FROM DIABETES MELLITUS AND MALIGNANT PATIENTS IN JOS, NIGERIA, International Journal of Current Research and Applied Studies (IJCRAS) 4 (3): Article No. 122, Sub Id 216

THERMOTOLERANT NON-ALBICANS CANDIDA ISOLATES FROM DIABETES MELLITUS AND MALIGNANT PATIENTS IN JOS, NIGERIA

Martha kangyang Gyang[1], John Danjuma Mawak[2] and Grace Mebi Ayanbimpe[1]

1Department of Medical Microbiology, Faculty of Clinical Sciences, College of Health Sciences, University of Jos, P.M.B. 2084, Jos, Plateau State, Nigeria.
2Department of Microbiology, Faculty of Natural Sciences, University of Jos, P.M.B. 2084, Jos, Plateau State, Nigeria.

DOI : https://doi.org/10.61646/IJCRAS.vol.4.issue3.122

ABSTRACT

Thermotolerant non-albicans Candida (NAC) species among immunocompromised patients pose a significant threat to public health. These species, including the multidrug-resistant C. auris, can thrive at high temperatures and survive NaCl2 concentration, allowing them to colonize and infect human skin. This study aimed to isolate and identify thermotolerant non-albicans Candida species from diabetic and malignant patients in Jos, Nigeria, and to determine the possible risk factors associated with candidiasis among the participants. A total of 702 samples, from the armpit and inguinal fold of the groin of patients, were inoculated on Sabouraud dextrose agar (SDA) containing chloramphenicol (250 mg/L), sub-cultured on three selective media, and incubated at 42 °C for 48 hours. Halotolerant and thermotolerant tests were conducted using a 10-fold serial dilution method. Twenty-three-point nine percent (23.9%) of patients tested positive, with Candida glabrata (12.5%) being the predominant species, followed by Candida tropicalis (5.1%), suspected C. auris (2.3%), and C. krusei and C. parapsilopsis, each at 1.4%. Some patients experienced co-infections. Identified risk factors included cardiovascular complications, prolonged use of antibiotics, immunosuppressive therapy, and catheterization. This study highlights the pathogenic thermotolerant non-albicans Candida species as a critical consideration for diagnostic processes to facilitate isolation, particularly among patients with diabetes and malignancy.

Keywords: Thermotolerance, non-albicans candida species, Candida auris, Diabetes mellitus, Malignancy, Superficial candidiasis.

INTRODUCTION

Thermotolerant Non-albicans Candida species, including C. glabrata, C. tropicalis, C. parapsilosis, C. auris, and others, have been increasingly recognized as significant pathogens in hospital settings, resulting in approximately two million fungal infections globally (1–3). They are responsible for a considerable fraction of nosocomial infections, such as bloodstream infections, urinary tract infections, respiratory infections, and surgical site infections (4), particularly in diabetic mellitus and malignant patients, and those with other underlying medical conditions (2,5). The concern is particularly focused on Candida auris, a multidrug-resistant yeast that exhibits resistance to fluconazole and other antifungal drugs, leading to clinical failure rates (5).

Clinical cases exhibited a steady annual growth rate, from 44% in 2019 to over 95% in 2021. Reported cases in the United States have increased rapidly from 479 in 1999 to 4,514 in 2023, with significant outbreaks in New In Plateau State, Candida parapsilosis was the most prevalent in the hospital environment at 31.25%, followed by Candida (Nakaseomyces) glabrata and Candida krusei, which had a prevalence of 28.13%.

The most common pathogens isolated from clinical samples of patients with diabetes mellitus and cancer are C. glabrata, C. parapsilosis, C. tropicalis, and C. krusei. These pathogens secrete hydrolytic and proteolytic enzymes that provide virulence factors, enabling the species to adhere to host cells. Immunological factors influence Candida skin infections, which tend to occur in occluded areas of the skin, such as the armpits, groin, and under the breasts, where humidity and CO2 accumulate, leading to superficial candidiasis (6).

Patients colonized with Candida auris release the fungus into their surroundings, leading to environmental contamination, thereby transmitting it to new patients during close contact, resulting in outbreaks (7). Thermotolerant NACs cause infections, leading to longer hospital stays, increased healthcare costs, and higher morbidity and mortality among hospitalized patients (8,9). Nosocomial infections by fungi have rarely been a focus in healthcare and research because physicians in Plateau and other parts of Nigeria typically concentrate on nosocomial infections caused by bacteria and parasites, often neglecting fungal infections, which may result in extended hospitalizations. Additionally, there is no documented data on candidiasis caused by thermotolerant non-albicans Candida in Nigeria, to the best of the researcher's knowledge. This study aims to isolate and identify thermotolerant NAC species from patients with diabetes mellitus and malignancy in Jos, Nigeria.

METHODS

STUDY AREA

The study was conducted at Jos University Teaching Hospital (JUTH) and Bingham University Teaching Hospital (BUTH) in Jos, Plateau State. These hospitals served as referral centers for Plateau and the northern central states, including Bauchi, Nasarawa, and Benue.

The hospital beds are positioned side by side, allowing for a minimum of 5 feet between them. These hospitals include public (government-owned) and private institutions in Plateau State.

The study received approval from the Ethical Committee of JUTH and BUTH Jos, Plateau State. Informed written consent was obtained from each patient after an adequate explanation was provided to patients who participated in the study.

RESEARCH DESIGN

The study, which was cross-sectional with laboratory analysis, aimed to isolate and identify thermotolerant non-albicans candida species from 351 (226 diabetes mellitus and 125 malignant) patients of both sexes aged 18 years and above drawn from the two hospitals.

RESEARCH DURATION: The work was carried out between 3rd October 2023 to 17th February 2024.

INCLUSION CRITERIA

Diabetes mellitus and malignant patients on admission with bright red or white rashes on the skin folds of the armpit or groin, or any form of skin infection, who consented to the study, were enrolled.

EXCLUSION CRITERIA

Diabetes mellitus and malignancy. Patients who had had antifungal treatment in the last 2 weeks from the enrolment date were excluded.

SAMPLE COLLECTION

The patient's axilla (armpit) and groin were cleaned with moist cotton wool soaked in sterile physiological saline. The sites were allowed to air-dry. A skin swab was collected individually from the axilla (armpit) and inguinal fold of the groin of each patient using sterile cotton swabs premoistened in sterile physiological saline. The samples were placed in capped propylene tubes, labeled, and transported to the hospital laboratory for analysis within an hour at ambient temperature.

1. SAMPLES PROCESSING

1.1 Fungal Culture

All samples from the patients were inoculated on SDA (Oxoid, UK) with chloramphenicol (25 mg/L) and incubated at 37°C for 24 hours.

Isolates with creamy, smooth, pasty, and convex colonies that appeared wrinkled on further incubation are considered *Candida species (Plate 5).*

1.2 Microscopic Examination

Positive samples were examined microscopically using 20% Potassium Hydroxide (KOH) to detect fungal

morphology, which formed budding yeast and/or pseudo-hyphae (Plate 1) as described by (10).

1.3 Subculturing on Oxoid Brilliance Candida Agar

All media used for subculturing were prepared according to the manufacturer's instructions. A sterile wire loop was employed to select a discrete colony of isolates from an SDA culture plate, which was then subcultured onto prepared Thermo Scientific™ Brilliance™ Candida Agar (BCA) and incubated aerobically at 37°C for 24 hours, as described by Plates 2a, 2b, and 2c.

The control strains used were sourced from previously cultured stocks identified as Candida tropicalis (dark blue colonies), C. krusei (brown or pink irregular colonies), and C. albicans (green colonies), all obtained from stock cultured isolated using BCA from Jos University Teaching Hospital, Nigeria.

1.4 Subculturing on Oxoid Chromagar Candida Agar and Oxoid Chromagar Candida Plus Medium

A sterile wire loop was used to pick a discrete colony of isolates on an SDA culture plate, which was then sub-cultured onto prepared Oxoid CHROMagar candida agar and CHROMagar candida PLUS media (bioMerieux, France, Odds and Davidson, 2002). The cultures were incubated aerobically for 48 hours at 37 °C and 42 °C. Two laboratory scientists evaluated plates 3, 4a, and 4b. Control strains for Oxoid CHROMagar candida agar and CHROMagar candida PLUS media were based on the manufacturer's description.

2. THERMOTOLERANT TEST

Thermotolerant testing for non-albicans Candida isolates was conducted as described by (17), using a modified 10-fold serial dilution method outlined by (18). One microliter (1µl) was drawn from the stock solution using a microtiter pipette, transferred into a microtiter plate containing 9µl of dilution liquid, and mixed thoroughly. The aliquots were then diluted exponentially from 10-fold to 1,000-fold, as per (17), and 1µl of each dilution, transferred into a microtiter plate containing 9µl of dilution liquid, and cell suspension from the different dilution factors was spotted on SDA and incubated at 42°C for 48 hours. The isolates that showed growth after 24 hours of incubation were marked as thermotolerant. Candida dubliniensis served as the negative control.

3. HALOTOLERANT TEST AT 42°C

Identified thermotolerant non-albicans candida isolates were inoculated onto freshly prepared SDA media with 18% $Nacl_2$, and incubated at 42°C for 24 hours as described by (11). The isolates that showed growth after incubation were marked as salt-tolerant and thermotolerant.

STATISTIC ANALYSIS

Data was collected and analyzed using Excel and IBM SPSS Statistics 24. Statistical analysis included frequency and percentage as descriptive, while chi-square tests were analytical.

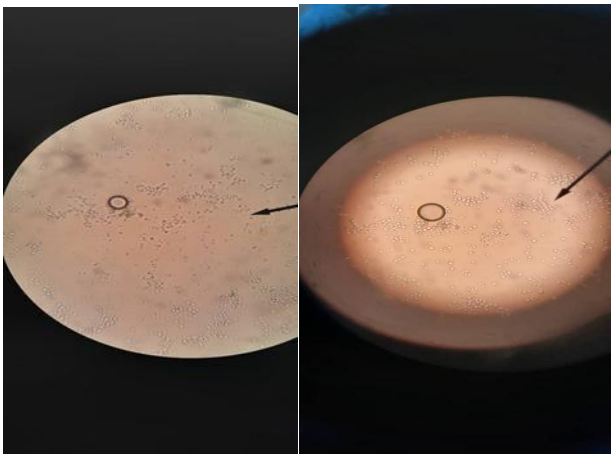

Plate 1: Microscopic appearance of non-albicans candida isolates showing Blastoconidia and pseudo-hyphae

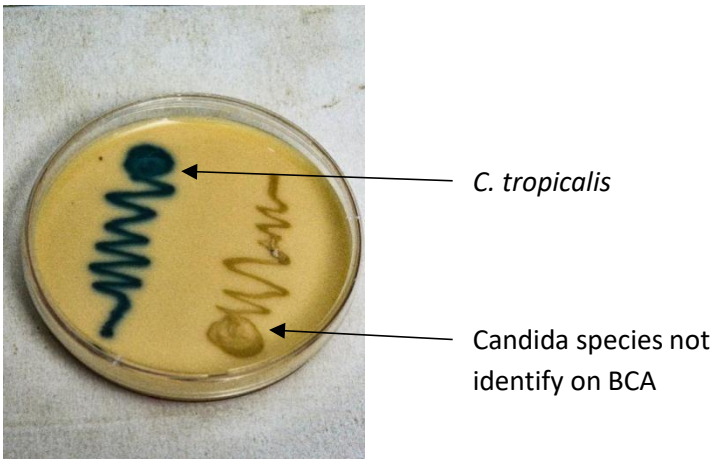

Plate. 2a. The Metallic dark blue color appearance of *C. tropicalis* on BCA

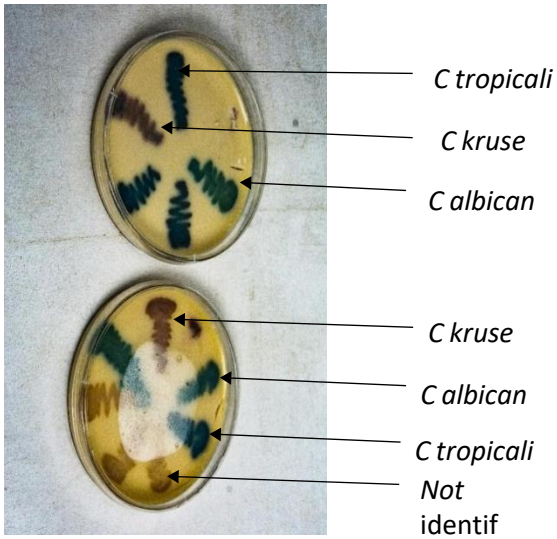

Plate 2b. *Candida krusei* appeared brown or pink*; C. tropicalis* metallic dark blue*; C. albicans* green-blue, while *C. glabrata, C. parapsilopsis, and C. auris* appeared beige to creamy colonies on BCA.

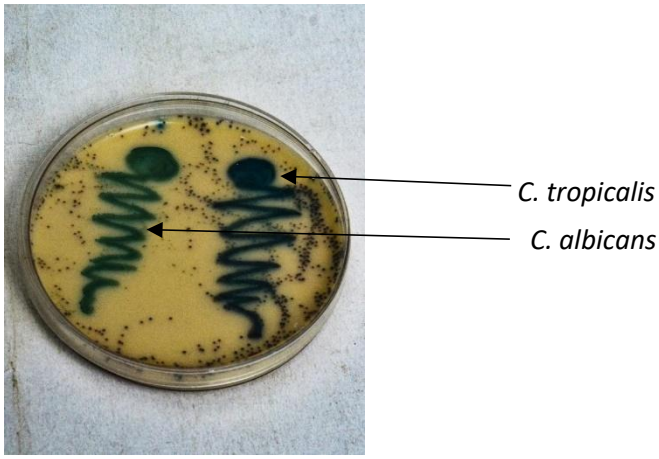

Plate 2c. The colour appearance of *C. tropicalis and C. albicans* colonies on BCA.

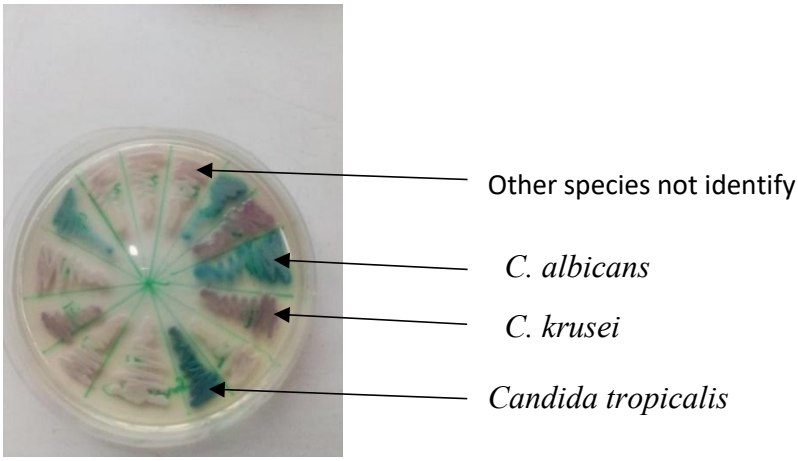

Plate 3. *Candida albicans* (green colonies), *Candida tropicalis* (metallic blue colonies), *C. krusei* (dry, irregular brown or purple colonies) on Oxiod CHROMagar Candida media

.

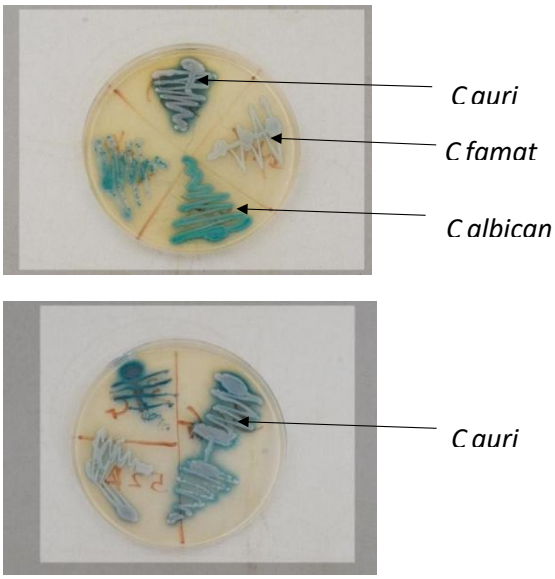

Plate 4. *Candida. auris* appeared on Oxoid CHROMagar Candida **PLUS** media as light blue or white, with a blue halo that diffuses into the medium

Plate 5. Creamy, smooth, pasty, and convex colonies of *Candida species on Sabouraud dextrose agar.*

RESULTS

The study revealed that out of 351 patients, 84 (23.9%) had thermotolerant non-albicans *Candida species* while 267 (76.1%) had no fungal growth seen at 42°C (Fig. 1). Overall mean age was 54.7± (12.4) years in which 122(34.8%) patients were 61 years and above (Table 1).

Candida glabrata 44(12.5%) was the predominant species isolated from patients' samples, followed by *C. tropicalis 18* (5.1%), *C. auris* 8 (2.3%), *C. krusei* 5 (1.4%), and *C. parapsilopsis* 5 (1.4%), respectively. Some of the study populations had double infection rates, like *C. tropicalis/C. Krusei*, 2(0.6%); *C. glabrata/C. parapsilopsis*, 1(0.3%); and *C. glabrata/C. tropicalis*, 1(0.3%), which happened to have the fewest occurrences, respectively (Table 2).

However, Patients with Diabetes mellitus had a prevalence rate of 48 (57.1%) (PV 0.86; P>0.05) compared with malignant patients, who had a prevalence rate of 36 (42.9%) (p = 0.81; P> 0.05). The result is, therefore, statistically insignificant (Table 3).

Table 4 shows the association between demographic variables and thermotolerant non-albicans *Candida species*. Statistically, age has a significant influence (PV= 0.001) on thermotolerant non-albicans *Candida species,* in which immunocompromised patients in the age range 51≥ years had a high risk of developing Candidiasis compared to other age groups. Sex, marital status, religion, occupation, and level of education of patients with diabetes mellitus and malignancy are not statistically significant.

Table 5 shows the association between risk factors and candidiasis among the study population.

Table 6, shows an

association between thermotolerant species and environmental precautional control, which were statistically insignificant (P≥0.05), however, 334 (95.5%) of healthcare givers observed hand hygiene, 348 (99.1%) wore protective clothing when attending to patients and the patient's bed space area was 343 (97.7%) cleaned.

Table 1: Demographic characteristics of patients

Variables	Frequency	%
Age group (years)		
≤ 20	2	0.6
21-30	13	3.7
31-40	36	10.3
41-50	59	16.8
51-60	119	33.9
61+	122	34.8
Mean±(SD)	54.7± (12.4)	
Total	351	100.0
Gender		
Female	220	62.7
Male	131	37.3
Total	351	100.0
Marital status		
Divorced	2	0.6
Married	330	94.0
Single	19	5.4
Total	351	100.0
Religion		
Christianity	259	73.8
Islam	92	26.2
Total	351	100.0
Level of Education		
None	22	6.3
Primary	37	10.5
Secondary	73	20.8
Tertiary	219	62.4
Total	351	100.0
Occupation	92	26.2

Business		
Civil servant	93	26.5
Clergy	11	3.1
Farmer	26	7.4
Full Housewife	51	14.5
Retired C/S	61	17.4
Students	17	4.8
Total	351	100.0

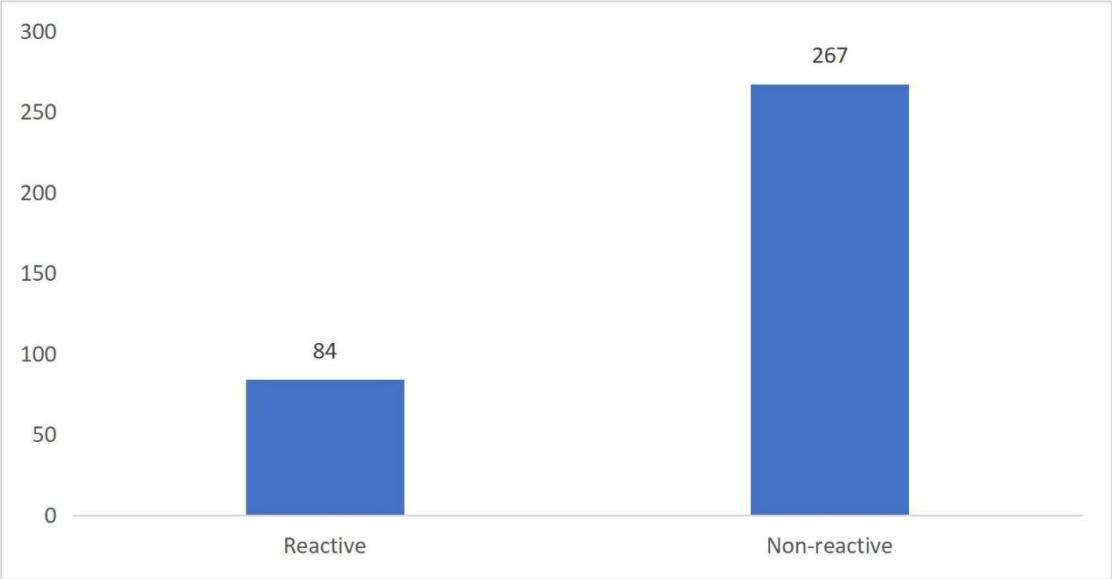

Fig. 1: Overall Prevalence of thermotolerant non-albicans *candida specie.*

Table 2: Distribution of thermotolerant non-albicans *candida (NAC) species* among the study population

Thermotolerant NACs	Frequency (f)	Percentage (%)
C. tropicalis	18	5.1
C. glabrata	44	12.5
C. krusei	5	1.4
C. tropicalis, C. krusei	2	0.6
C. glabrata, C. parapsilopsis	1	0.3
C. auris	8	2.3
C. parapsilopsis	5	1.4

C. glabrata, C. tropicalis	1	0.3
No fungal growth	267	76.1
Total	351	100.0

Table 3: Distribution of thermotolerant NAC species among diabetes mellitus and malignant patients

NAC species	No. Examine	Malignancy (%)	Diabetes mellitus (%)
C. tropicalis	**18**	**8(44.4)**	**10(55.6)**
C. glabrata	**44**	**20(45.5)**	**24(54.5)**
C. krusei	**5**	**2(40.0)**	**3(60.0)**
C. tropicalis/C. krusei	**2**	**1(50.0)**	**1(50.0)**
C. glabrata/C. parapsilopsis	**1**	**0(0.0)**	**1(100.0)**
C. auris	**8**	**3(37.5)**	**5(62.5)**
C. parapsilopsis	**5**	**2(40.0)**	**3(60.0)**
C. glabrata/C. tropicalis	**1**	**0(0.0)**	**1(100.0)**
Total	**84**	**36(42.9)**	**48(57.1)**
Statistical results		**X^2 = 4.519; df = 8; p-v = 0.81; P > 0.05**	**X^2 = 4.981; df = 8; p-v = 0.86 P > 0.05**

Table 4: Association between demographic variables and Thermotolerant Non-albicans *Candida Species* among Diabetes mellitus and Malignant Patients.

Variables	Thermotolerant non-albicans candida species		**Chi-square** ($\chi 2$)	p-value
	Positive (%)	Negative (%)		
Age group				
≤ 20	0(00.0)	1(100.0)	884.428	0.001*
21-30	5(38.5)	8(61.5)		
31-40	9(25.0)	27(75.0)		
41-50	9(15.3)	50(84.7)		

51-60	35(28.9)	86(71.1)		
61≥+	26(21.5)	95(78.5)		
Total	84(23.9)	267(76.1)		
Gender	35(26.9)	95(73.1)	9.067	0.697
Male	49(22.2)	172(77.8)		
Female	84(23.9)	267(76.1)		
Total				
Marital status				
Divorced	0(0.0)	2(100.0)	37.246	0.412
Single	7(36.8)	12(63.2)		
Married	77(23.3)	253(76.7)		
Total	84(23.9)	267(76.1)		
Religion				
Christianity	60(23.2)	199(76.8)	8.971	0.705
Islam	24(26.1)	68(73.9)		
Total	84(23.9)	267(76.1)		
Level of Education				
None	8(36.4)	14(63.6)		
Primary	4(17.1)	33(82.9)	31.901	0.664
Secondary	16(8.0)	23(92.0)		
Tertiary	56(16.0)	163(84.0)		
Total	84(23.9)	267(76.1)		
Occupation	17(19.1)	72(80.9)	175.587	0.796
Business	24(21.8)	86(78.2)		
Civil servant	0(0.0)	5(100.0)		
Clergy	7(36.9)	12(63.2)		
Farmer	9(17.6)	42(82,4)		
Full house wive	20(33.3)	40(66.7)		
Retired C/S	7(41.2)	10(58.8)		
Students	84(23.9)	267(76.1)		
Total				

Mean Age: 54.7±12.4

Association between thermotolerant isolates and Age $p < 0.05$ - *Statistically significant

Table 5: Risk factors associated with the Prevalence of candidiasis in hospital wards

	Prevalence			Chi-square	p-value
Risk factors	**Positive**	**Non-Positive**	**Total**		
Diabetes mellitus with cardiovascular complications				0.664	1.000
No	39(46.4)	124(42.7)	163(16.8)		
Yes	45(53.6)	143(57.3)	188(83.2)		
Total	84(100.0)	267(100.0)	351(100.0)		
Immuno-suppressive therapy				14.412	0.275
No	27(32.1)	68(25.5)	95(27.1)		
Yes	57(67.9)	199(74.5)	256(72.9)		
Total	84(100.0)	267(100.0)	351(100.0)		
Prolonged use of antibiotics				14.412	0.275
No	22(26.2)	70(26.2)	92(26.2)		
Yes	62(73.8)	197(73.8)	259(73.8)		
Total	84(100.0)	267(100.0)	351(100.0)		
Catheterization				123.203	0.001*
No	58(69.0)	182(68.2)	240(68.4)		
Yes	26(31.0)	85(31.8)	111(31.6)		
Total	84(100.0)	267(100.0)	351(100.0)		
Invasive med. Devices.				2.379	0.123
No	65(77.4)	226(84.6)	291(82.9)		
Yes	19(22.6)	41(15.4)	60(17.1)		

Total	84(100.0)	267(100.0)	351(100.0)		
Candidiasis in past				0.605	0.437
No	63(75.0)	211(79.0)	274(78.1)		
Yes	21(25.0)	56(21.0)	77(21.9)		
Total	84(100.0)	267(100.0)	351(100.0)		
Diabetics				1.139	0.286
No	34(40.5)	91(34.1)	125(35.6)		
Yes	50(59.5)	176(65.9)	226(64.4)		
Total	84(100.0)	267(100.0)	351(100.0)		
Malignancy				1.157	0.282
No	48(57.1)	170(63.7)	218(62.1)		
Yes	36(42.9)	97(36.3)	133(37.9)		
Total	84(100.0)	267(100.0)	351(100.0)		

The association between thermotolerant isolates and catheterization is P<0.05*, which is statistically significant.

Table 6: Association between Thermotolerant non-albicans *Candida species* and Environmental Precautional Control

Variables	**Frequency(F) (%)**	**Positive (%)**	**Negative**	**Chi-square**	**P-value**
Hand hygiene by healthcare givers					
No	17 (4.8)	3 (3.6)	14 (5.2)	20.346	0.677
Yes	334 (95.2)	81 (96.4) (94.8)	253		
Total	351 (100.0)	84 (100.0) (100.0)	267		

Use of hand sanitizers by patients					
No	223 (63.5)	50 (59.5)	173 (64.8)	40.263	0.287
Yes	128 (36.5)	34 (40.5)	94 (35.2)		
Total	351 (100.0)	84 (100.0) 9100.0)	267		
Wearing protective clothes.					
No	3 (0.9)	1 (1.2)	2 (0.7)	1.493	1.000
Yes	348 (99.1)	83 (98.8) (99.3)	265		
Total	351 (100.0)	84 (100.0) (100.0)	267		
Sterilization of medical equipment.					
No	163 (46.4)	40 (47.6) (46.1)	123	16.086	1.000
Yes	188 (53.6)	44 (52.4) (53.9)	144		
Total	351 (100.0)	84 (100.0) (100.0)	267		
Environmental hygiene					
No	8 (2.3)	2 (2.4)	6 (2.2)	2.017	1.000
Yes	343 (97.7)	82 (97.6) (97.8)	261		

Total	351 (100.0)	84 (100.0) (100.0)	267

P≥0.05 is statistically insignificant.

DISCUSSION

The increasing prevalence of non-albicans Candida (NAC) species among immunocompromised patients poses a significant threat to public health (11–14). This study identified *Candida glabrata* 44 (12.5%), *Candida tropicalis* 18(5.1%), suspected *C. auris* 8(2.3%), *C. krusei* 5 (1.4%), *and C. parapsilosis* 5 (1.4%) as predominant thermotolerant NAC species in patients with diabetes mellitus and malignancy (Table 2). The isolation of these species, particularly the multidrug-resistant *C. auris*, highlights the need for enhanced infection control measures and antifungal stewardship in Nigerian healthcare facilities. This study observed that thermotolerant non-albicans *Candida species* can thrive at high temperatures (up to 42°C), survive 18% $NaCl_2$ concentration, and form biofilms on medical devices, allowing them to colonize and infect humans. They can adhere to the skin and mucous membranes of patients with compromised immune systems due to their physiological adaptations, such as effective osmoregulation mechanisms that allow them to maintain cellular homeostasis in changing environmental salt concentration and temperature. The presence of the organisms on the skin increases their chances of transmission. *Candida auris*, in particular, has emerged as a global health threat due to its rapid spread across continents, facilitated by human migration and health. These findings are consistent with a previous study that suggested that the adaptive features of *C. auris* are the ability to adhere to surfaces and persist in hospital environments and medical devices, thus leading to the spread of this fungal pathogen from patient to patient (11). This study indicates that thermotolerant non-albicans *Candida species* can survive and spread to other body sites of immunocompromised patients, such as those with diabetes mellitus and cancer, due to occluded skin regions where humidity and body sweat accumulate, and the skin is constantly experiencing friction, causing co-infection with different species of Candida. This justifies why two distinct Candida species are isolated on a patient's skin. However, more research is needed to unravel the complex interactions between thermotolerant non-albicans Candida species and the host immune response to provide insights into their invasive mechanisms and disease-causing potential.

A high prevalence rate was observed among diabetes mellitus 48(57.1%) compared to malignancy 36(42.9%). However, the relationship between diabetes mellitus and malignancy is statistically insignificant (PV=0.86; P>0.005). Such results are consistent with the findings of the study (15) which report that patients with diabetes mellitus made up the most significant percentage (49.4%) of superficial fungal infection, followed by cancer (23.8%), while those with renal failure made up the lowest percentage (4.4%). This could be due to the type and extent of immune suppression and hormonal changes in diabetes mellitus patients. However, malignancy can also be a risk factor for acquiring candidiasis caused by thermotolerant NACs. These findings suggest that elevated blood glucose levels in diabetic patients create an ideal environment for candida growth and proliferation. Vijayalakshmi (16) showed that diabetes mellitus individuals are prone to a hyperglycemic state, favoring the growth and establishment of Candida

species.

The results of the suspected finding corroborate the findings from other parts of the country. However, to the researchers' knowledge, this is the first case of suspected *C. auris* isolated in a hospital setting in Nigeria. This is inconsistent with the previous study (17)' which reported that 600 Candida isolates from different sites in Nigeria were sent for sequencing in search of possible *C. auris*, 210 were successfully sequenced, and none were *C. auris'*. This contradicts their report of the first evidence of *C. auris* infections in Nigeria and West Africa.

The findings found a high-risk factor with a prevalence rate of 45 (53.6%) among diabetic mellitus patients with cardiovascular complications. This suggests cardiovascular complications, such as atherosclerosis and peripheral artery disease, can reduce or impair blood flow to tissues and decrease oxygenation. This weakens the immune system and makes it harder for the body to fight fungal infections. This can impair wound healing and increase the risk of candida infection caused by thermotolerant NACs. *Candida species* are more widespread in the feces of patients with type 1 and type 2 DM with poor glycemic control than in healthy subjects (18). In this study, some of the subjects had uncontrolled diabetes mellitus, which led to hyperglycemia. This can damage tissues and create oxidative stress, making it easier for fungi to colonize and infect. High blood sugar levels lead to a decrease in the ability of phagocytosis and polymorphonuclear cells to kill Candida in diabetes, resulting in oral candidiasis (19). Also, Rodrigues, Rodrigues, and Henriques (20) suggested that uncontrolled hyperglycemia in diabetes mellitus can lead to an increased susceptibility to Candida species infections.

A high prevalence rate was found among patients on immunosuppressive therapy, 57(67.9%), which can impair macrophage function and reduce the number and function of neutrophils, essential for fighting and killing fungal pathogens, making patients more susceptible to candidiasis. This study also suggests that immunosuppressive therapy increases the risk of candidiasis by impairing immune function, disrupting mucosal barriers, and creating an environment that fosters fungal growth. 'Immunosuppressive agents such as steroids that are administered during some medical procedures, including organ transplants and treatments for conditions such as cancer, place patients at risk for *C. auris* invasive infection and mortality due to their inability to fight disease and prevent its spread within the body. (21).

A high prevalence rate was observed among patients with prolonged antibiotics, 62(73.8%). This study agreed that prolonged antibiotics can disrupt the skin's natural barrier, causing co-infection with multiple *Candida species,* such as *C. tropicalis* and *C. Krusei,* or *C. glabrata and C. tropicalis*. This is consistent with a recent study (14) that found *Candida tropicalis* from a liver biopsy and *C. glabrata* from an abdominal fluid culture of a patient on prolonged antibiotic use. Other studies also observed the use of broad-spectrum antibiotics as a predisposing factor to candidiasis (22,23).

This study suggested that catheterization (PV=0.001) increases the risks of candidiasis caused by non-albicans *Candida species* in immunocompromised patients, disrupting normal flora, facilitating biofilm

formation, and increasing susceptibility. Blood culture obtained from the tunneled catheter that was inserted under the skin grew Candida auris in a 60-year-old male known to have type 2 diabetes who had defaulted on clinic attendance for 15 years(17). This study found that the use of invasive medical devices and a history of candidiasis were statistically insignificant.

Major infection control practices and standard precautionary measures observed in this study were: hand hygiene by healthcare givers (95.2 %), wearing of protective clothing by healthcare givers (99.1 %), sterilization of medical equipment (53.6%), and cleaning of patients' immediate environment (97.7%). These variables are statistically insignificant with P≥ 0.05. The low prevalence rate of 23.9% of candidiasis caused by thermotolerant non-albicans *Candida species* is due to standard precautions observed in the hospitals.

In conclusion, thermotolerant non-albicans Candida (NAC) species, which may constitute an important cause of nosocomial candidiasis, were found colonizing superficial sites on immunocompromised patients in the study population. Diabetes mellitus, malignancy, prolonged antibiotic use, catheterization, and immunosuppressive therapy were identified as significant risk factors for candidiasis caused by thermotolerant NACs. Evidence-based infection prevention strategies, including hand hygiene, sterilization of medical equipment, and proper cleaning of patients' environments, can help mitigate the spread of thermotolerant NAC species and reduce the risk of healthcare-associated infections in hospitals.

Transparency declaration

All authors declare no conflicts of interest in this article.

Authorship contributions

Martha Kangyang Gyang and Grace Mebi Ayanbimpe conceptualized and designed the study. Martha K. Gyang carried out the survey with the help of a research assistant, was involved in data analysis with the statistician, wrote the manuscript, performed Laboratory practical parts of the study with Emmanuel Nnadi, and acquired data. John Danjuma Mawak and Grace Mebi Ayanbimpe reviewed the draft of the manuscript, providing comments and making necessary corrections.

Acknowledgments

This work was partially supported by a grant from the Tertiary Education Trust Fund (TETFUND) Research grant from the Office of Research and Development (ORD), University of Jos, Nigeria.

REFERENCES

1. Akinbobolaid AB, Kean R, Manzoor S, Hanifi A, Quilliam RS. Environmental reservoirs of the drug-resistant pathogenic yeast Candida auris. 2023; Available from: https://doi.org/10.1371/journal.ppat.1011268.g001

2. Abdel-Hamid RM, El-Mahallawy HA, Abdelfattah NE, Wassef MA. The impact of increasing non-albicans Candida trends on diagnostics in immunocompromised patients. Brazilian J Microbiol. 2023 Dec 1;54(4):2879–92.

3. Heaney H, Laing J, Paterson L, Walker AW, Gow NAR, Johnson EM, et al. The environmental stress sensitivities of pathogenic candida species, including candida auris, and implications for their spread in the hospital setting. Med Mycol. 2020;58(6):744–55.

4. Bhandari S, Agarwal S, Bhargava S, Samdhani S, Singh SN, Sharma BB, et al. Post Covid-19 Sinonasal Candidiasis: A Crisis Within the Pandemic. Indian J Otolaryngol Head Neck Surg. 2023 Jun 1;75(2):523–8.

5. Elkholy RM, El-Hendy AA, Nassar HSM, Zaher EM. Study of Virulence Genes, Biofilm Formation and Antifungal Susceptibility of Medical Device Associated Candida Infection in ICU Hospitalized Patients. Egypt J Med Microbiol. 2025;34(2):121–32.

6. Kühbacher A, Burger-Kentischer A, Rupp S. Interaction of candida species with the skin. Microorganisms. 2017;5(2):1–12.

7. Sansom SE, Gussin GM, Schoeny M, Singh RD, Adil H, Bell P, et al. Rapid Environmental Contamination with Candida auris and Multidrug-Resistant Bacterial Pathogens Near Colonized Patients. Clin Infect Dis [Internet]. 2024;78(5):1276–84. Available from: https://doi.org/10.1093/cid/ciad752

8. Jones CR, Neill C, Borman AM, Budd EL, Cummins M, Fry C, et al. The laboratory investigation, management, and infection prevention and control of Candida auris: a narrative review to inform the 2024 national guidance update in England. J Med Microbiol. 2024;73(5):1–19.

9. Systemic candidiasis by Candida kefyr: Case series from Pakistan. J Med Case Reports Case Ser [Internet]. 2023 May 4; Available from: https://www.acquaintpublications.com/article/systemic_candidiasis_by_candida_kefyr_case_series_from_pakistan

10. Amini N, Mohammadi R. Phospholipase Activity of Candida Species Isolated from Diabetic Patients. 2023;1–3.

11. Semenya MD, Aladejana AE, Ndlovu SI. Characterization of susceptibility patterns and adaptability of the newly emerged Candida auris. Int Microbiol [Internet]. 2024;(0123456789). Available from: https://doi.org/10.1007/s10123-024-00563-1

12. Chowdhary A, Sharma C, Meis JF. Candida auris: A rapidly emerging cause of hospital-acquired multidrug-resistant fungal infections globally. PLoS Pathog. 2017 May 1;13(5).

13. Yadav A, Singh A, Wang Y, Haren MHI Van, Singh A, Groot T De, et al. Colonization and Transmission Dynamics of Candida auris among Chronic Respiratory Diseases Patients Hospitalised in a Chest Hospital, Delhi, India : A Comparative Analysis of Whole Genome Sequencing and Microsatellite Typing. 2021;

14. Said AM, Afridi F, Redell MS, Vrana C, O'Farrell C, Scheurer ME, et al. Invasive Candidiasis in Pediatric Hematologic Malignancy: Increased Risk of Dissemination With Candida tropicalis. Pediatr Infect Dis J. 2024;44(1):58–63.

15. Wajid M. Risk Factors of Superficial Fungal Infections among Immunocompromised Patients in Thi-Qar Governorate during 2021-2022. 2023;1(1).

16. Vijayalakshmi, et al. 2020. A Case-Control Study to Evaluate Candidal Parameters in the Oral Cavity of Patients with Type 2 Diabetes Mellitus. 2020;389–93.

17. Oladele R, Uwanibe JN, Olawoye IB, Ettu AWO, Meis JF, Happi CT. Emergence and Genomic Characterization of Multidrug-Resistant Candida auris in Nigeria, West Africa. J Fungi. 2022 Aug 1;8(8).

18. Gosiewski T, Salamon D, Szopa M, Sroka A, Malecki MT. Quantitative evaluation of fungi of the genus Candida in the feces of adult patients with type 1 and 2 diabetes - a pilot study. 2014;1–5.

19. Parisihni K, Mulawarmanti D, Widowati K. Potency of Hyperbaric Oxygen Therapy on Oral Candidiasis Diabetes Mellitus. Eur J Dent. 2024;

20. R CF, Rodrigues ME, Henriques M. Candida sp . Infections in Patients with Diabetes Mellitus Candida sp. Infections in Patients with Diabetes Mellitus. 2019;(January).

21. Azar MM, Turbett SE, Fishman JA, Pierce VM. Donor-derived transmission of candida auris during lung transplantation. Clin Infect Dis. 2017;65(6):1040–2.

22. Spiliopoulou A, Kolonitsiou F, Vrioni G, Tsoupra S, Lekkou A, Paliogianni F. Invasive Candida kefyr infection presenting as pyelonephritis in an ICU hospitalized COVID-19 patient: Case report and review of the literature. J Med Mycol [Internet]. 2022;32(2):101236. Available from: https://doi.org/10.1016/j.mycmed.2021.101236

23. Soriano A, Honore PM, Puerta-alcalde P, Garcia-vidal C, Gonçalves-bradley DC, Verweij PE, et al. Invasive candidiasis : current clinical challenges and unmet. J Antimicrob Chemother [Internet]. 2023;78(7):1569–85. Available from: https://doi.org/10.1093/jac/dkad139