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Research Article

Fungal Pathogens Associated with Hair Combs Used by Undergraduate Female Students of a Private University in South West Nigeria: Prevalence, Risk Factors and Anti-Fungal Susceptibility Study

Seyi Samson Enitan[1]*, John Okeleke Ochei[1], Esther Ngozi Adejumo[1], Ileoma Emmanuel[1], Stanley Osahon Usiobeigbe[1], Comfort Bosede Enitan[2], Mary Oluwatosin Ogunmuyiwa[1]

[1]*Department of Medical Laboratory Science, Babcock University, Ilishan-Remo, Nigeria*

[2]*Department of Pathology, Igbinedion University Teaching Hospital, Okada, Nigeria*

***Corresponding Author:** Seyi Samson Enitan, *Department of Medical Laboratory Science, Babcock University, Ilishan-Remo, Nigeria, +2348065483761, +2348152356453*

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ABSTRACT:

Hair combs may serve as potential vehicles for fungi capable of causing infections of the hair and other parts of the human body. This study was designed to assess fungal contaminants associated with hair combs used by undergraduate female students of Babcock University, Ilishan-Remo, Ogun state, identify associated risk factors and determine the anti-fungal susceptibility pattern of the fungal isolates. A total number of one hundred and twenty (120) female students were recruited for the study, swabs of their hair combs were obtained, and the samples were inoculated onto Sabouraud Dextrose Agar (SDA). The plates were incubated at 25^0C for 7 days and fungal isolates were identified both macroscopically and microscopically. Antifungal susceptibility pattern of the isolates was determined by the disc diffusion method. The outcome of this study show that 111 (92.5%) out of the 120 hair combs examined had fungi contaminants, while the remaining 9 (7.5%) were fungi-free. 29 (24.2%) had one fungi isolate (mono-fungi contamination), 60 (50.0%) had two fungi isolates (dual-fungi contamination), while 22 (18.3%) had more than two fungi isolates (poly-fungi contamination). The percentage occurrences of dermatophytes (Microsporum sp. and Trichophyton sp.) and Non-dermatophytes (Aspergillus sp. and Candida sp.) were 52.8% and 39.7%, respectively. The organism with the highest percentage occurrence was Microsporum sp. (30.4%), followed by Trichophyton sp. (26.7%), Aspergillus sp. (26.3%), and Candida sp. (16.6%). 78% of the hair combs examined had acceptable level of fungal load (Below 20 CFU/25cm^2), while 14% had unacceptable level of fungal load (Above 50 CFU/25cm^2). The fungal isolates were sensitive to the antifungal agents tested with different levels of sensitivity. This current study further strengthens the earlier claim that hair combs may serve as potential vehicles for fungal pathogens capable of causing hair infections. It is therefore important for female folks to be acquainted with factors that promote fungal contamination and colonization of their hair combs and discourage the same in other to forestall the occurrence of fungal infection of their hair and scalp in the future.

Key words: Hair combs, Fungal Pathogens, Contamination, Risk factors, Anti-fungal Susceptibility

1.0 INTRODUCTION

The hair has been described as the crowning glory of a person. It is one of the greatest assets of the female folks. It is deeply symbolic, and its meaning extends into multiple dimensions of culture and life. It is viewed as a marvelous tool to which the female folks can express their beauty and sexuality [1, 2].

Beauty tools such as hair combs are used in everyday life for the purpose of hair care. However, they are rarely kept clean and thus give rise to likely contamination and colonization of these items by microorganisms. Daily care and maintenance of hair combs is very important in order to prevent or minimize fungal infection of the hair [3-5].

Every female knows she has to take care of her beauty tools, but for some reason, hair combs are often forgotten. “Like all beauty tools, hair combs get dirty with repeated use, especially if one is using styling products on one’s hair," says a dermatologic surgeon. Along with hair clumps and product residue, dust mites, dead skin cells, and oils can accumulate. The buildup of such on one’s hair combs can serve as media for bacteria and fungi overgrowth, resulting in an infection risk [6-8].

Hair infection is common in Nigeria among both old and young and has been associated with fungal contamination of beauty tools such as hair combs. The handle and row of teeth have been reported as potential vehicles for microbes, particularly fungal pathogens capable of causing hair infections [9-11].

Furthermore, the practice of sharing hair combs among female folks has also contributed to the spread of fungal pathogens. There are reports of people who have been infected with head lice from direct hair-to hair contact with someone who has head lice [12]. Unfortunately, many females are not aware of established regulations, guidelines and best practices for hair care and risk factors associated with hair infection.

To the best of our knowledge, no data exist on the load, frequency and distribution of fungi contaminants present on the hair combs of undergraduate female students of Babcock University, Ilishan-Remo, Ogun State. Besides the need to isolate and characterize fungal pathogens present on hair combs, it is also very important to determine the antifungal susceptibility pattern of these fungal isolates in order to guide empirical therapy for hair infection resulting from contaminated combs. This will reduce number of hospital visits, cost of treatment and the risk of treatment failure associated with emerging antifungal resistant strains. Identification of risk factors associated with fungal contamination of hair combs will be found very helpful in developing control and prevention programs aimed at reducing hair infections associated with fungal contamination of hair combs. Scarcity of data in this regard, therefore, necessitates this research.

2.0 MATERIALS AND METHODS:

Study Design

This is a cross-sectional descriptive study.

Study Area

This cross-sectional institutional based study was carried out at Babcock University, Ilishan-Remo, Ikenne Local Government Area, Ogun State, a first class Seventh-day Adventist Institution of higher learning located in the South-Western region of Nigeria, coordinates: 6.8862^{o} N, 3.7055^{o} E. The University has nine (9) schools with a total Student population of about ten thousand (10, 000) offering different academic and professional courses; both at the undergraduate and post-graduate levels. The University has a staff strength of more than 500 Teaching and Non-Teaching Staff combined.

Duration of Study

The study was carried out between the months of April and June 2019.

Study Population

Undergraduate female students of Babcock University are the target population. They consist of young female adults within the age range of 16 and above years from different ethnic, religious and cultural background.

Sample Size Calculation

The sample size (n) was estimated using the population proportion formula described by Charan and Biswas [13]:

$$N = Z^2PQ/d^2$$

Where.

N = required sample size,

Z = Standard normal variate at 5% ($p<0.05$) error or 95% confidence interval is 1.96

P = Proportion of hairbrushes with fungal contaminants from previous study,

Q = Proportion of hairbrushes without fungal contaminants (1 – P) and

d = Absolute error margin is 0.05

For the calculation, a 95% confidence interval, a P value of 0.930, i.e, a prevalence rate of 93.0% (0.930) from previous study by Edward et al. [11] and margin of error (d) set at 0.05 was used to determine the minimum sample size required. To minimize errors arising from the likelihood of non-compliance, 10% of the sample size was added to obtain a final sample size of 110. In order to make our work robust, a total of 120 participants were recruited for this study.

Sample Size

A total of 120 hair combs were collected randomly from consenting 120 undergraduate female Students in 8 different schools in Babcock University, Ilishan-Remo, Ogun State and were examined using standard mycological methods.

Eligibility of subjects

Inclusion Criteria

Undergraduate female Students of Babcock University who use combs for their hair care were recruited randomly from the various schools for the study.

Exclusion Criteria

Undergraduate female Students of Babcock University who don't use combs for their hair care, as well Post-graduate female Students of Babcock University were excluded from the study.

Data collection

Prior to specimen collection, demographic and clinical information of the participants were obtained using structured questionnaires which were administered to the participants. Each questionnaire had a unique participant identification number (PIDN). The first part of the questionnaires contained the biodata of the participants such as occupation, gender, marital status, age, tribe and name of School. The second part included data relating to comb care and maintenance, history of hair infection, risk factors, personal hygiene and health care-seeking behaviour.

Specimen Collection and Transportation

Using appropriate aseptic techniques (including wearing of sterile hand gloves), the handles and the teeth of each participant's combs was swabbed using two separate sterile cotton tipped applicators (swab sticks). Each of the swab stick was corked properly immediately. Afterwards, the specimens were transported in a tight sealed case to the laboratory for mycological examination. Analysis was performed immediately upon arrival to the laboratory.

Laboratory analysis

Sample Culture

The comb swabs were streaked on Sabouraud Dextrose Agar (SDA) plates containing 0.5mg chloramphenicol in duplicates. One of the plates was incubated at a temperature of 25^0C and the other at 37^0C for 7 days. The agar plates were examined every other day for fungal growth.

Identification of Fungal Isolates

Fungal isolates were identified on the basis of macroscopic and microscopic characteristics as described by Rajesh and Rattan [14].

Macroscopic examination

The colonial morphology (growth form, color, periphery and size), rate of growth and presence of pigmentation in the medium was noted and features compared to those contained in the Atlas of Mycology.

Microscopic examination

A drop of lactose phenol cotton blue reagent was placed on a clean free slide. Using a straight needle and forcep, a small portion of the fungal culture (the sporing surface growth from midway between the centre and the periphery of the colony), was transferred to the drop of lactophenol cotton blue reagent. This portion was gently and properly teased apart in the drop of lactophenol cotton blue reagent using a sterile scapel blade. The preparation was covered with a cover glass and placed in a petri dish with a damp piece of filter paper to prevent the preparation from dying out. The preparation was examined microscopically under low (×10) and high (×40) power objectives for the presence of fungal elements including hyphae, arthrospores, microconidia and macroconidia.

Storage of fungal Isolates

Pure cultures of the identified fungal isolates were stored on Sabouraud Dextrose agar slant plate at 4^oC in a refrigerator for subsequent determination antifungal susceptibility test.

Anti-fungal susceptibility test

The antifungal susceptibility pattern of the fungal isolates was determined using commercially prepared antifungal disc of known concentration according to the modified Kirby-Bauer disc diffusion technique described by Bauer et al. [15] and Cheesbrough [16]. Using the Interpretative Chart, the zones sizes of each antifungal disc were interpreted, and the isolate reported as 'Resistant', 'Intermediate/Moderately susceptible', or 'Susceptible'.

Data analyses

Raw data were entered into Microsoft Excel. Statistical analysis was carried out using SPSS Statistics software package (version 18.0). One-way analysis of variance (ANOVA) and Tukey-Kramer Multiple Comparisons Test was used to test for significant differences (if any) in the load, frequency and distribution of fungal contaminants associated with the hair combs of female undergraduate Students of Babcock University, Ilishan-Remo, Ogun State according to their demographic characteristics. P value <0.05 was considered significant. Comparisons of categorical data was made using the Chi square test, while Fisher's exact test was used for small values that are less than five. Statistical analysis outputs were presented using tables and charts.

3.0 RESULTS AND DISCUSSION

The present study assessed the mycological quality of hair combs of Undergraduate female students of Babcock University, Ilishan Remo, Ogun State using standard methods. The demographic characteristics of the participants are presented in Table 1. A total of 120 participants were recruited for the study. Majority of the participants belong to the age group 21-25 years (56%), Based on their marital status, 96% were single, while 3% were married. 1% was divorced. On the account of religion, majority of the participants were Christians (86%), while the least were Muslims (14%). There was no record of Traditionalists (0%) among the participants. Based on tribe, most of them were Yoruba (43%) while the least were Ibo (6%). On the account of study level, majority of the participants were in 500level (40%), while the least were in 600level (2%). Based on School, majority of the participants were from the School of Public and Allied Health (SPAH) (30%), while the least were from School of Computer Sciences (3%).

The outcome of this study shows that 111 (92.5%) out of the 120 hair combs examined had fungi contaminants, while the remaining 9 (7.5%) were fungi-free (Figure 1). Also, out of the 120 hair combs examined, 29 (24.2%) had one fungi isolate (mono-fungi contamination), 60 (50.0%) had two fungi isolates (dual-fungi contamination), while 22 (18.3%) had more than two fungi isolates (Figure 2).

Table 1: Socio-demographic Characteristics of the study participants

Characteristics	Category	Number (N)	Percentage (%)
Age range	16-20yrs	53	44.2
	21-25yrs	67	55.8
	26-30yrs	0	0
	Above 30yrs	0	0
	Total	120	100.0
Marital status	Single	114	95.0
	Married	4	3.3
	Divorced	2	1.7
	Total	120	100.0
Study Level	100 Level	6	5.0
	200 Level	21	17.5
	300 Level	12	10.0
	400 Level	30	25.0
	500 Level	49	40.8
	600 Level	2	1.7
	Total	120	100.0
Religion	Christianity	103	85.8
	Islam	17	14.2
	Traditional	0	0
	Others	0	0
	Total	120	100.0
Tribe	Yoruba	52	43.3
	Ibo	7	5.8
	Hausa	40	33.3
	Others	21	17.5
	Total	120	100.0
School	SPAH	36	30.0
	BBS	27	22.5
	SEAH	7	5.8
	SCS	4	3.3
	BCSM	6	5.0
	SNS	14	11.7
	SBAS	13	10.8
	SLSS	13	10.8
	Total	120	100.0

KEYS: SPAH = School of Public& Allied Health, BBS = Babcock Business School, SEAH = School of Education & Humanity, SCS = School of Computer Sciences, BCSM = Benjamin Carson School of Medicine, SNS = School of Nursing Sciences, SBAS = School of Basic and Applied Sciences, SLSS = School of Law & Security Studies.

The percentage occurrences of dermatophytes and non-dermatophytes fungal contamination of hair combs of the study participants were 52.8% and 39.7%, respectively (Figure 3). The percentage occurrence of the different fungal types is shown in Figure 4 using a bar chart. In all, a total of 217 fungal isolates was obtained. The organism with the highest percentage occurrence was Microsporum sp. (30.4%), followed by Trichophyton sp. (26.7%), Aspergillus sp. (26.3%), and Candida sp. (16.6%). There were significant differences (P>0.05) in the distribution of fungal contaminants present on the hair combs of the participants between and within the study categories.

Table 2 shows the fungal load on the hair combs of the study participants according to their demographic characteristics. 87% of the hair combs examined had fungal load below 20 CFU/25cm^2 (Acceptable level of contamination), 8% falls between 20–50 CFU/ 25cm^2 (Inconclusive), while 16% had fungal load above 50 CFU/25cm^2 (Unacceptable level of contamination).

Table 2: Fungal load on the hair combs according to the Socio-demographic Characteristics of the study participants

Demographic Characteristics	Category	Number of hair combs contaminated N (%)	Fungal Load			P-value	Pearson Chi-Square (χ2)
			<20 CFU/25cm2 N (%)	20-50 CFU/25cm2 N (%)	>50 CFU/25cm2 N (%)		
Age range	16-20yrs	47 (42.3)	37 (42.5)	3 (2.7)	7 (6.3)	0.955	12.279
	21-25yrs	64 (57.7)	50 (57.4)	5 (4.5)	9 (8.1)	0.955	
	26-30yrs	0 (0)	0 (0)	0 (0)	0 (0)		
	Above 30yrs	0 (0)	0 (0)	0 (0)	0 (0)		
	Total	111 (100)	87 (78.4)	8 (7.2)	16 (14.4)	0.028*	
Study Level	100 Level	6 (5.4)	6 (5.4)	0 (0)	0 (0)	0.064	12.051
	200 Level	19 (17.1)	14 (12.6)	4 (3.6)	1 (0.9)	0.679	
	300 Level	11 (10.0)	9 (8.1)	0 (0)	2 (1.8)	0.684	
	400 Level	24 (21.6)	15 (13.5)	1 (0.9)	8 (7.2)	0.675	
	500 Level	49 (44.1)	41 (36.9)	3 (2.7)	5 (9.9)	0.073	
	600 Level	2 (1.8)	2 (1.8)	0 (0)	0 (0)	0.681	
	Total	111 (100)	87 (78.4)	8 (7.2)	16 (14.4)	0.028*	
School	SPAH	36 (32.4)	28 (25.2)	4 (3.6)	4 (3.6)	0.758	13.037
	BBS	22 (19.8)	15 (13.5)	2 (1.8)	5 (4.5)	0.694	
	BCSM	7 (6.3)	6 (5.4)	0 (0)	1 (0.9)	0.999	
	SLSS	3 (2.7)	2 (1.8)	0 (0)	1 (0.9)	0.999	
	SCS	4 (3.6)	2 (1.8)	1 (0.9)	1 (0.9)	0.999	
	SNS	14 (12.6)	12 (10.8)	0 (0)	2 (1.8)	0.996	
	SEAH	13 (11.7)	11 (9.9)	1 (0.9)	1 (0.9)	0.999	
	SBAS	12 (10.8)	11 (9.9)	0 (0)	1 (0.9)	0.999	
	Total	111 (100)	87 (78.4)	8 (7.2)	16 (14.4)	0.028*	

Keys: Fungal load < than 20 CFU per 25cm^2 = Acceptable level of contamination, Fungal load between 20-50 CFU per 25 cm^2 = Inconclusive, Fungal load >50 CFU per 25 cm^2 = Unacceptable level of contamination. SPAH = School of Public & Allied Health, BBS = Babcock Business School, SEAH = School of Education & Humanity, SCS = School of Computer Sciences, BCSM = Benjamin Carson School of Medicine, SNC = School of Nursing Sciences, SBAS = School of Basic and Applied Sciences, SLSS = School of Law & Security Studies. **NB**: *Percentage of hair combs with unacceptable level of contamination was significantly lower (P <0.05) than those with acceptable level of contamination. ** Percentage of hair combs with unacceptable level of contamination was significant higher (P<0.05) among participants who were singles and Yorubas by tribe.

The percentage of hair combs with unacceptable level of contamination was significantly lower (P<0.05) than those with acceptable level of contamination. Meanwhile, there was significant difference (P>0.05) in the level of contamination between and within the categories of participants.

Table 3 shows the risk factors associated with fungal contamination. Majority of the participants agreed to the use of hair comb for their hair care (97%). Only 26% of them use their combs all the time, while 55% of them do so very often. About 87% of the participants indicated that they are aware that comb serve as a vehicle for fungal pathogen.

Table 3: Risk factors associated with fungal contamination of hair combs of the study participants

Characteristics	Responses	No. of Participants N (%)	No. with contaminated hair combs N (%)	No. with fungi-free hair combs N (%)
Use comb for hair care	Yes	117 (97.5)	108 (90.0)	9 (7.5)
	No	3 (2.5)	3 (2.5)	0 (0)
Frequency of using hair comb	Less often	22 (18.3)	19 (15.8)	3 (2.5)
	Often	66 (55.0)	63 (52.5)	3 (2.5)
	Very Often	32 (26.7)	29 (24.2)	3 (2.5)
Awareness that comb can serve as vehicle for fungal pathogens causing hair infection	Yes	105 (87.5)	98 (81.7)	7 (5.8)
	No	15 (12.5)	13 (10.8)	2 (1.7)
Storage for keeping comb when not in use	Yes	97 (80.8)	90 (75.0)	7 (5.8)
	No	23 (19.2)	21 (17.5)	2 (1.7)
Frequency of changing of hair comb	Every month	13 (10.8)	13 (10.8)	0 (0)
	Every 3 months	19 (15.8)	17 (14.2)	2 (1.7)
	Every 6 months	22 (18.3)	20 (16.7)	2 (1.7)
	Every 12 months	26 (21.7)	24 (20.0)	2 (1.7)
	Never	40 (33.3)	37 (30.8)	3 (2.5)
Share hair combs	Yes	102 (85.0)	95 (79.2)	7 (5.8)
	No	18 (15.0)	16 (13.3)	2 (1.7)
Frequency of removing hair strands from comb after use	Less often	16 (13.3)	16 (13.3)	0 (0)
	Often	49 (40.8)	43 (35.8)	6 (5.0)
	Very often	55 (45.8)	52 (43.3)	3 (2.5)
Frequency of removing hair product or oil after use	Less often	86 (71.7)	80 (66.7)	6 (5.0)
	Often	9 (7.5)	8 (6.7)	1 (0.8)
	Very often	23 (19.2)	21 (17.5)	2 (1.7)
	None	2 (1.7)	2 (1.7)	0 (0)
Materials used for washing of hair comb	Water only	33 (27.5)	28 (23.3)	5 (4.2)
	Water & shampoo	40 (33.3)	38 (31.7)	2 (1.7)
	Water & soap	38 (31.7)	36 (30.0)	2 (1.7)
	Water & detergent	9 (7.5)	9 (7.5)	0 (0)
History of Dandruff	Yes	79 (65.8)	73 (60.8)	6 (5.0)
	No	41 (34.2)	38 (31.7)	3 (2.5)
History of ringworm infection of the scalp	Yes	8 (6.7)	8 (6.7)	0 (0)
	No	112 (93.3)	103 (85.8)	9 (7.5)
Duration of history of hair infection	< 1 Month	32 (26.7)	31 (25.8)	1 (0.8)
	3 Months	12 (10.0)	12 (10.0)	0 (0.0)
	6 Months	9 (7.5)	7 (5.8)	2 (1.7)
	>12 Months	13 (10.8)	10 (8.3)	3 (2.5)
	None	54 (45)	51 (42.5)	3 (2.5)

Only 80% indicated they have storage for keeping their combs when not in use, while 21% of the participants agreed to changing of their combs every 12 months. 18% of them do so every 6 months, 15% of them do so every 3 months, 10% of them do so every month. While 85% of the participants agreed to sharing of combs. About 45% of the participants agreed to removal of hair strands from comb after use all the time, while 40% of them do so very often, also, 71% of the participants agreed to removing hair product or oil after use less often, while 19% of them do so very often. 7% of them do so often.

Furthermore, 27% of participants use water for washing of hair combs, while 33% use water and shampoo, 31% use water and soap, 7% use water and detergent. About 65% of the participants agreed to the history of dandruff. 6% of them agreed to history of ringworm infection. 26% of the participants indicated more than 1month duration of history of hair infection, while 10% of them 3 months, 9% of them 6 months, 10% of them more than 12 months, 45% of them had no duration of history infection.

Indications of fungal hair infection among the study participants in relation to the occurrence of fungal contamination of their hair combs are presented in Figure 5. 12 (10.0%) participants indicated large crusts form over the scalp, 6 (5.0%) indicated matting, 16 (13.3%) had dull broken hair, 19 (15.8%) complained of hair loss, 4 (3.3%) indicated black dots, while 7 (5.8%) indicated painful areas on the scalp. All these people had fungal contaminants on their hair combs.

Figure 6 shows the antifungal susceptibility pattern of fungal isolates recovered from the hair combs of the study participants. Candida sp. was most sensitive (75-100%) to Ketoconazole, Fluconazole and Griseofulvin, Itraconazole and Nystatin. Microsporum sp. were most sensitive (80-100%) to Ketoconazole, Fluconazole and Griseofulvin, but least sensitive (10-40%) to Itraconazole and Nystatin. Aspergillus sp. were most sensitive (87.5-100%) to Ketoconazole, Fluconazole and Griseofulvin but least sensitive (0-25%) to Itraconazole and Nystatin. Trichophyton sp. were most sensitive to Fluconazole and Griseofulvin (55.7666.7%) and least sensitive to Ketoconazole, Itraconazole and Nystatin (0-33.3%).

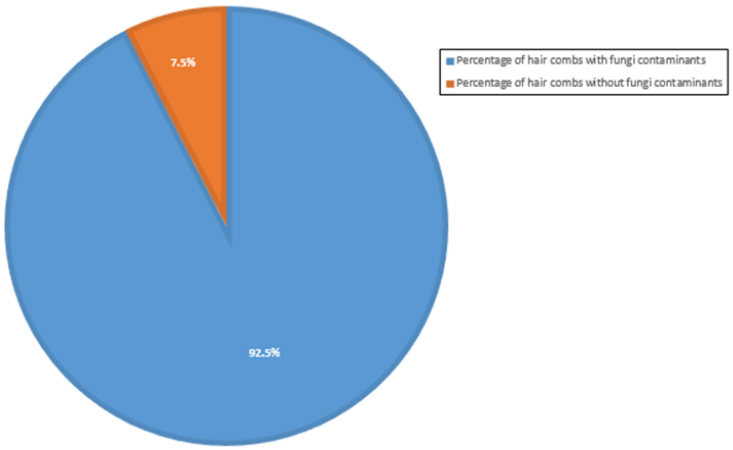


Figure 1: A pie chart showing percentage of hair combs of the study participants with and without fungi contaminants.

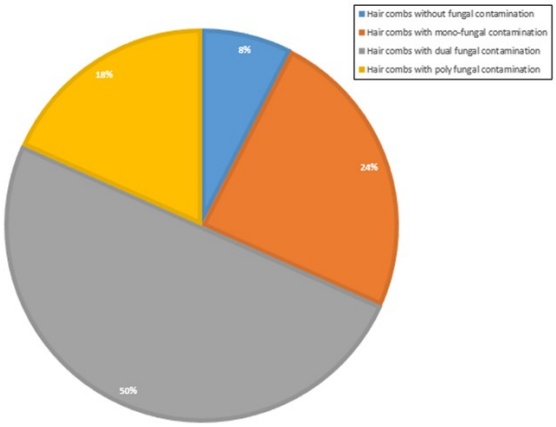


Figure 2: A pie chart showing percentage of the different forms of fungal contamination of hair combs of the study participants.

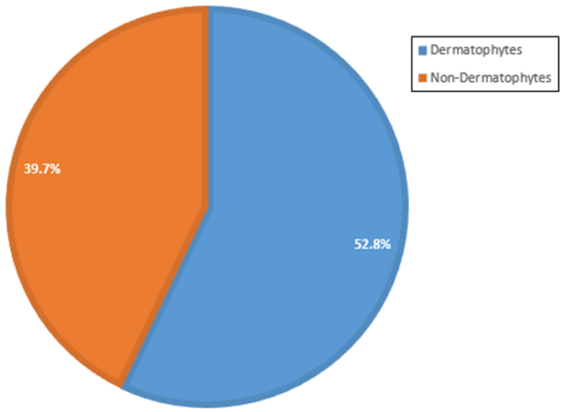


Figure 3: A pie chart showing percentage of dermatophytes and Non-dermatophytes fungal contamination of hair combs of the study participants.

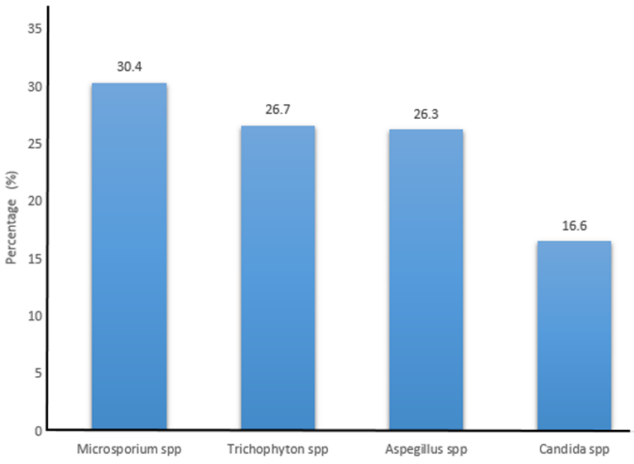


Figure 4: Bar chart showing percentage occurrence of each fungal isolate on the hair combs of the study participants

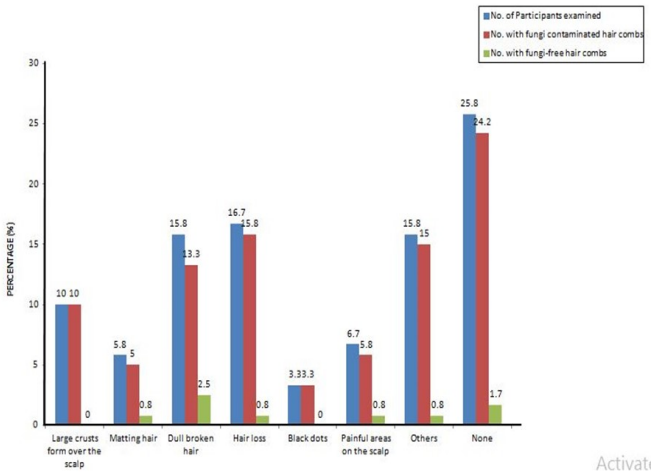
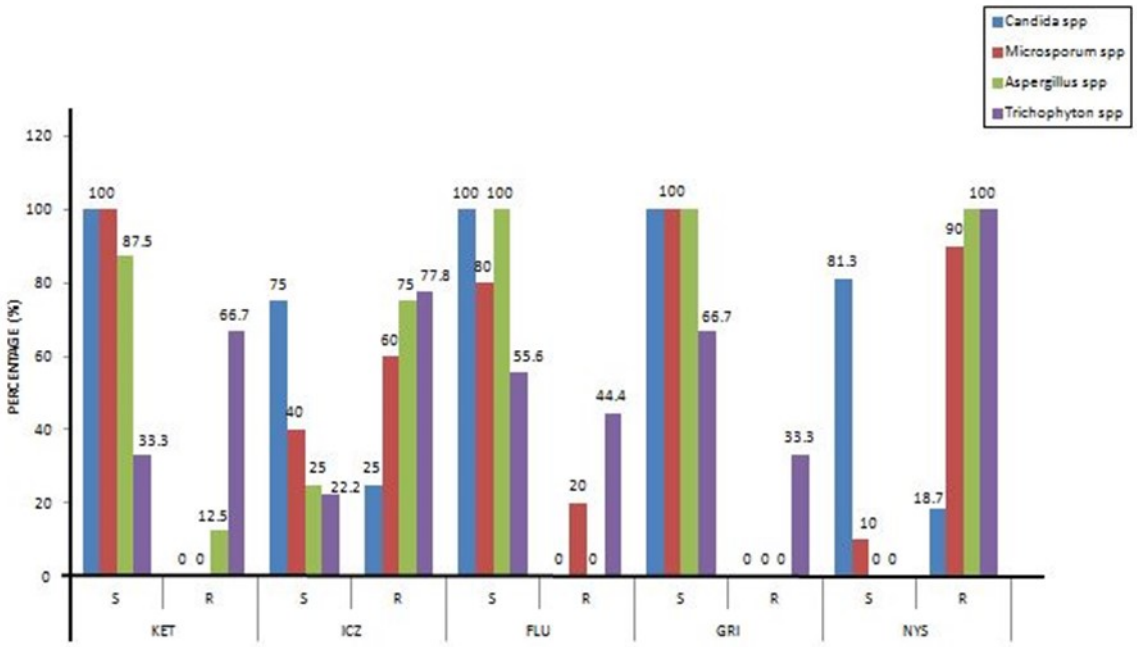


Figure 5: Indications of fungal hair infection among the study participants in relation to the occurrence of fungal contamination of their hair combs



KEYS: S= Sensitive, R= Resistant, KET = Ketconazole, ICZ = Itraconazole, FLU = Fluconazole, GRI = Griseofulvin, NYS = Nystatin

Figure 6: Antifungal susceptibility pattern of fungal isolates recovered from the hair combs of the study participants

The outcome of this study show that majority of the hair combs (92.5%) examined, had fungal contaminants, similar to the works of Edward et al. [11], who reported fungal contaminants in 93% of the hair brushes examined. The percentage occurrences of dermatophytes (52.8%) and Non-dermatophytes (39.7%) on the hair combs examined in this study are in contrast to the work of Edward et al. [11] who reported higher percentage of non-dermatophytes (90%) compared to the Dermatophytes (3%) on hair brushes. The reason for this discrepancy is plausible and would require further investigation. This strengthen the earlier claim that items used in everyday life such as hair combs are rarely kept clean or sanitized.

Furthermore, the mono-, dual- and poly-fungal contamination of the hair combs recorded in this study shows that the fungi ecology is vast and diverse. They can exist in isolation or in groups, depending on their genetic relatedness and compatibility, as well as the prevailing nutritional and environmental factors in their habitats. Also, the frequency of occurrence of each fungal pathogen on the examined hair combs is thought to be associated with the degree exposure of the hair combs to sources of contamination, as well as the individual genetic and environment dominance of each pathogen. The result obtained in this study further lends credence to the vastness and diversity of the fungi organisms even in the same environment or habitat [17].

Therefore, the category of participants with high level of fungal contaminants on their hair combs need to give more serious attention to their personal hygiene including that of their hair combs. It is important that they dedicate more efforts and time to keeping their hair combs clean to avoid colonization by fungal pathogens.

The types of fungal contaminants present on the hair combs examined in this study (Microsporum sp., Aspergillus sp., Candida sp. and Trichophyton sp.) are the same with those isolated by Enemuor et al. [9], except for Penicillium sp., Mucor sp., Rhizopus sp., and Cephalosporium sp., Stanely et al. [10], except for mucor spp and Rhizopus spp., as well as Edward et al. [11], except for Penicillium and Fonseceae species on hair brushes and/combs. This study is also in agreement with the work of Alghamdi et al. [18] who isolated Aspergillus sp., Penicillium sp., Alternaria sp., Chrysosporium sp. Cladosporium sp. and Trichosporon sp. from the hairs of female subjects in Kingdom of Saudi Arab (KSA).

Possible sources of fungal contamination include soil, air, user's normal flora, clothes and bags. Materials such as cupboards, books and files have been implicated as viable sources. House-keeping activity such as sweeping or using dry dust mops can aerosolize particles that may contain microorganisms. Ambient temperature, relative humidity and presence of moisture are three important factors for fungal spore generation, release and dispersal; particularly in indoor environments [19]. Users of hair combs must ensure that these factors are addressed to discourage factors that promote fungal contamination of their personal effects such as the hair combs.

The fungi contaminants identified in this study are mostly monophic in nature particularly the Microsporium sp., Trichophyton sp. and Aspergillus sp., except for Candida sp. that is dimorphic. The former takes on a mold form both in the environment and in the host, while the latter is a dimorphic mold in the environment and a yeast in the body [17, 20].

Furthermore, the fungi identified in this study exist naturally in the environment, except for *C. albicans* which is part of normal human flora. It exists in the gut and can be transferred via fecal contamination. It has been implicated in cutaneous and systemic infections including folliculitis, oral thrush, vaginal thrush and Candidaemia [11, 21]. Microsporium sp., Trichophyton sp., and Aspergillus sp. on the other hand, are important pathogenic molds found naturally in the environment including soil and have been implicated in scalp, hair, nails, skin and respiratory tract infection. Microsporium sp. and Trichophyton sp. in particular belong to a group of fungi called the dermatophytes that cause infections of the keratinized tissues (skin, hair, nails, etc.) in animals and humans known as ringworm or tinea. The aggressiveness of these fungal pathogens can be accrued to the possession of the enzyme keratinase required for colonization of the keratinized tissues of the host [22, 23].

No doubt there is a relationship between fungal contamination of hair combs and occurrences of hair and scalp infections of fungi origin among the study participants. The outcome of this study confirms these as fungal pathogens were recovered from the hair combs of participants who indicated large crusts form over the scalp (10.0%), matting (5.0%), had dull broken hair (13.3%), complained of hair loss (15.8%), had black dots (3.3%) and painful areas on the scalp (5.8%).

The following were identified as risk factors associated with occurrence of fungal contamination of hair combs: poor knowledge/lack of awareness that hair combs could serve as potential vehicles for fungi pathogens, sharing of hair combs, not removing hair strands from comb after use, not removing hair product or oil after use, nature of the materials used for washing of hair comb, history of Dandruff and ringworm infection of the scalp and duration of history of hair infection amongst others.

A small portion of the study participants with fungal contaminants on their hair combs (10.8%) are not aware that their hair combs could serve as vehicle of fungi pathogen. This is partly responsible for the fungal contamination of their hair combs. It is said, "Knowledge is power". One cannot fight what one knows nothing about. Knowledge/information is a vital epidemiologic tool in the prevention and control of infectious diseases. Sharing of personal effects like hair combs is also another contributing factor. 79.2% of participant that share their hair combs, had fungal contaminants, therefore the practice of sharing should also be discourage.

In addition to the above, poor care and maintenance of hair combs including not removing hair strands from comb after use and not removing hair product or oil after use may as well favor fungal contamination and colonization of the hair combs examined. This is largely due to ignorance, negligence, laziness or procrastination on the part of the hair comb users.

Poor personal hygiene amongst users of hair combs is a major factor contributing to the occurrence of fungal contaminants on the hair combs examined. Most persons in Nigeria do not always wash their hands thoroughly with soap and water after making use of the toilets and when not sanitized or washed properly, it becomes a good medium for transfer of microbial contaminants to whatever that is been handled.

Regarding the nature of materials used for washing of hair combs, most of the participants use water and shampoo (33%) to wash their hair combs, some use water and detergent (7%), some use water and soap (31%), while some use water only (27%). The implication of this is that their hair combs are not properly disinfected as the detergent does not possess fungicidal properties, hence upon washing created a wet, moist condition that favors fungi colonization and growth. Even though most people are of the opinion that using water and shampoo were the best option, but that was put in doubt as fungi were isolated from hair combs of the individuals who used water and shampoo as seen in this study. This observation agrees with that of Edward et al. [11], hence the need for proper and regular washing of the hair combs.

Lastly history of dandruff and ringworm infection of the scalp and duration of history of hair infection amongst others are critical risk factors that predispose to both fungal contamination of hair combs, as well as occurrences of indications of fungal infection among the study participants. Pathogenic fungi by nature are recalcitrant and difficult to treat. Treatment usually takes several weeks, and months and re-infection is common when antifungal therapy is stopped or discontinued. Once an individual is exposed to fungi infection, the propensity for re-occurrence to occur is high depending on the success of the initial treatment, the aggressiveness to cause infection and the resistance of the fungal pathogen to the available antifungal drugs, level of personal hygiene, the nutritional and immune status of the individual amongst others. Immunosuppression in particular has been associated with re-occurrence of candidiasis due to the opportunistic nature of Candida sp. [24, 25].

For the antifungal susceptibilty pattern of the fungal isolates recovered from the hair combs of the study participants, Candida sp. was most sensitive (75-100%) to Ketoconazole, Fluconazole and Griseofulvin, Itraconazole and Nystatin. Microsporum sp. were most sensitive (80-100%) to Ketoconazole, Fluconazole and Griseofulvin. Aspergillus sp. were most sensitive (87.5-100%) to Ketoconazole, Fluconazole and Griseofulvin. While Trichophyton sp. were most sensitive to Fluconazole and Griseofulvin (55.7-66.7%).

This shows that infections caused by these fungal pathogens are treatable by the available antifungal agents with varied levels of success rates. However, to prevent the development of resistance to these drugs, antifungal susceptibility testing using standard laboratory procedures must always precede prescription and medication. Also, indiscriminate use of antifungal agents through self-medication must be discouraged. Unfortunately, in this part of the world, antifungal susceptibility testing is infrequently carried out in our hospitals, either due to lack of expertise, facility or sheer ignorance of its importance.

4.0 CONCLUSION

This current study further strengthens the earlier claim that beauty tools like hair combs may serve as potential vehicles for microbes, particularly fungal pathogens capable of causing hair infections. It is therefore important for female folks to be acquainted with factors that promote fungal contamination and colonization of their hair combs and discourage the same in other to forestall the occurrence of fungal infection of their hair and scalp in the future.

CONSENT

All authors declare that 'written' informed consent was obtained from the participants with assurance of anonymity and confidentiality before the commencement of the study.

ETHICAL APPROVAL

Ethical approval for the study was obtained from the Babcock University Health Research Ethics Committee (BUHREC) with ethical approval registration number: BUHREC392/19.

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