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RESEARCH ARTICLE

Bacterial Contamination of Fingernails and Artificial Nails in Enugu Metropolis

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Abstract

Fingernails are hard, claw-like structures at the ends of fingers and toes in most primates, including humans, where they are located at the tips of the hands. They are often exposed due to daily activities and have been identified as potential sources of bacterial infections, as they tend to harbor microbes. This is further aided by bacterial biofilms that promote microbial adherence. This study examined bacterial contamination of natural and artificial fingernails among students of the University of Nigeria, Enugu Campus, and traders at Ogbete Main Market, within Enugu metropolis. A cross-sectional approach was adopted to evaluate bacterial contamination in fingernails. A total of 200 fingernail samples were collected, 100 from university students and 100 from market traders. Although there was no significant difference in the average number of bacterial isolates based on nail type or participant group ($p>0.05$), a significant difference was observed in the distribution of specific bacterial types between natural and artificial nails ($X^2 = 41.56$, $p = 0.0005$), indicating that artificial nails harbor more diverse bacteria. Among traders, *Staphylococcus aureus* was the most common isolate (21.36%), followed by *Bacillus subtilis* (19.42%). Among students, *Bacillus subtilis* (16.67%) was slightly more prevalent than *Staphylococcus aureus* (15.63%). Both artificial and natural fingernails can carry bacterial contaminants, with artificial nails harboring a greater variety and quantity. Promoting hand hygiene and discouraging the use of artificial nails are recommended preventive strategies.

Keywords: Fingernails, Artificial Nails, Natural Nails, Bacterial Contamination, Staphylococcus Aureus, *Bacillus subtilis*, Nail Length And Hygiene, Market Traders, Microbial Isolates, Hand Hygiene.

1. Introduction

One of the most common means for the transmission of bacteria seen in the healthcare environment is through touch done directly or indirectly. These microorganisms could be transient or resident, viral, bacterial, or fungal.[1] Bacteria are single- celled prokaryotic organisms that can be found almost anywhere on the planet and are vital to its ecology and can come in a variety of shapes and sizes, including rods, spirals, and spheres.[2] Day after day, the hands

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come in contact with a variety of materials, and the rising demand for fashion among men and women has led to a growth in the number of people who fix artificial nails, exposing them to a variety of contaminants, including bacteria especially in the finger nails.[3] On the hands, there are various microorganism-infested regions, particularly beneath the nails.[4] This research focuses on identification of bacteria pollutants found on both natural and artificial nails.

Microorganisms thrive under the fingernails, making cleaning them even more difficult. Bacteria find it simpler to attach themselves to the nails,[5] whether on the nails or beneath them,[3] due to their propensity to form biofilms, which is one of its intrinsic properties.[6] Biofilms are a complex group of microbial cells that make it easier for bacteria to attach to the exo-polysaccharide matrix on the surface of any object, enhancing their pathogenicity.[7] Bio films are basically mucilage layers held together by an extracellular matrix generated by the organisms themselves.[8] Persistent cells in biofilms may contribute to biofilm cells' higher resistance to environmental stress.[9] Bacteria infection may allow Paronychia to grow.[10] Paronychia is a fungal infection of the proximal and lateral fingernails and toenails that affects both the root and sides of the nail, as well as the tissues that surround the nail's sides.[11]

This condition can be caused by a variety of factors, including trauma or manipulation.[12] Even hand washing is insufficient to totally eliminate the bacteria that become attached to the finger nails and artificial nails over time because the hand is almost always moist.

Nail cosmetics have been used by women to improve their appearance for decades, dating back to 5000 BC when women in India, China, and Egypt used Henna to colour their fingernails to make them more attractive to others.[13] Under the nails, higher populations of bacteria are frequently detected, and they are more difficult to eradicate than on other parts of the hands. The effectiveness of microbial clearance from beneath the nails is also affected by fingernail length and texture.[14] After washing the hands, long and polished nails tend to house more bacteria than short and unpolished nails. Because artificial nails are usually longer, they may be a powerful factor impacting the efficacy of hand washing. Artificial nails have been known to harbour more bacteria than natural nails, although a study analysed the number of microbes on nails with gel and discovered that there was no increase in the number of microorganisms on nails with gel polish; however, they found out that gel nails may be more difficult to clean using alcohol hand gel.[15] This contrasted with another report made by Wu and Lipner, where they stated that gel nails are associated with higher numbers and more species of microbes compared to bare nails.[16] Natural nails should be chopped, and artificial nails should not be worn.[17] In order to avoid disease transmission through the nails, effective hand washing measures to remove microorganisms from both artificial and natural fingernails are required.

The human hands are the body parts that have the most contact with the outside world. Every day, people use their hands for a range of tasks. Different bacteria are particularly easy to come into contact with and transfer to other objects, including people. Surprisingly, fingernails have the highest concentration of microorganisms on human hands.[18] Because of their potential to contain a wide range of bacteria, fingernails are increasingly being considered as a major source of worry in many health-related disorders.[19] As a result, fingernails play a critical role in the transmission of various diseases, both mechanically and physiologically.

2. Materials and Methods

A cross-sectional method was employed in this study involving female students of University of Nigeria Enugu Campus and female traders in Ogbete main market. The Study population included students from the faculties Health Science Students, Law Faculty students, Business students and Basic medical students; the market traders include Tomatoes traders, Cloth traders, Food vendors, and Nail technicians.

The sample size was determined using Leslie Fisher's formula for estimating a population proportion.

$$n = \frac{Z^2 \cdot p \cdot (1 - p)}{d^2}$$

Where:

n is the required sample size

Z is the standard normal deviate corresponding to a 95% confidence level (1.96)

p is the assumed prevalence of the condition

d is the acceptable margin of error (0.05).

$$n = \frac{(1.96)^2 \cdot 0.101 \cdot (1 - 0.1010)}{(0.05)^2} = \frac{3.8416 \cdot 0.101 \cdot 0.899}{0.0025} = \frac{3.8416 \cdot 0.090799}{0.025} = \frac{0.3491}{0.025} = 139.64$$

Based on a previous study by Ukaegbu-Obi et al. (2017), which reported a 10.1% prevalence of *Staphylococcus aureus* from fingernail swabs among students, an assumed prevalence p=0.101p = 0.101p=0.101 was used. Substituting into the formula yielded a minimum sample size of approximately 140. However, to increase the reliability of the findings and allow subgroup comparisons, a total of 200 fingernail samples were collected and analyzed.

Sample was collected from under fingernail with a swab after dipping into peptone water amongst the populace of Enugu metropolis. Fingernail swabs were cultured on MacConkey agar (Oxoid, and Nutrient agar (Batec) and then incubated at 37°C for 24 hours for isolation of Gram negative and Gram positive bacteria. The bacterial colonies grown on the agar media were presumptively identified by colonial morphology and Gram staining and a battery of biochemical tests like reaction on catalase, nitrate, and motility tests. Standard identification procedures were followed in the identification of the organisms.

All statistical calculations were done using SPSS for windows version 22 (SPSS, Chicago, IL, USA). Descriptive statistics were computed to determine the rate of bacteria and other variables. The relationships between the presence of bacteria and various risk factors were tested using the Chi square test. A value of $p \leq 0.05$ was considered statistically significant.

3. Results

A total of 200 fingernail swabs were collected from female students across various faculties at the University of Nigeria, Enugu Campus, and female traders selling different goods at the Ogbete Main Market. One hundred swabs were obtained from the students and another 100 from the traders. Within each group, 50 swabs were taken from natural fingernails and 50 from artificial nails. A total of 15 bacterial species were isolated from the 200 swabs, with *Staphylococcus aureus* showing the highest frequency.

Table 1 Showed the frequency and percentage of the bacteria species isolated from the finger nail swabs.. *Staphylococcus aureus* had the highest frequency 37(18.6) followed by *Bacillus subtilis* 36(18.1%) [See Figure 1].

Table 1. *General Distribution of bacterial isolates from the study*

Bacterial isolates	Number isolated	Percentage (%) frequency
Staphylococcus aureus	37	18.6%
Bacillus subtilis	36	18.1%
Bacillus megaterium	17	8.5%
Escherichia coli	16	8.%
Enterococcus faecalis	16	8.%
Pseudomonas aeruginosa	15	7.5%
Diphtheroids	14	7%
Proteus vulgaris	9	4.5%
Klebsiella pneumonia	8	4%
Lactobacillus acidophilus	7	3.5%
Bacillus pumilus	6	3%
Bacillus cereus	5	2.5%
Enterobacter cloacae	5	2.5%
Acinetobacter baumannii	3	1.5%
Salmonella spp	2	1%
Staphylococcus epidermidis	2	1%
Aeromonas hydrophila	1	0.5%
TOTAL	199	100%

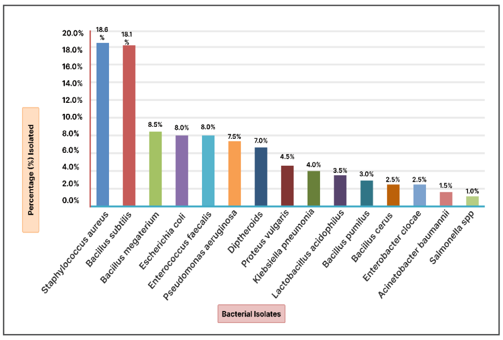

Figure 1. *General Distribution of bacterial isolates from the study*

Table 2 shows the distribution of bacterial isolates according to source. A total of 96 (48.2%) and 103 (51.8%) bacterial isolates were isolated from students and market traders respectively. *Staphylococcus aureus* was the most isolated bacterial isolate from market traders followed by *Bacillus subtilis* while *Bacillus subtilis* was the most isolated bacteria from students followed by *Staphylococcus aureus*. There was no statistically significant difference in the mean number of bacterial isolates according to source ($p>0.05$). There was also no statistically significant difference in the proportion of each bacterial isolate according to source ($X^2=25.34$, $p=0.0640$). [See figure 2]

Table 2. *Distribution of bacterial isolates according to Source*

Bacterial isolates	Source		Total	P-value
	Students	Market traders		
Staphylococcus aureus	15	22	37	0.6877
Bacillus substilis	16	20	36	
Bacillius megaterium	7	10	17	
Escherichia coli	10	6	16	
Enterococcus faecalis	6	10	16	
Psedomonas aeruginosa	8	7	15	
Diptheriods	4	10	14	
Proteus vulgaris	2	7	9	
Klebsiella pneumonia	7	1	8	
Lactebacillus acidophilus	4	3	7	
Bacillus pumilus	4	2	6	
Bacillus cerus	3	2	5	
Enterobacter cloacae	5	0	5	
Acintobacter baumannii	2	1	3	
Salmonella spp	0	2	2	
Staphylococcus epidermidis	2	0	2	
Aeromonas hydrophila	1	0	1	
TOTAL	96 (48.2%)	103 (51.8%)	199 (100%)	

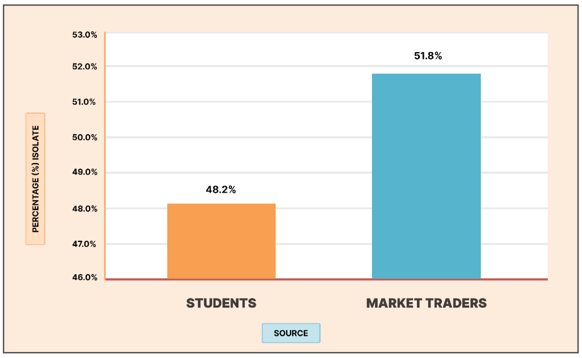

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Table 3 shows the distribution of bacterial isolates according to type of finger nail. A total of 80 (40.2%) and 119 (59.8%) bacterial isolates were isolated from natural and artificial finger nails respectively. *Staphylococcus aureus* was the most isolated bacterial isolate from natural finger nails followed by *Bacillus subtilis* while *Bacillus subtilis* was the most isolated bacteria from artificial finger nail followed by *Staphylococcus aureus*. There was no statistically significant difference in the mean number of bacterial isolates according to type of finger nail ($p>0.05$), However, there was a statistically significant difference in the proportion of each bacterial isolate according to type of finger nail (X^2=41.56, p=0.0005). [See Figure 3]:

Table 3. *Distribution of bacterial isolates according to nail type*

Bacterial isolates	Finger nail type		Total	P-value
	Natural	Artificial		
Staphylococcus aureus	25 (67.6%)	12 (32.4%)	37	0.2808
Bacillus substilis	18 (50%)	18 (50%)	36	
Bacillius megaterium	8 (47%)	9 (53%)	17	
Escherichia coli	3 (18.8%)	13 (81.2%)	16	
Enterococcus faecalis	6 (37.5%)	10 (62.5%)	16	
Psedomonas aeruginosa	1 (6.7%)	14 (93.3%)	15	
Diptheriods	6 (42.9%)	8 (57.1%)	14	
Proteus vulgaris	0 (0%)	9 (100%)	9	
Klebsiella pnemonia	1 (12.5%)	7 (87.5%)	8	
Lactebacillus acidophilus	3 (42.9%)	4 (57.1%)	7	
Bacillus pumilus	3 (42.9%)	3 (50%)	6	
Bacillus cerus	2 (40%)	3 (60%)	5	
Enterobacter cloacae	0 (0%)	5 (100%)	5	
Acintobacter baumannii	2 (40%)	1 (33.3%)	3	
Salmonella spp	0 (0%)	2 (100%)	2	
Staphylococcus epidermidis	2 (1000%)	0 (0%)	2	
Aeromonas hydrophila	0 (0%)	1 (100%)	1	
TOTAL	80 (40.2%)	119 (59.8%)	**199 (100%)**	

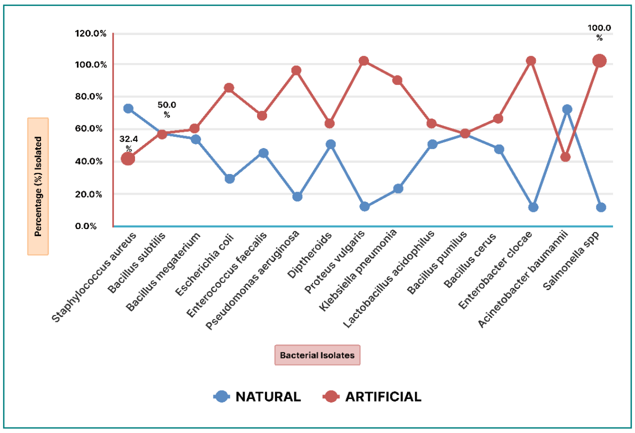

Figure 3. *Distribution of each bacterial isolate according to type of finger nail*

Figure 3 showed the distribution of bacterial isolates according to type of finger nail. A total of 80 (40.2%) and 119 (59.8%) bacterial isolates were isolated from natural and artificial fingernails respectively. *Staphylococcus aureus* was the most isolated bacterial isolate from natural fingernails followed by *Bacillus subtilis* while *Bacillus subtilis* was the most isolated bacteria from artificial fingernail followed by *Staphylococcus aureus*. There was no statistically significant difference in the mean number of bacterial isolates according to type of finger nail (p>0.05), However, there was a statistically significant difference in the proportion of each bacterial isolate according to type of finger nail (X^2=41.56, p=0.0005).

Table 4 shows the distribution of bacterial isolates according to type of trade. There was no statistically significant difference in the mean number of bacterial isolates according to type of trade (p>0.05). [See Figure 4]

Table 4. *Distribution of bacterial isolates according to Source*

Bacterial isolates	Type of Trade				
	Nail Technicians	Tomato sellers	Food Sellers	Cloth Sellers	P-value
Staphylococcus aureus	6	6	5	5	0.5503
Bacillus substilis	5	8	5	2	
Bacillius megaterium	1	3	5	2	

Escherichia coli	2	1	1	2	
Enterococcus faecalis	4	3	2	1	
Psedomonas aeruginosa	1	4	1	1	
Diptheriods	2	4	4	0	
Proteus vulgaris	1	3	2	1	
Klebsiella pnemonia	0	0	0	1	
Lactebacillus acidophilus	1	1	1	0	
Bacillus pumilus	2	0	0	0	
Bacillus cerus	0	0	2	1	
Enterobacter cloacae	0	0	0	0	
Acintobacter baumannii	0	0	0	1	
Salmonella spp	0	1	0	1	
Staphylococcus epidermidis	0	0	0	0	
Aeromonas hydrophila	0	0	0	0	
TOTAL	25	34	28	18	

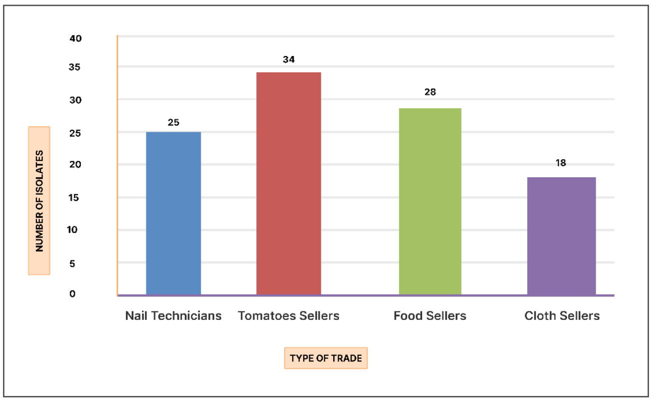

Figure 4. *Distribution of bacterial isolates according to type of trade*

Figure 4 showed the distribution of bacterial isolates according to type of trade. There was no statistically significant difference in the mean number of bacterial isolates according to type of trade (p>0.05).

4. Discussion

The fingernails has been found to be a source for the spread of bacterial infections because of its ability to attract and harbour some microbial agents as it is always exposed with the hands used for many activities,[20] with bacterial biofilms aiding the colonisation,[6] this research was done to compare the bacterial agents found in both natural fingernails and artificial nails. The result of this study showed that the 135 fingernail swabs studied all had bacteria isolated from them. A total of 80 (40.2%) and 119 (59.8%) bacterial isolates were isolated from natural and artificial fingernails respectively and even though there was no statistically significant difference in the mean number of bacterial isolates according to type of finger nail (p>0.05), there was a statistically significant difference in the proportion of each bacterial isolate according to type of finger nail. The bacteria isolated generally from the nails during the course of this study include, *Staphylococcus aureus* which had the highest frequency 37 (18.6%) followed by *Bacillus subtilis* 36 (18.1%), *Bacillus megaterium* 17 (8.5%), *Escherichia coli* 16(8%) with the least being *Staphylococcus epidermidis* 2 (1%) and *Aeromonas hydrophila* 1 (0.5%) agrees with the work of Wu and Lipner,[16] who found various gram positive bacteria and gram negative bacteria under the fingernails. This report agrees with the work of Overgaauw *et al.,* which found out that fingernails contain a wide range of bacteria hence should be a major source of worry for many health related disorders.[19] Many of these disorders may not affect the healthy person but would affect immunologically impaired individuals.

The results gotten from the comparison of bacterial isolates from natural nails and from artificial nails, shows that there is a greater number of bacteria isolated from the artificial nails than in the natural nails this probably due to the artificial nails generally being longer than the natural nails giving it room to house more bacterial contaminants which agrees with the work of Ukaegbu-Obi *et al.,* which says that the effectiveness of microbial clearance from beneath the nails is also affected by fingernail length and texture.[14]

The results gotten from this study in artificial nails differed from the study done at Micheal Okpara university where the most frequent bacteria found in artificial nails were *Klebsiella spp*, *Staphylococcus aureus, and Proteus* spp[14] compared to Bacillus subtilis 18 (15.1%) was found to be the highest frequently occurring bacteria followed closely by *Pseudomonas aeruginosa* 14 (11.76%) and then *Escherichia coli* 13 (10.9%) in Enugu metropolis, this may be due slightly differently climate conditions in the two areas. When compared to other work done in Ibadan the organisms found are coagulase negative *staphylococci*, *Staphylococcus aureus*, *Pseudomonas* species.[3]

The analysis also showed that there was no statistically significant difference in the mean number of bacterial isolates according to source ($p>0.05$) and there was also no statistically significant difference in the proportion of each bacterial isolate according to source which could suggest that either students did not take proper hygienic measures thereby leaving themselves at the risk of contracting or spreading bacterial infections or that the traders in the market also practised the same type of hygienic measures which the students practised. The amount of bacteria isolated in this study which was though limited in population studied, is still a cause for concern.

5. Conclusion

This study has shown that both natural and artificial fingernails work as reservoirs for diverse bacterial pollutants, with artificial nails exhibiting a greater bacterial load and diversity. While there was no statistically significant difference in the total mean number of bacterial isolates between nail types or sources (students and traders), artificial nails exhibited a considerably greater proportion of specific bacterial species. Staphylococcus aureus and Bacillus subtilis were the most often isolated organisms in both groups, highlighting their prevalence and probable involvement in bacterial transmission.

Conflict of Interest

The authors declare no conflict of interest.

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