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Threats and Treasure in the Use of Human Jewelry Using Microbial Analysis

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Abstract

This study aims at examining the prevalence of microbial contamination of human jewelries and determining the antibiotic susceptibility of the isolates. Fifty pieces of gold jewelries comprising 25necklaces and wristwatches each that have not been washed for over four months pre-study were swabbed from volunteer students. Total viable bacteria, coliforms and fungal count were obtained on nutrient agar, MacConkey agar and potato dextrose agar respectively. Pure isolates obtained were characterized in accordance with standard procedures. Antimicrobial susceptibility profiles of the bacterial isolates were determined using Kirby-Bauer. Necklace samples recorded total viable bacteria count (TVBC) ranged from 1.4 x 10^4 to 4.3 x 10^4 cfu/ml while total coliform counts ranged from 0to 2.9 x 10^3 cfu/ml. Fungal counts ranged from 1.1x 10^3 to 3.1x 10^3 cfu/ml. In wristwatch

samples, TVBC ranged from 1.3 x 10^4 to 3.6 x 10^4 cfu/ml and TCC ranged from 0 to 1.8 x 10^4 cfu/ml while fungal counts ranged from 1.2x 10^3 to 2.7x 10^3 cfu/ml. Bacteria isolates include; *Staphylococcus aureus, Escherichia coli, and Klebsiella* species, while fungi include *Aspergillus niger*, *Alternaria* species, *Penicillus* species and *Epidermophyton* species. *Staphylococcus aureus* and *Bacillus* species were resistance to septrin, amoxicillin, gentamicin and tarivids while *Klebsiella* species, *Pseudomonas aeruginosa, Salmonella* species and *Proteus* species were susceptible to sparfloxacin. All isolates were susceptible to augmentin and perfloxacin. This study revealed that pieces of necklaces and wristwatches could be colonized by pathogenic microorganisms. It is therefore very pertinent to regularly sanitize jewelries.

***Keywords**:* Jewelry, Antibiotic, Susceptible, Isolates, Pathogens

Introduction

Jewelry is a form of personal adornment, manifesting itself as brooches, rings, necklaces, earrings and bracelets. Jewelry may be made from any material, usually gemstones, precious metals, beads or shells. Factors affecting the choice of materials include cultural differences and the availability of the materials. Jewelry may be appreciated because of its material properties, its patterns or for meaningful symbols [1]. The first pieces of jewelries were made from natural materials such as bone, animal teeth, shell, wood and carved stone [2]. Some jewelry throughout the ages may have specifically been as an indication of a social group as more exotic jewelry is often for wealthier people, with its rarity increasing its value.

Jewelry makes intimate contact with the skin or clothing of the person wearing it. As a result they easily get colonized by bacteria and fungi on the skin or clothes of the wearer thus serving as formites. These colonizing organisms can get established on jewelries using glycocalyx and later develop into a biofilm or microbial mat on or around the jewelry [3], causing skin diseases and can penetrate the blood system creating life-threatening diseases particularly in immune-suppressed individuals [4,5]

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The relationship between wearing rings and the transmission of microorganisms is

still unclear. The Center for Disease Control and Prevention guideline has categorized this as an "unresolved issue" in need of additional research [6]. The draft WHO guidelines also do not have a stated recommendation against the wearing of rings but note that “the consensus recommendation is to discourage the wearing of rings or other jewelry during healthcare" [7]. A number of studies have shown that ring wearing increases the likelihood of bacterial contamination; in particular these studies have demonstrated that the skin under rings can be more heavily colonized than areas of skin without rings and can be a major contributor to hand contamination. Previous research studied 66 surgical intensive care unit nurses, culturing each staff nurse's hands before and after he or she performed hand hygiene; they found that wearing rings was associated with a 10-fold higher median count of skin microorganisms, especially with yeast species or Gram-negative bacilli and a stepwise increase risk of contamination with any transient organism as the number of rings worn increased [8]. It was reported that mean bacterial counts were higher on ring-wearing fingers (1600 compared to 180 for non-ring wearing fingers) (8).They survey included 50 nurses working on medical and surgical wards that permanently wore rings and studied the microorganisms isolated from skin under the rings. Forty percent of these nurses (20 nurses) had Gram-negative bacilli on the skill under their rings, and 16 of these 20 nurses still had most strains each time the nurses were sampled during the five-month study [9]. A similar study found that even after washing hands with povidone-iodine, those with rings had higher bacterial counts than those without [10]. Another study states that rings were the only substantial risk factor for carriage of Gram-negative bacteria and *S. aureus* on the hands [11] found that there was a higher reduction after hand washing by healthcare workers without rings than by those with rings. The published research appears to show that jewelry is a significant vehicle for the transmission of pathogens.

Main objectives of the study are to determine the microbial load of used necklaces and wristwatches by students of Olabisi Onabanjo University, Ogun State, compare the percentage frequency of bacterial species isolated from the necklaces and wristwatches and determine antibiotic susceptibility of the bacterial isolates. This study aims at examining the prevalence of microbial contamination of human jewelries and determining the antibiotic susceptibility of the isolates.

Materials and methods

Fifty pieces of gold jewelries comprising 25necklaces and wristwatches each that have not been washed for over four months pre-study were swabbed from volunteer students.

Sample collection

A total of 50 pieces of gold jewelries (25 necklaces and 25 wristwatches), that have not been washed for over four months pre-study were collected from volunteer students of Olabisi Onabanjo University, Ago-Iwoye, Nigeria for this study. Presence of skin rash (if any) was noted. All jewelry samples were collected in a piece of aluminum foil, carefully folded, and then placed in an envelope for storage in air-tight containers to await microscopy and cultural analyses.

Microscopy and culture of samples

The jewelry samples were aseptically picked with sterile forceps. The inner parts of the necklaces and wristwatches were cleaned with sterile swap stick and dipped in sterile saline water for five minutes. This was shaken vigorously for uniform distribution to make a stock solution; after which they were aseptically removed using sterile forceps. 1.0 ml of the stock solution was serially diluted for up to 10^8 and 0.5 ml of the dilution samples was inoculated separately in duplicate plates of nutrient agar and potato dextrose agar using the pour plate method.

All media used were prepared according to manufacturer's specification. The nutrient agar plates were incubated at 37^{o}C for 24 hours while the potato dextrose agar plates were incubated at room temperature (28 ± 2^{o}C) for 5-7 days. Pure isolates of resulting growth were identified and sub-cultured accordingly.

The fungal isolates were examined microscopically and macroscopically following staining with lactophenol in cotton blue wet mount technique [13]. Dermatophytes species were identified by gross and microscopic morphology and by *in vitro* tests, when required [14, 15].

Characterization of the Isolated Organisms

The bacterial isolates were characterized using morphological and biochemical characteristics which include Gram staining, motility, coagulase, catalase, oxidase, indole, urease production, citrate utilization, methyl red, vogues proskauer, bile solubility and carbohydrate fermentation tests such as mannitol, sucrose, glucose and lactose [13].

Antibiotic Sensitivity Using Standard Commercial Drugs

This was used to test the susceptibility of the bacteria to commercial antibiotics. Mueller Hinton agar was prepared according to manufacturer's specification and 20mL was dispensed into each petri dish, and allowed to solidify. The test bacteria were introduced into the petri dishes. The antibiotics used include both gram positive and gram negative. Antibiotic discs were placed on the media containing the test bacteria and incubated at 37°C for 24 hours. The zones of inhibition which showed the antibacterial activity were determined around the antibiotic discs. Results were recorded by measuring the zones of inhibition and comparing with the NCCLS interpretive performance standard for antimicrobial disk susceptibility testing [16].

Results

Table 1 shows microbial count from used necklaces. Total viable bacteria count (TVBC) ranged from 1.4 x 10^4 to 4.3 x 10^4 cfu/ml as occurred in samples N9 and N2 respectively, while total coliform count ranged from 0to 2.9 x 10^3 cfu/ml. Coliform was not encountered in samples N6, N7, N8, N9, N12, 13, N14, N19, N22 and N23. Fungal counts ranged from 1.1x 10^3 to 3.1x 10^3 cfu/ml as occurred in samples N12 and N2.

Table 2 shows the population counts of bacteria and fungi isolated from used wristwatches. Total viable bacteria count (TVBC) ranged from 1.3 x 10^4 to 3.6 x 10^4cfu/ml as recorded in W13 and W25. Total coliform count (TCC) ranged from 0 to 1.8 x 10^4 cfu/ml; no coliform was present in samples W1, W4, W8, W12, W13, W14, W18, W21 and W22. Fungal count ranged from 1.2x 10^3 to 2.7x 10^3 cfu/ml as occurred in samples W7 and W16.
Seven (7) bacteria species were isolated and characterized in this study after carrying out

biochemical tests. These include *Staphylococcus aureus, Escherichia coli, Klebsiella* species, *Pseudomonas aeruginosa, Salmonella* species, *Proteus* species and *Micrococcus* species. Five fungal species were identified and these include; *Aspergillus niger, Alternaria* species. *Penicillus* species, *Epidermophyton* species and *Aspergillus flavus.*

Figure 1 showed the occurrence of microbial species in different samples of used necklaces and wristwatches. Different microbes were associated with different samples and each sample contributed to the microbial population encountered in this study.

The antibiotic susceptibility of bacteria isolated from used necklaces and wristwatches was shown in Table 3. The antibiotics used were Septrin (30 μg), Chloramphenicol (30 μg), Sparfloxacin (10 μg), Ciprofloxacin (10 μg), Amoxicillin (30 μg), Augmentin (30 μg), Gentamicin (10 μg), Perfloxacin (30 μg), Tarivids (10 μg) and Streptomycin (30 μg). *Staphylococcus aureus* and *Bacillus* sp showed resistance to septrin, amoxicillin, gentamicin and Tarivids while other bacterial isolates were susceptible to these antibiotics. *Klebsiella* sp, *Pseudomonas aeruginosa, Salmonella* sp and *Proteus* sp were susceptible to sparfloxacin while *Staphylococcus aureus, E. coli* and *Bacillus* sp were intermediately susceptible. All isolates were susceptible to augmentin and perfloxacin, but *Staphylococcus aureus, Klebsiella* sp and *Bacillus* sp showed intermediate resistance to perfloxacin.

Discussion and conclusion

Samples of necklaces and wristwatches were found to harbor high microbial load. This could be due to the fact that these two jewelries are always in contact with human skin and regularly removed either before washing or bathing, devoid of contact with water or soap. The accumulation of sweat and dirt on these samples can support microbial growth. The growth of these bacteria could be encouraged by sweat which contains some salt. When these pathogens get into the food or water of healthy consumers, this could pose dangerous health risk. It was reported bacteria to cause food poisoning, and that staphylococcal food poisoning occurs through an infected food handler [5].

Table 1: Population counts of bacteria and fungi from used necklaces in cfu/ml

Sample code	TVBC	TCC	Fungal growth
N1	4.2×10^4	2.6×10^3	2.1×10^3
N2	4.3×10^4	2.4×10^3	3.1×10^3
N3	3.7×10^4	2.7×10^3	2.2×10^3
N4	4.2×10^4	2.9×10^3	2.1×10^3
N5	3.4×10^4	2.2×10^3	1.2×10^3
N6	2.2×10^4	Nil	2.2×10^3
N7	3.2×10^4	Nil	2.6×10^3
N8	2.8×10^4	Nil	2.5×10^3
N9	1.4×10^4	Nil	2.3×10^3
N10	2.2×10^4	1.9×10^3	2.1×10^3
N11	2.4×10^4	1.9×10^3	2.2×10^3
N12	2.6×10^4	Nil	1.1×10^3
N13	1.6×10^4	Nil	2.5×10^3
N14	2.6×10^4	Nil	1.3×10^3
N15	2.6×10^4	1.5×10^3	1.2×10^3
N16	3.2×10^4	1.6×10^3	1.3×10^3
N17	2.2×10^4	1.3×10^3	1.7×10^3
N18	1.7×10^4	1.9×10^3	2.6×10^3
N19	1.6×10^4	Nil	2.7×10^3
N20	2.5×10^4	2.8×10^3	2.4×10^3
N21	3.2×10^4	1.4×10^3	1.6×10^3
N22	2.4×10^4	Nil	1.5×10^3
N23	1.7×10^4	Nil	2.3×10^3
N24	1.8×10^4	2.2×10^3	2.4×10^3
N25	2.8×10^4	1.6×10^3	1.5×10^3

Keys: TVBC – total viable bacterial count, TCC – total coliform count, CFU – colony forming unit.

Table 2: Population counts of bacteria and fungi from used wristwatches in cfu/ml

Sample code	TVBC	TCC	Fungal count
W1	1.7×10^4	Nil	2.6×10^3
W2	3.5×10^4	1.7×10^3	$2.2x\ 10^3$
W3	2.6×10^4	1.5×10^3	$2.4x\ 10^3$
W4	1.7×10^4	Nil	2.6×10^3
W5	2.3×10^4	1.3×10^3	$2.4x\ 10^3$
W6	2.4×10^4	1.6×10^3	2.6×10^3
W7	2.5×10^4	1.3×10^3	$1.2x\ 10^3$
W8	1.7×10^4	Nil	2.6×10^3
W9	2.7×10^4	1.4×10^3	1.4×10^3
W10	2.4×10^4	1.3×10^3	1.3×10^3
W11	3.3×10^4	1.8×10^3	$1.6x\ 10^3$
W12	2.5×10^4	Nil	$1.8x\ 10^3$
W13	1.3×10^4	Nil	2.5×10^3
W14	1.6×10^4	Nil	2.5×10^3
W15	2.3×10^4	1.2×10^3	2.5×10^3
W16	3.3×10^4	1.4×10^3	$2.7x\ 10^3$
W17	2.7×10^4	1.6×10^3	$2.3x\ 10^3$
W18	1.4×10^4	Nil	2.5×10^3
W19	2.6×10^4	1.4×10^3	2.3×10^3
W20	2.7×10^4	1.6×10^3	2.4×10^3
W21	2.8×10^4	Nil	2.6×10^3
W22	1.6×10^4	Nil	1.4×10^3
W23	2.7×10^4	1.4×10^3	1.3×10^3
W24	2.6×10^4	1.7×10^3	$1.6x\ 10^3$
W25	3.6×10^4	1.4×10^3	1.4×10^3

Keys: TVBC – total viable bacterial count, TCC – total coliform count, CFU – colony forming unit

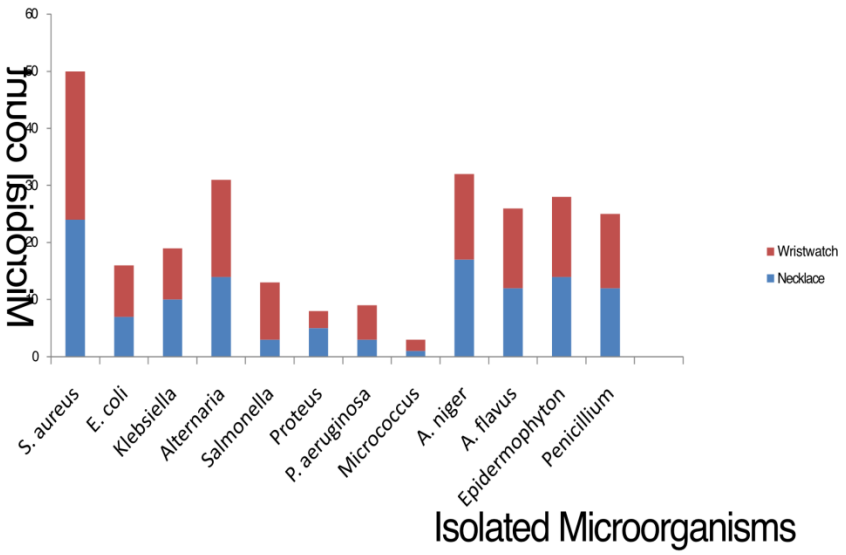

Figure 1: Occurrence of microbial species in different samples of used necklaces and wristwatches

Table 3: Antibiotic susceptibility of bacteria isolated from used necklaces and wristwatches

	Zones of inhibition (mm)									
	Gram-negative discs					Gram-positive discs				
Bacteria isolates	Septrin (30 µg)	Amoxycillin (30 µg)	Sparfloxacin (30µg)	Gentamicin (10µg)	Chloramphenicol (30µg)	Streptomycin (10µg)	Augmentin (30µg)	Ciprofloxacin (30µg)	Tarivids (10 µg)	Perfloxacin (30µg)
Staphylococcus aureus	7.0	7.0	12.0	6.0	13.0	11.0	14.0	16.0	9.0	11.0
E. coli	15.0	14.0	11.0	16.0	15.	2.0	13.0	19.0	16.0	14.0

Klebsiella sp	19.0	16.0	16.0	15.0	10.0	9.0	13.0	11.0	11.0	12.0
Pseudomonas aeruginosa	14.0	16.0	14.0	17.0	9.0	12.0	15.0	16.0	15.0	13.0
Bacillus sp	3.0	8.0	11.0	6.0	7.0	7.0	16.0	11.0	6.0	11.0
Salmonella sp	13.0	18.0	13.0	12.0	11.0	7.0	19.0	19.0	16.0	15.0
Proteus sp	16.0	15.0	18.0	16.0	6.0	6.0	13.0	18.0	16.0	19.0

$\leq$ 7 = Resistant, 8 -12 = intermediately susceptible, $\geq$13 = Susceptible.

Some of the fungi isolated are of significance to human health. *Aspergillus* sp. is responsible for a disease called aspergillosis while *Aspergillus flavus* is known to produce aflatoxin which is deadly to humans when consumed. Microorganisms including the normal body flora that were isolated, such as *Proteus* sp are not likely to cause diseases but when the skin is broken the normal body flora could become opportunistic, causing diseases. This is in agreement with previous findings which reported that some normal flora can become opportunistic pathogens, which may cause infection if tissue injury occurs at specific sites or if the resistance of the body to infection is reduced [17]. This also corresponds with the previous findings of [3] who reported that proper cleanliness habits and good hygienic practices tend to prevent the establishment of non-indigenous microorganisms among the natural skin microflora by preventing the build–up of excessive concentrations of organic matter [3].

These findings are in accordance with the previous results [17, 18] that isolated similar bacteria and fungi except the dermatophytes (*Trichophyton mentagrophytes, Microsporum gypseum*, and *Epidermophyton* sp from human jewelries. The occurrences of the bacteria on the jewelries suggest a relationship with the amount of moisture at the body sites where they are worn. The presence of the *Staphylococcus, Pseudomonas* species *and Micrococcus* specie, is attributable to colonization of the jewelry by skin flora, while the *Escherichia coli* and *Proteus* species, are likely to be contaminants from environmental sources. They can be shed into food during handling; their presence is significant because they are associated with gastrointestinal tract infections [5].

Staphylococcus aureus was isolated from samples of wristwatches and necklaces. Infant and young children can get infected by exfolatin-producing *Staphylococcus aureus* from pieces of Jewelry which they tend to put in the mouth. This can result in scalded skin syndrome, which could be fatal. This mode of transmission applies to other pathogenic strains of all these organisms isolated resulting to a range of diseases [4]**.**

Furthermore, most of the fungal isolates are the major culprits of dermatophytoses. *Epidermophyton* sp.*, Microsporum gypseum* and *Trichophyton mentagrophytes* are the major cause of ringworm (*Tinea corporis, Tinea capitis, Tinea pedis, Tinea unguium*). These infections could be contagious. They are acquired from active ringworm lesions on humans. The fungus settles on the skin, germinates, and forms a mass of hyphae, which eventually grows to produce circular lesions [4].

Pieces of jewelries harbouring these organisms could serve as a vehicle for transmission of diseases to immune-compromised patients. *Aspergillus* species have been associated with human infection (*Aspergillus flavus* is a common cause). Immuno-compromised patients exposed to sources contaminated with *Aspergillus* species may become colonized and subsequently infected. It may present as allergic broncho-pulmonary aspergillosis, necrotizing skin ulcers (in immune compromised patients), endocarditis, post-operative infections, and so on. [19]**.**

Infections are also caused by *Penicillium* spp. Superficial infections (Keratitis and Otomycosis) are commonly caused by *Penicillium* spp. *Trichoderma* species are common fungal species usually found in humid soil, decaying wood, and water related sites. They have been linked to several cases of human invasive infection in immune-compromised host [19]. This study revealed that pieces of necklaces and wristwatches could be colonized by pathogenic microorganisms. Some of these organisms may produce very toxic substances that could be very fatal when ingested. Hence, regular sanitization of jewelry is very important.

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