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Public Countertops as Sources of Microbial Infections in Calabar, Nigeria

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Abstract

Contamination of inanimate objects and environmental surfaces by microorganisms plays a significant role in the transmission of infection. This study was carried out to ascertain the role of **countertops** as infection source. A total of 240 public counters including wood, granite, tiles and plastics in different establishments were screened for the presence of potential bacterial and fungal pathogens using standard microbiological and biochemical methods. Countertops were swabbed using sterile moist swabs and cultured using peptone water, Blood Agar, CLED, and Sabouraud dextrose agar. Of the 240 countertops examined, 220 (91.6%) harbored microbes with Police Stations counters ranking highest 50 (100%) followed by Banks counters 58 (97.0%) while Bakeries counters had the least 10 (66.7%). The prevalence of microbes by location was statistically significant (p= 0.0001). Wooden countertops carried more microbes 35 (97.2%) than other countertops p=0.3295). Generally, the studied countertops carried more bacteria (90.8%) than fungi (12.5%). Countertops of banks carried more bacteria (96.6%) while those of bakeries carried the least (66.7%) whereas countertops of police station harbored more fungi (24.0%) than those in other establishments with eateries counters carrying no fungi at all. *Staphylococcus aureus* was the most frequently encountered bacteria (95.0%) followed by *Proteus mirabilis* and *Pseudomonas aeruginosa* (1.8% each), and *Shigella* species (1.3%). *Candida albicans* dominated among the fungal isolates (80.0%) followed by *Aspergillus flavus* (13.3%) and *Trichophyton rubrum* (6.6%). This study has demonstrated high prevalence of potential microbial pathogens on public counters which may constitute a public health risk to users. Regular cleaning, periodical microbiological assessment of public countertops and cautiousness whenever interacting with environment is recommended.

Keywords: *countertops, microorganisms, infection, inanimate objects*

Introduction

A countertop is a horizontal surface that forms a boundary between space for public use and space for workers to carryout service task. The surface is positioned at an ergonomic height for the user and a particular task for which it is designed. Studies have implicated counter surfaces in the transmission of microorganisms with the hands acting as chief organ for physical contamination of environmental surfaces. Human hands harbor microbes as a normal flora as well as transit microorganisms contracted from the environment (Fraser *et al*., 2015). Several microorganisms possess the potentials to survive the dry surfaces and this has become a rising health problem as these surfaces act as an inanimate means of transmission of infectious organisms responsible for diseases outbreaks. The major source of microbial contamination of counter is through aerosol droplets during talking, coughing, sneezing, sweeping and deposition by infected individuals who visit the establishment. Also, in hospital settings, the major source of contamination is from samples containing viable infectious agents, either of parasitological, bacteriological or fungal origin (Brecher and Hay, 2005).

Microorganisms colonizing the surfaces of counters range from bacteria genus such as *Staphylococcus*, *Pseudomonas*, fungi e.g., *Aspergillus* species and parasites which are divided into protozoan parasites such as *Entamoeba histolytica, Giardia intestinalis,* etc. and helminths such as hookworm, *Ascaris lumbricoides* and *Schistosoma* species (Harhay *et al*., 2010). These organisms have developed complicated separate physiologic resting stages which accord them the potentials to hibernate effectively due to low water activity (Grant, 2004; John and Adegoke, 2018).

Counters of public places serve as a canter at which people are served thus making it the beehive of activities, especially in a growing population of Calabar metropolis and people of different works of life, tribes and beliefs gather at these important centers that can involve possible interaction around and or between different inanimate objects which could harbor microorganisms. These counters serve as potential source for the transmission of microorganisms including fungal and bacterial agents (Flores *et al*., 2011). We are constantly surrounded by diverse microbial communities both in Banks, Hotels, Churches, Mosques, Police Stations and Eateries, etc. Humans get infected when we play or sit on contaminated surfaces. Microbiological contamination of public counters is well documented and these fomites serve as vehicle for cross-infection and recontamination of washed hands (Monarca *et al*., 2000). Some of the contaminants can be highly pathogenic and can be transferred from one person to another or may result in cross-inoculation leading to serious health consequences, hence the need to investigate pubic counters in Calabar, Nigeria for potential microbial pathogens, to ascertain their role as infection reservoir.

Materials and methods

Study Area

The study was carried out in Calabar, the capital of Cross River State in southern Nigeria. Calabar is often described as the tourism capital of Nigeria, especially due to several initiatives implemented during the administration of Donald Duke (1999-2007), which made the city the cleanest and environmentally friendliest city in Nigeria. Administratively, the city is divided into Calabar Municipal and Calabar South Local Government Areas. It has an area of 406 Km^2 and a population of 371,022 as at 2006 census (Ering, 2010). Calabar is a large urban city with several hotels, good road network, hospitals, schools and many other establishments. The annual Calabar carnival attracts thousands within and beyond Nigeria into the city. Study sample site included countertops in police stations, banks, eateries, hospitals, hotels in both local Government areas.

Study Design

A cross sectional study design was used for this study.

Informed Consent

This was sought and obtained from the managers of the selected establishments where the samples were to be collected who were also briefed on the type, purpose, and benefits of the study.

Administration of questionnaires

Interviewer's administered questionnaires were used to obtain information about the counters e.g., type of counter surface, cleaning frequency, type of cleaning materials etc.

Sample collection and sampling technique

A total of 240 samples were collected at convenience from countertops of selected establishments in the Calabar metropolis (including; banks, eateries, hospitals, police stations, and hotels) at the close of work. Sterile swab dipped in sterile peptone water was used to swab the surface of each countertop in different establishments. All samples were immediately transported to the laboratory for processing.

Examination of samples and identification of bacteria

The samples collected were inoculated into freshly prepared blood agar plates for morphological and haemolysis display and Cysteine lactose electrolyte deficient agar (CLED). The plates were incubated aerobically at 37°C for 24hrs-48hrs (Cheesbrough, 2006). All typical colonies were identified morphologically with the aid of hand lens by their colour, consistency, size, shape, odour, and presence of haemolysis (on blood agar).

At the end incubation, a suspected colony was picked using sterile wire loop and evenly spread to form smear on a clean grease free glass slide. It was allowed to air-dry in a safe dry place, fixed by heat and gram stained and viewed microscopically using 100x objective lens (Cheesbrough, 2006).

Already prepared smear was flooded with crystal violet for 30 seconds, rinsed with water and flooded with gram's iodine for 30 seconds also. The Iodine was then rinsed out with 70% alcohol and water. Safranin was then applied on the smear for 60 seconds. The slide was rinsed, allowed to dry and viewed in the microscope using 100x objective lens (Cheesbrough, 2010). Bacterial isolates were identified using standard biochemical tests including oxidase, urease, catalase, coagulase, indole and Kligler iron agar.

Examination of samples and identification of fungi

The samples collected were inoculated each into 2 freshly prepared Sabouraud Dextrose agar, one plate incubated at 37°C for 24 - 72 hours and the other at room temperature aerobically for extended period (2-7days) (Cheesbrough, 2010). Cultures were examined with unaided eye for color, odour, size, consistency and shape of colonies. This was carried out using lactophenol cotton blue stain to evaluate the morphology of yeast and to determine the presence or absence of hyphae. A yeast colony from the culture plate was inoculated into 0.5ml of serum in a test tube and incubated at 37°C for 3 hours. Using a Pasteur pipette, a drop of the serum yeast culture was placed on a glass slide and covered with cover slip. The preparation was examined under the microscope with the x10 and x40 objective lenses. A tube-like outgrowth from the cell (germ tube) was looked out for.

Statistical analysis

Statistical analysis was carried out by the use of the Statistical Package for Social Science (SPSS) version 21.0. Proportions were compared using Chi-square test. *p*-value less than 0.05 was considered statistically significant at 95% confidence interval.

Results

The results obtained in this study are shown in tables 1 – 4 respectively.

The distribution of microorganisms on countertops by location is shown in table 1. Overall, 220 (91.6%) of the 240 countertops examined harbored microbes with countertops of police station ranking highest 50 (100.0%) followed by those of banks 58 (97.0%), eateries 28 (93.0%), hospitals 30 (88.7%), hotels 44 (88.0%), and bakeries 10 (66.7%). The prevalence of microorganisms by location (establishment) was statistically significant ($X^2 = 262.05, p < 0.0001$).

The frequency of microbes on public counters by types of countertops is displayed in table 2. Wooden counters were observed to carry more microbes 35(97.2%) while marble/Granite carried the least 70(87.55%) among the different countertops examined. The differences in occurrence by types of countertops was statistically insignificant. ($X^2=3.4334, p=0.3295$).

Fig.1 displays the distribution of bacteria and fungi on countertops by location. Out of the 240 countertops examined, 218 (90.8%) harbored bacteria and 30 (12.5%) fungi. Countertops located in banks carried more bacteria (96.6%) closely followed by those in police station (96.0%) and eateries (93.3%), hotels (88.0%), hospitals (85.7%) and bakeries (66.7%). Police station counters carried more fungi (24.0%) than those located in other establishments with eateries countertops showing no fungal growth at all.

Frequency of potential microbial pathogens based on species is demonstrated in table 3. Among the bacterial isolates, *Staphylococcus aureus* was the most frequently isolated (95.0%) followed by *Proteus mirabilis* and P*seudomonas aeruginosa* (1.8% each), and *Shigella species* (1.3%). *Candida albicans* dominated among the fungal species isolated (80.0%). Others were *Aspergillus flavus (*13.3%) and *Trichophyton rubrum* (6.6%).

Table 1: Distribution of microorganisms on countertops by location

Counter Location	No. Examined	No. (%) with Microbes
Eateries	30	28 (93.3)
Banks	60	58 (96.7)
Hotels	50	44 (88.0)
Police Station	50	50 (100)
Hospitals	35	30 (85.7)
Bakery	15	10 (66.7)
Total	**240**	**220 (91.7)**

Table 2: Frequency of microbes on public counters by types of countertop

Countertop Types	No. Examined	No. (%) with Microbes
Concrete	94	87 (92.6)
Wooden	36	35 (97.2)
Marble/Granite	80	70 (87.5)
Plastic Laminate	30	28 (93.3)
Total	**240**	**220 (91.6)**

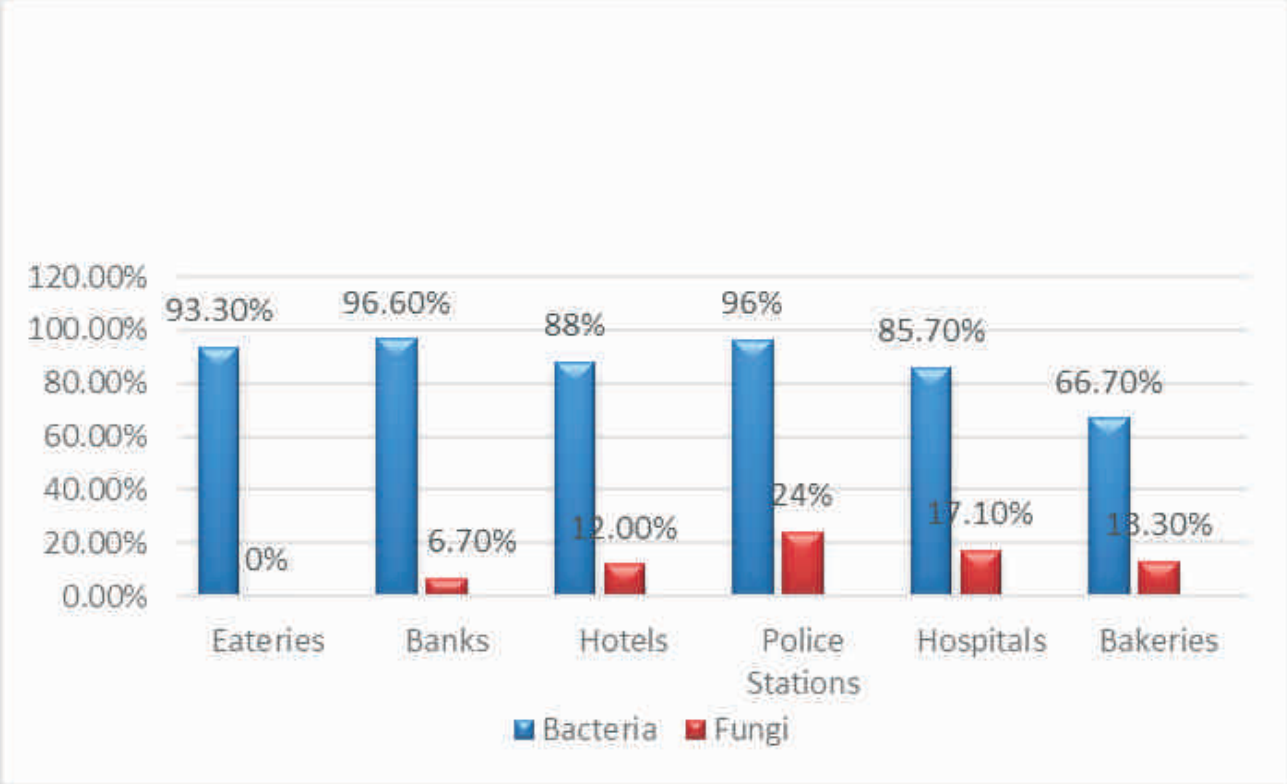

Figure 1: Distribution of bacteria and fungi on countertops by Location

Table 3: Frequency of potential microbial pathogens based on species

Species	Frequency	Percentage (%)
Bacteria		
Staphylococcus aureus	207	95.0
Proteus mirabilis	4	1.8
Shigella species	3	1.3
Pseudomonas aeruginosa	4	1.8
Subtotal	218	100.0
Fungi		
Candia albicans	24	80.0
Trichophyton rubrum	2	6.6
Aspergillus flavus	4	13.3
Subtotal	30	100.0

Discussion

The high prevalence of bacteria recorded in this work (90.8%) is in agreement with earlier works by Zubair *et al*. (2018) in Pakistan which reported bacteria as having a high prevalence of 96.2%. Similarly, *John and Adegoke (2018),* in Uyo, Nigeria, observed bacterial load range of log10 1.5±0.3 CFU/cm^2 - log10 6.3 ± 0.7CFU/cm^2 on the contact surfaces, including countertops at the bus terminals. The result obtained in this study is higher than the rate of 88.8% obtained in Ghana (Tagoe *et al*., 2011) and 78% obtained from frequently-touched objects in a tertiary care hospital of Pokhara, Nepal (Bhatta *et al*., 2018).

The fungal prevalence, 12.5% is much lower than 55.6% recorded in Recife-pe, Brazil (Silva *et al*., 2019) and 88% in Bobo-Dioulasso, Burkina Faso (Matotou *et al*., 2021). Bacterial contamination could be as a result of contamination of hands by wounds, faeces, vomits, discharge and other body fluids by the transmitting subjects (World Health Organization, 2009). Kingston *et al. (2017)* suggested constant and regular washing of hands after use of the toilet, or after getting in contact with other body fluids. Routine cleaning and sanitization of these public countertops surfaces with disinfectants like, Izal, sodium hypochlorite, methylated spirit, alcohols every 2-3 hours will help reduce the microbial loads on the surfaces.

The increasing incidence of epidemic outbreaks of certain diseases and their rate of spread from one person to the other has become a major public health concern (WHO, 2009). Surfaces of counters of public places like hotels, banks police stations, eateries, bakeries and betting (sport) centers in Calabar may serve as a source of microbial contamination. Counters located in police stations and banks had more contaminations (100%) and (97%), respectively. It is interesting to note that most of these establishments had wooden tops which were also observed to be the most contaminated. This is so because wooden countertops tend to be a good environment for the habitation of microorganisms than other countertops. Record has shown that contamination and colonization of counters by microorganisms is mostly encouraged by poor maintenance of the counter surface and that the frequency of contamination and microbial load on a counter surface is determined by the material the counter is made of smooth counters made of tiles and ceramics usually have less contamination than wooden or concrete counters which are rough, thus allowing for easy deposition of microbes on their surfaces; Wassmann *et al*. (2017) linked surface roughness and wettability to adhesion properties of bacteria to biomaterials.

Staphylococcus aureus (94.5%) was the most commonly isolated organism in this study. Our finding is in agreement with earlier reports, ding

those of Bhatter *et al.* (2018) (20%), Tagoe *et al*. (2011) (57.6%) and Shawk *et al. (2018)* (68.8%.) which showed *Staphylococcus aureus* as having highest prevalence. This organism is a potentially pathogenic organism that can cause an array of infections ranging from simple abscesses to life threatening infections including pneumonia, endocarditis, meningitis and many others (Tong *et al*., 2015). The dominance of *Staphylococcus aureus* could be attributed to the ubiquitous nature of the organism being found as part of the normal flora of the human skin and hands which often make contact with objects in the environment. This organism being a member of the normal flora of the skin and nares of humans is easily discharged by several human activities (Cole *et al*., 2001). All the other bacterial isolates in the study were members of the family Enterobacteriaceae. Their presence may have been as a result of fecal contamination and poor hygiene.

Among the fungal isolates, *Candida albicans* had the highest prevalence, 24(80.0%) followed by *Aspergillus flavus,* 4(13.3%) and *Trichophyton rubrum,*2(6.6%). This agrees with an earlier work by Anibijuwon *et al. (2015)* in Ilorin, Nigeria, though with much lower prevalence,14.5%. Fungal elements may be spread through airborne spores, droplets and inanimate objects, including handsets, handbags/purses which are often kept and moved between clean and dirty environments such as kitchen tables, restrooms floor/countertops, and other public countertops (Biranjia-Hurdoyal *et al*., 2015).

Most of the samples examined had more than one type of bacterial isolate, and the fact that these contaminants were at high levels in these environments is an indication of poor hygiene practice on the part of the studied establishments as revealed in the questionnaires. The level of contaminants observed in public counters and the variety of organisms associated is of great concern and calls for an urgent intervention as the staff, customers, in fact, all counter users and the general population, especially in this era of COVID -19 pandemic to reduce the risk of infection and epidemic outbreak.

Conclusion

The present study has revealed a high prevalence of microbial contaminants, including potential bacterial and fungal pathogens on the surfaces of public counters, especially wooden counters in Calabar metropolis. This poses serious public health risk as they may be health-related time bombs due to their potentials to cause epidemic outbreaks. Observing a high level of personal/group hygiene, including regular handwashing and proper sanitation, and the use of microbial resistant and easy-to-clean materials such as marble/granite for countertops to reduce microbial contamination should be encouraged.

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Conflict of interest

The authors declare no conflict of interest.

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