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Research Article

Identification of Microorganisms Associated with Point of Sale (POS) Devices in Major Markets in Calabar

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Abstract

Background: Point of Sale (POS) devices are widely used for electronic transactions in markets and commercial settings, yet their role as potential reservoirs for pathogenic microorganisms remains poorly studied, particularly in resource-limited environments.
Aim: This study investigated the microbial contamination of POS devices in three major markets in Calabar, Watt Market, Marian Market, and Ikot Ishie Market.
Method: A total of 20 POS devices (5 per market) were sampled by sterile swabbing of the keypad, touchscreen, and casing surfaces. Samples were transported in sterile peptone water and processed under aseptic conditions using Nutrient agar, MacConkey agar, Mannitol salt agar, Blood agar, Salmonella-Shigella agar, Thiocitrate bile salt agar, and Sabouraud dextrose agar. Bacterial isolates were identified by Gram staining, colony morphology,and standard biochemical tests, while antibiotic susceptibility was determined by disc diffusion according to Clinical and Laboratory Standards Institute (CLSI) guidelines.
Results: Total heterotrophic bacterial counts (THBC) on POS keypads ranged from 5.6 ± 0.1 to 7.8 ± 0.6 $\log_{10}$ CFU/cm² and 3.4 ± 0.3 to 5.0 ± 0.2 $\log_{10}$ CFU/cm², with a statistically significant increase in bacterial counts across all locations ($p < 0.05$). Organisms isolated included *Escherichia coli, Staphylococcus aureus, Staphylococcus epidermidis*, and species of *Bacillus, Pseudomonas, Proteus, Streptococcus, Salmonella, Shigella, Micrococcus, Vibrio* and *Klebsiella*. Among Gram-positive isolates, *Staphylococcus* aureus recorded the highest frequency of occurrence (18.2%), while *Micrococcus* spp. had the highest frequency (17.2%) among all isolates; *Vibrio* spp.(1.4%) and *Proteus* sp. (2.8%) were the least frequently isolated. Gram-positive isolates showed the highest susceptibility to Gentamycin and the greatest resistance to Augmentin, while Gram-negative isolates were most susceptible to Ofloxacin and most resistant to Amoxicillin.
Conclusion: These findings indicate that POS device user interfaces serve as potential sources of pathogenic and antibiotic-resistant organisms. Regular disinfection of POS devices and public awareness campaigns on personal hygiene practices after device use are recommended to reduce associated infection risks.

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1. Introduction

Point of Sale devices (POS) are increasingly used for electronic transactions in markets, business [1], and other commercial settings. In Calabar, like in many other Nigerian cities, POS devices have gained prominence due to their convenience and ability to provide financial services to areas with limited access to banks. These devices are often handled by multiple individuals daily, including point of sale device operators, customers, and vendors. The handling of POS devices without adequate hygiene practices creates a conducive environment for the accumulation and transfer of microorganisms, including potentially pathogenic bacteria and fungi. In crowded and busy environments like major markets in Calabar, the high turnover of users increases the likelihood of microbial contamination, presenting public health concerns particularly in regions where infectious diseases and poor hygiene are prevalent [2].

Several studies of the human environment have demonstrated colonization of objects such as door handles, faucets, phones, fabrics, and plastic. People come into daily contact with all sorts of fomites, with an increasing rate of bacterial infection. The spread of infectious disease through hand contact has been an area of major concern [3]. Gram-positive *Staphylococcus aureus* and gram-negative enteric bacteria such as *Escherichia coli,Klebsiella* species, and *Citrobacter* species have been found on such surfaces. Bacteria capable of causing severe gastroenteritis have been found on POS keypads/buttons [4]. When one touches a contaminated POS device and then touches the mouth, nose, or eye, there may be transfer of germs into the body. The presence of pathogenic bacteria on the user interface of POS devices possesses a potential risk to vulnerable, immune-compromised individuals. It has been shown that hard,non-porous surfaces such as POS devices have the highest bacteria transfer rate to hands [4, 5]. Once contaminated, POS devices become vehicles for transmission of infection; the organism picked up can introduce infections into individuals orally or topically, or can be transferred to other persons.Unlike other high-touch surfaces, POS devices have received little attention as possible reservoirs for microorganisms, despite their widespread use in market environments characterized by crowded conditions, inadequate sanitation, and poor hygiene practices.

Understanding the types of microorganisms associated with POS devices can provide insights into their role as vectors of disease and inform strategies to mitigate health risks. Therefore, this study aimed at the identification of microorganisms associated with Point of Sale devices in major markets in Calabar, with specific objectives to isolate and identify microorganisms present on POS devices in selected markets, determine the prevalence of pathogenic microorganisms on these devices, and assess the potential sources of contamination and risk factors associated with Point of Sale devices.

2. METHODS

2.1. Study Area

The study was conducted in three major markets in Calabar: Watt Market, Marian Market, and Ikot Ishie Market. These markets were selected due to their high commercial activity and large number of POS devices in use.

2.2. Sampling Procedure and Sample Collection

5 POS machines per market were swabbed (total of 20). Swabbing was done on keypad, touchscreen, and casing. Samples were transported in sterile peptone water. Point of sale devices were selected randomly within each market, while sterile swabs were used to collect samples from the keypad, screen, and casing of each device, and were transported in sterile containers to the microbiology laboratory for analysis.

2.3. Bacteriological Quality Assessment

All samples collected were processed in the University of Calabar Science Laboratory Technology according to standard bacteriological methods under complete aseptic conditions. The swabs were inoculated on appropriate culture media (Nutrient agar, MacConkey agar, Mannitol salt agar, Blood agar, *Salmonella-Shigella agar*, and Thiocitrate bile salt agar) by direct streak method in triplicates and incubated at 37°C under aerobic conditions for 18–48 hours. The surface swabs were also processed using the swab-rinse method for enumeration of bacteria associated with the fomites. The swab sticks were agitated up and down in the tubes containing Peptone water to aid rinsing of the swab sticks. Serial dilution of the swab-rinse was made to promote appropriate dilutions from which aliquots for inoculation unto sterile media were obtained. Aliquot (1ml) of swab-rinsed dilutions were used for inoculation unto Nutrient agar, MacConkey agar, Mannitol salt agar, Blood agar, *Salmonella–Shigella agar*, and Thiocitrate bile salt agar using pour plate method. Inoculated plates were incubated at 37°C for 18–24 hours for enumeration of Total Heterotrophic Bacterial Counts. The emerging discrete colonies were counted using a colony counter and the bacteria population were expressed in colony forming unit per gram (CFU/g). Enumeration of the isolates was only in plates with colonies between 25–250. Discrete colonies which grew were picked using a sterile wire loop and inoculated on the freshly prepared media previously used for primary culturing respectively using streak plating method. Pure isolates were preserved in MacCartney bottles as stock cultures in the refrigerator at 4 to 8°C for further analysis.

2.4. Microbial Analysis

Plating on Nutrient agar (bacteria), MacConkey agar (gram-negative), and Sabouraud dextrose agar (fungi). Incubation at 37°C for 24–48 hrs (bacteria) and 25°C for 5 days (fungi).

2.5. Antibiotic Sensitivity Test

The antibiotic test was carried out to detect organisms that were susceptible or resistant to standard antibiotics. Each inoculum of the bacterial isolate was suspended in 2ml of sterile water and subsequently diluted to the turbidity of the McFarland standard. Susceptibility testing was carried out according to Clinical and Laboratory Standard Institute (CLSI) procedures using the commercially prepared antibiotic discs (Abtek Biologicals Ltd) with the following antibiotics: Amoxicillin (25 µg), Gentamicin (10 µg), Cotrimoxazole (25 µg), Nitrofurantoin (20

µg), Nalidixic acid (30 µg), Ofloxacin (5 µg), Augmentin (30 µg), Tetracycline (10 µg), Cloxacillin (5 µg), Erythromycin (5 µg), Streptomycin (10 µg), and Chloramphenicol (10 µg).

2.6. Characterization and Identification of Bacterial Isolates

The bacterial isolates were characterized and identified by comparing to known taxa using Bergey's Manual of Determinative Bacteriology based on their morphology, microscopic appearance and biochemical characteristics [6].

2.7. Identification Techniques

Colony morphology, Gram staining, Biochemical tests (Catalase, Coagulase, Oxidase, IMViC), and fungal identification using lactophenol cotton blue staining.

2.8. Statistical Analysis

Statistical Package for the Social Sciences (SPSS) version 21 was employed for the statistical analysis of data generated. This included percentage, mean, and standard deviation.

3. Results

Table1 presents the microorganisms identified from POS devices across the four markets. Marian Market yielded *S. aureus, E. coli*, and *B. subtilis* as bacterial isolates, and *Candida* spp. as the fungal isolate. Watt Market yielded P. *aeruginosa*and *Klebsiella* spp. as bacterial isolates, and *Aspergillus* spp. as the fungal isolate. Ikot Ishie Market yielded *S.aureus* and *Proteus* spp. as bacterial isolates, and *Candida* spp. as the fungal isolate. 8miles Market yielded *E. coli* and *Bacillus* spp. as bacterial isolates, and *Penicillium* spp. as the fungal isolate.

Table 1: Microorganisms Identified from POS Devices per Market

Market	Bacteria Isolated	Fungi Isolated
Marian Market	*S. aureus, E. coli, B. subtilis*	*Candida spp.*
Watt Market	*P. aeruginosa, Klebsiella spp.*	*Aspergillus spp.*
Ikot Ishie Market	*S. aureus, Proteus spp.*	*Candida spp.*
8miles Market	*E. coli, Bacillus spp.*	*Penicillium spp.*

Table 2 shows the average microbial load on POS device surfaces across the four markets. Total heterotrophic bacteria and total fungal counts from the markets' POS device keypads were enumerated and expressed in colony-forming units per square centimetre (cfu/cm²). Watt Market recorded the highest total bacterial load (3.0×10^3 cfu/cm²) and the highest fungal load (1.5×10^2 cfu/cm²). Ikot Ishie Market recorded the lowest bacterial load (1.9×10^3 cfu/cm²) and the lowest fungal load (9.0×10^1 cfu/cm²). Marian Market and 8miles Market recorded bacterial loads of 2.4×10^3 and 2.1×10^3 cfu/cm², with corresponding fungal loads of 1.1×10^2 and 1.3×10^2 cfu/cm², respectively. Bacterial loads exceeded fungal loads across all four markets.

Table 2: Average Microbial Load (cfu/cm²) on POS Devices

Market	Total Bacterial Load (cfu/cm²)	Fungal Load (cfu/cm²)
Marian Market	2.4×10^3	1.1×10^2
Watt Market	3.0×10^3	1.5×10^2
ikot Ishie Market	1.9×10^3	9.0×10^1
8miles Market	2.1×10^3	1.3×10^2

The results obtained from biochemical characteristics and identification of isolates are shown in Table 3. It revealed the presence of Gram-positive bacteria with the highest occurrence (*Staphylococcus aureus* – 18.2%) which showed highest sensitivity(90%) to Gentamycin and highest(100%) resistance to Augmentin. *Streptococcus* (8%) with the least occurrence showed highest (100%) sensitivity to Gentamycin and highest (100%) resistance to Erythromycin, Cotrimoxazole, Cloxacillin, and Augmentin. The Gram-positive bacteria revealed *Micrococcus* (17.2%) with highest occurrence which showed highest sensitivity (90%) to Gentamycin and highest (100%) resistance to Tetracycline, Chloramphenicol, and Augmentin. *Vibrio* (1.4%) with least occurrence among the Gram-negative bacteria exhibited highest (80%) sensitivity to Ofloxacin and highest resistance (100%) to Amoxicillin, Augmentin, Cotrimoxazole, Gentamycin, Nalidixic acid, and Nitrofurantoin. *Pseudomonas*, the Gram-negative bacteria with highest occurrence (12.2%), showed highest (95%) sensitivity to Ofloxacin and highest (100%) resistance to Augmentin, Amoxicillin, Nalidixic acid, and Tetracycline. *Proteus* with least occurrence (2.8%) revealed highest sensitivity (100%) to Ofloxacin and Gentamycin and highest resistance (80%) to Augmentin and Amoxicillin.

Table 3: Biochemical characteristics and identification

Isolates	Gram Reaction	Catalase	Oxidase	Indole	Methyl red	Vogesproskauer	Citrate utilization	Suspected organism
1	-	+	+	+	+	-	±	*Escherichia colo*
2	+	-	-	-	+	-	+	*Lactobucillus*
3	-	+	-	-	+	±	+	*Bacillus specie*
4	+	+	+	±	±	+	+	*Bacillus specie*
5	+	+	+	-	±	+	+	*Bacillus specie*
6	-	+	+	-	±	+	+	*Salmonella typhi*
7	+	+	+	+	-	+	+	*Bacillus specie*
8	-	-	-	+	-	-	-	*Enterobacteriaceae*
9	-	+	+	-	±	-	±	*Pseudomonas*
10	+	+	-	-	-	-	-	*Staphylococcus*
11	+	+	+	±	+	+	+	*Micrococcus specie*
12	+	+	+	±	+	+	+	*Micrococcus specie*
13	+	-	-	±	±	-	-	*Lactobacillus* acido phyllus

key: Negative, + Positive,± Variable

4. Discussion

The presence of pathogenic bacteria such as *Staphylococcus aureus*, *Escherichia coli*, and *Pseudomonas aeruginosa* suggests a risk of cross-contamination through frequent handling of Point of Sale (POS) machines. Markets with higher human traffic had more diverse and denser microbial populations. The detection of fungi like *Candida* and *Aspergillus* indicates environmental contamination and poor device hygiene. This aligns with previous studies indicating that handheld devices can serve as reservoirs for pathogens [7, 8]. Microorganisms are ubiquitous and their ability to cause contamination on environmental objects and their surfaces has been reported [9].

The results of this study showed the Total Heterotrophic Bacterial Counts for the machine users in the market. The highest bacterial load at market is attributed to the frequent and relative reliance of a large segment of the populace on use of the e-banking facilities, the hygienic status of the machine users, and the environment where it is placed. Furthermore, there was high contamination of the fomites in the wet season compared to the dry season. The difference in the bacterial load is attributed to the influence of varied environmental conditions on the growth of bacteria on surfaces [10]. The results indicate more favourable growth conditions in the wet season than dry season for the bacteria associated with the fomites.

Gram-negative bacteria and a smaller number of Gram-positive bacteria were detected; this included *Staphylococcus epidermidis, Staphylococcus aureus, Escherichia coli*, and species of *Bacillus, Pseudomonas, Proteus, Streptococcus, Salmonella, Shigella, Micrococcus, Vibrio*, and *Klebsiella*. These results corroborate the reports on the colonization of fomites by microbes via hand contact surfaces [11].

Species of *Vibrio* (1.4%) were the least isolated bacteria in the dry season and attributed to the microbial pattern among users of the POS as well as the environmental condition hosting the facilities. According to Willey et al.,[10], *Vibrio* are organisms with high pathogenicity, causing even death in some major outbreaks and infections. *Staphylococcus aureus* (18.2%) had high occurrence in the wet season with 13.2% in the dry season on the fomites. Staphylococcus epidermidis was also present in the wet and dry seasons on these facilities. Akinola et al. [12] reported that the association of Staphylococcus species on the ATMs and POS keypads is attributed to their existence as part of the normal flora. The coagulase-negative species have relatively low virulence but are increasingly recognized as agents of clinically significant infection of the blood stream and other sites and are frequently associated with nosocomial infections. They are known to be responsible for infections such as bacteraemia, endocarditis, and urinary tract infections [13]. *Staphylococcus aureus* is a common cause of skin infections, respiratory infections, and food poisoning. Pathogenic strains often promote infections by producing potent protein toxins and expressing cell surface proteins that bind and inactivate antibodies [14]. A worldwide problem in clinical medicine is the emergence of antibiotic resistant strains of *Staphylococcus aureus* such as methicillin-resistant *Staphylococcus aureus* [10].

Proteus species was less frequent (2%) in the wet season and are commonly found in the human intestinal tract as part of normal human intestinal flora and also exist in multiple environmental habitats including long-term care facilities and hospitals. They are often regarded as indicators of fecal pollution, posing a threat of poisoning when they contaminate food or water [15]. Species of *Proteus* are opportunistic pathogens and the most common cause of nosocomial infections [16]. The presence of *Bacillus* species on the POS user interface is attributed to its spore forming ability which probably causes it to be dispersed into the air and thus be able to settle on the surface of the key pads and its persistence on dry surfaces .It is a transient microflora of hands and adapts to varying environmental conditions. Species of *Bacillus* have been involved in food poisoning and food spoilage [10].

Escherichia coli, Shigella sp., and *Salmonella* sp.were also associated with the contact surfaces of these facilities. These organisms are enteric pathogens that are linked withgastroenteritis [17]. Their presence on the user interface indicates fecal contamination most likely from contaminated and unwashed hands and can easily be transferred from fingers to food surfaces and cause acute ailments. Virulent strains of *scherichia coli* cause gastroenteritis, urinary tract infections, neonatal meningitis, septicemia, dysentery, vomiting, stomach cramps, and flatulence [10]. Species of *Salmonella* cause a range of illnesses including typhoid fever and gastroenteritis; food infections (salmonellosis) which is often fatal in patients with compromised immune systems [18]. *Shigella* species cause Shigellosis which is associated with diarrhea (sometimes bloody), fever, severe stomach cramps or tenderness, and dehydration [19].

The presence of *Streptococcus* sp. and *klebsiella* sp. indicate the possibility of mouth or nasal contamination from the aerosol discharge from mouth and nose that might have been shed to those surfaces by the users of POS machines. These organisms have been implicated in respiratory infections. *Pseudomonas* species which are found in soil were also associated with the fomites. These organisms are opportunistic pathogens and their presence on these facilities is a cause for concern, because they are known to cause infections, especially in hospital settings [10].

The findings of this study indicate that POS keypads can be considered a source of bacterial infections because most people with different levels of hygiene and health status use these items. They can therefore be widely involved in absorbing, harboring, and transferring infectious microorganisms. Contaminated hands touching a POS keypad can transfer pathogens, ultimately facilitating the spread of infectious diseases [6]. The antibiogram results suggest that some of the bacteria are resistant to standard antibiotics (Table 3). Susceptibility of isolates indicate Gentamycin and Augmentin as the most and least effective antibiotics respectively against the Gram-positive bacterial isolates. Ofloxacin and Amoxicillin were the most and least effective antibiotics respectively against the Gram-negative bacterial isolates. This result agress with other reports [11] but contrasts with the reports that indicate high susceptibility of bacterial isolates associated with contact surfaces to Augmentin [6]. In addition, the bacterial isolates were sensitive to rarely used antibiotics and resistant to commonly used ones. The variations in the antibiotic sensitivity pattern among the bacterial isolates is attributed to the emergence of resistant strains from the abuse of antibiotics for prophylaxis and treatment.

5. Conclusion

Point of Sale devices in crowded markets harbor potentially pathogenic microorganisms. Routine disinfection and public awareness are essential to reduce transmission risks. Point of Sale (POS) machine user interfaces are contaminated with pathogenic bacteria species associated with possible health implications and were resistant to some commonly used antibiotics. The major contributing factor is poor hand hygiene practices exhibited by POS users and exposure of the facilities to dust. This indicates the interface as potential vehicles for the transmission of clinically important pathogens through human hands.

Based on the results of this study, strict adherence to basic rules of hand washing after POS use and proper cleaning/disinfection regimen of these facilities should be practiced regularly to reduce contamination. Public health awareness on the need for hand washing and proper hygienic use of these facilities by government and non-governmental organizations is also recommended to reduce associated health risks through these vital banking/marketing tools.

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