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# Assessment of Microbial Contamination and Antibiotic Resistance Profiles of Bacteria on Nigerian Currency Notes: Implications for Public Health and Antimicrobial Resistance

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***Authors' contributions***

*This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.*

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## ABSTRACT

**Background:** Many microbes have been associated with the contamination of Naira notes, and most of these microbes have shown high resistance to antimicrobials, with different resistance profiles including multidrug-resistant (MDR), extensively drug-resistant (XDR), and pandrug-resistant (PDR). Therefore, the aim of this study was to investigate the microbial contamination and antibiotic resistance profiles of isolated microorganisms on Nigerian currency notes, emphasizing their public health implications.
**Methods:** A total of 112 currency notes, spanning all eight denominations, were collected from rural (Oyan) and urban (Osogbo) regions in Osun State, Nigeria. Microbial isolation and identification were performed using standard culture techniques, while antibiotic susceptibility was assessed via the Kirby-Bauer disc diffusion method. Data were analyzed using SPSS.
**Results:** Microbial analysis revealed high contamination rates, with *Klebsiella* sp (35.7% rural, 23.2% urban) and *Staphylococcus aureus* (28.6% rural, 26.8% urban) being the most prevalent bacterial isolates. *Aspergillus* sp was the dominant fungal contaminant, particularly in rural areas. Polymer-based notes exhibited lower contamination compared to paper-based notes. Antibiotic susceptibility tests highlighted alarming multidrug resistance (MDR), with *Staphylococcus aureus* showing high resistance to Penicillins and Cephalosporins. *Pseudomonas aeruginosa* displayed extensive drug resistance (XDR) to multiple antibiotic classes, leaving limited treatment options.
**Conclusion:** Nigerian currency notes are significant reservoirs of microbial contamination and multidrug-resistant pathogens, posing severe public health risks. The study underscores the need for improved hygiene practices, public awareness campaigns, and a transition to polymer-based notes. Strengthened antibiotic stewardship programs and regulatory measures are essential to combat rising antimicrobial resistance and prevent pathogen dissemination through currency handling.

*Keywords: Multidrug-resistant (MDR); extensively drug-resistant (XDR); pandrug-resistant (PDR); contamination; fungi.*

## 1. INTRODUCTION

Currency notes, used daily in financial transactions, are among the most frequently handled objects worldwide, making them potential vehicles for pathogen transmission. Since the early 1900s, researchers have acknowledged that banknotes can harbor a variety of microorganisms, including bacteria, viruses, and fungi, for extended periods (Yar, 2020). This raises significant public health concerns, especially in regions with high cash usage and limited awareness of currency hygiene practices. The role of contaminated currency in spreading infectious diseases is particularly important to explore in areas with poor sanitation and a reliance on cash, such as Nigeria.

In West Africa, studies have highlighted the risks of microbial contamination on currency. For example, research conducted in Ghana found that circulating banknotes harbored diverse bacterial species, both pathogenic and non-pathogenic, indicating that currency could serve as a reservoir for harmful microorganisms (Yar, 2020). Similarly, in Nigeria, studies on commonly touched surfaces, such as toilet door handles, have revealed the presence of skin- and soil-associated bacteria, reinforcing the idea that everyday objects, including currency, can facilitate the transmission of infectious agents (Alonge et al., 2018; Huang et al., 2017).

Banknotes are produced from various materials, including cotton, linen, and synthetic fibers, to enhance durability. Many countries, including Nigeria, have adopted polymer-based notes, which tend to resist wear and microbial contamination better than traditional paper-based notes (Alemu, 2014; Angelakis et al., 2014; Majiya et al., 2015). However, both polymer and paper notes remain susceptible to contamination, particularly in environments with high humidity and population density, such as Nigeria, where public health policies regarding currency hygiene are not strictly enforced (Oyelami et al., 2020). Research from Nigeria and nearby countries shows that banknotes, especially those in street markets, are often contaminated with bacteria (Ngwai, 2011; Yar, 2020; Riduan et al., 2020). Cultural practices, such as using saliva to wet fingers while counting money, further contribute to this contamination.

In Nigeria, bacteria isolated from naira notes include *Escherichia coli*, *Staphylococcus aureus*, *Pseudomonas aeruginosa*, *Klebsiella pneumoniae*, *Salmonella typhi*, *Vibrio cholerae*, *Aspergillus niger*, and *Blastomyces dermatitidis* (Musa et al., 2020; Orababa et al., 2021). Alarmingly, some studies have identified high levels of resistance to commonly used antibiotics among bacterial pathogens found on currency notes, posing a significant public health challenge (Orababa et al., 2021). While previous research has documented bacterial contamination on currency, few studies have provided detailed antibiotic resistance patterns. None have explored the resistance profiles, including multidrug-resistant (MDR), extensively drug-resistant (XDR), and pandrug-resistant (PDR) microorganisms. Understanding these resistance profiles could offer critical insights into the public health risks associated with currency use (Wang et al., 2020).

The emergence and spread of MDR, XDR, and PDR bacteria present a major threat to global health. Multidrug-resistant bacteria are defined as those resistant to at least one agent in three or more antimicrobial categories, while extensively drug-resistant bacteria are resistant to all but two or fewer antimicrobial categories (Aslam et al., 2018; Bassetti & Garau, 2021). Pandrug-resistant bacteria are resistant to all available antimicrobial agents (Bassetti & Garau, 2021). These classifications are vital for tracking antimicrobial resistance trends and are essential for epidemiological surveillance, informing treatment strategies, and guiding public health policies (Lorenzoni et al., 2018). However, the extent to which these resistant bacteria are present on Nigerian currency remains underexplored.

To address this gap, the present study aims to systematically assess the microbial contamination of Nigerian currency notes, compare the contamination levels across different note denominations and types (paper versus polymer) and analyze the antibiotic resistance patterns of the isolated bacteria (Xu et al., 2005). This study contributes to understanding how currencies plays a role in the transmission of drug-resistant pathogens in Nigeria and provide valuable data to inform public health strategies aimed at combating antimicrobial resistance in the region.

## 2. METHODOLOGY

### 2.1 Study Design

This experimental study, conducted in Osun State, Nigeria, aimed to investigate the bacterial contamination of Nigerian currency notes collected from different banks. Samples were gathered from both a local settlement (Oyan-Odo Otin/Ila local government) and an urban area (Osogbo town), targeting the general public in each location. The study included all eight denominations of the Nigerian naira notes (N1000, N500, N200, N100, N50, N20, N10, and N5). To ensure a representative sample, seven notes from each denomination were collected from both locations, resulting in a total of 56 samples per location and 112 samples overall.

### 2.2 Sample Collection

Currency samples were collected from various cash handlers, who provided informed consent to ensure voluntary participation and compliance with ethical standards, and were then transported in sterile ziplock bags to the laboratory for analysis. Currency notes were collected at hourly interval from persons walking into a bank location for cash deposit. Seven (7) samples were collected daily, sample size was achieved in eight working days (Ofoedu *et al*., 2021).

### 2.3 Processing of Samples

An empty Ziploc bags were cultured as a control. Each denomination was soaked in sterile peptone water for about 50 min with regular shaking to dislodge the microbial cells into suspension. The suspensions were subsequently analysed for total bacteria by serial diluting (10 fold) and plating 1 ml of each suspension on nutrient agar using pour plate method (Collins 1967). The plates were incubated at 37°C for 24 h for bacteria growth. Also, 1ml of the suspension were inoculated into Sabourad Dextrose Agar (SDA) with antibiotics (with chloramphenicol, gentamicin, and tetracycline core) and incubated at room temperatures and at 37°C for 48 hours to isolate fungal agents.

To ensure the validity of the results, empty Ziploc bags were used as a control to check for any potential contamination from the bags themselves. This step was crucial to confirm that any microbial growth observed in the samples was solely from the naira notes and not from the storage bags.

Each denomination of the Nigerian naira notes (N1000, N500, N200, N100, N50, N20, N10, and N5) was soaked in sterile peptone water for approximately 50 minutes with regular shaking to dislodge microbial cells into suspension. The suspensions were then analyzed for total bacterial count by performing serial ten-fold dilutions and plating 1 ml of each suspension on nutrient agar using the pour plate method (Collins, 1967). The plates were incubated at 37°C for 24 hours to allow bacterial growth. Additionally, 1 ml of each suspension was inoculated onto Sabouraud Dextrose Agar (SDA) containing antibiotics (chloramphenicol, gentamicin, and tetracycline) and incubated at room temperature and at 37°C for 48 hours to isolate fungal agents. This dual incubation ensured the growth of a wide range of fungal species.

### 2.4 Isolation and Identification of Bacterial and Fungal Isolates

Discrete colonies were subcultured on chocolate agar, MacConkey agar, and Mannitol salt agar to obtain pure cultures. These pure cultures were stored at 4°C and subsequently used for microscopic characterization and biochemical tests, following the methods described by Cheesebrough (2006). After incubation, bacterial colonies were counted to determine the total bacterial load. The colonies were then characterized based on their morphological features such as shape, size, color, and texture. Further biochemical tests, including Gram staining and catalase tests, were performed to identify the bacterial species. Fungal isolates were characterized and identified based on the method outlined by Fawole and Oso (2001), which included morphological characteristics, including colony color, texture, and spore formation, microscopic examination to observe the hyphal structure and spore types, which helped in identifying the fungal species.

### 2.5 Antibiotics Susceptibility Tests

Antibiotics susceptibility patterns of bacteria isolates was determined using modified Kirby-Bauer disc diffusion technique on Mueller Hinton agar plates according to the Clinical and Laboratory Standards Institute (CLSI) guidelines (2020). The antibiotics used on Gram-Positive isolates included: Ampiclox (25 µg), Erythromycin (15 µg), Cotrimoxazole (25 µg), Ciprofloxacin (10 µg), Gentamicin (10 µg), Zinacef/Cefuroxime (30 µg), Rocephin/ Ceftriaxone (30 µg), Augmentin (30 µg). While for Gram-Negative antibiotics disc used included: Chloramphenicol (30 µg), Streptomycin (10 µg), Cotrimoxazole (25 µg), Ciprofloxacin (5 µg), Gentamicin (10 µg), Zinacef/Cefuroxime (30 µg), Rocephin/Ceftriaxone (30 µg), Augmentin (30 µg). A turbid suspension of the isolates in sterile saline, matching the 0.5 McFarland standards was prepared. Using a sterile swab, we dipped it into the suspension, removed excess liquid, and streaked the Mueller-Hinton agar evenly. After drying for a few minutes, we placed antibiotic discs on the agar using sterile forceps. This was done for all isolates, and the plates were incubated at 37°C for 24 hours. Results were interpreted as susceptible, intermediate, or resistant based on CLSI guidelines (2020).

### 2.6 Data Analysis

Statistical analysis was carried out using SPSS-Statistical package.

## 3. RESULTS

All samples collected were studied independently from both locations to be able to ascertain the degree of contamination when compared. Table 1 shows the comparison between rural (Oyan) and urban (Osogbo) areas shows that *Klebsiella sp* and *Staphylococcus aureus* were the most common bacterial isolates in both locations, with *Klebsiella sp* being more prevalent in the rural area (35.7% vs. 23.2%) and *Proteus mirabilis* showing a significant difference in prevalence between the locations (8.9% in rural vs. 3.6% in urban). There was a significant difference in bacterial prevalence between the locations ($p = 0.024$). In terms of fungal isolates, *Aspergillus sp* was more common in rural areas (37.5% vs. 16.1% in urban). There was a significant difference in fungal prevalence between the locations ($p = 0.014$) (Table 1).

It is observed in Fig. 1 that the rural area (Oyan) maintained higher percentages in currency contamination than the urban site (Osogbo). The #100 note recorded 85.7% for both locations (Fig. 1).

**Table 1. Occurrence and comparison of microbes in both locations**

| Variable | Rural (Oyan) Organism n(%) | Urban (Osogbo) Organism n(%) | Df | $X^2$ | p-value |
|---|---|---|---|---|---|
| **Bacterial Isolate** | | | | | |
| *Escherichia coli* | 2(3.6) | 2(3.6) | | | |
| *Klebisella sp* | 20(35.7) | 13(23.2) | | | |
| *Proteus mirablis* | 5(8.9) | 2(3.6) | 5 | 14.508 | 0.024* |
| *Pseudomonas aeruginosa* | 0 | 1(1.8) | | | |
| *Staphylococus aureus* | 16(28.6) | 15(26.8) | | | |
| NBG | 13(23.2) | 23(41.1) | | | |
| **Fungal Isolates** | | | | | |
| *Aspergillus sp* | 21(37.5) | 9(16.1) | | | |
| *Candida* spp. | 8(14.3) | 6(10.7) | 2 | 12.444 | 0.014* |
| NFG | 27(44.2) | 41(73.2) | | | |

*Key: No bacterial growth (NBG), no fungal growth (NFG)*

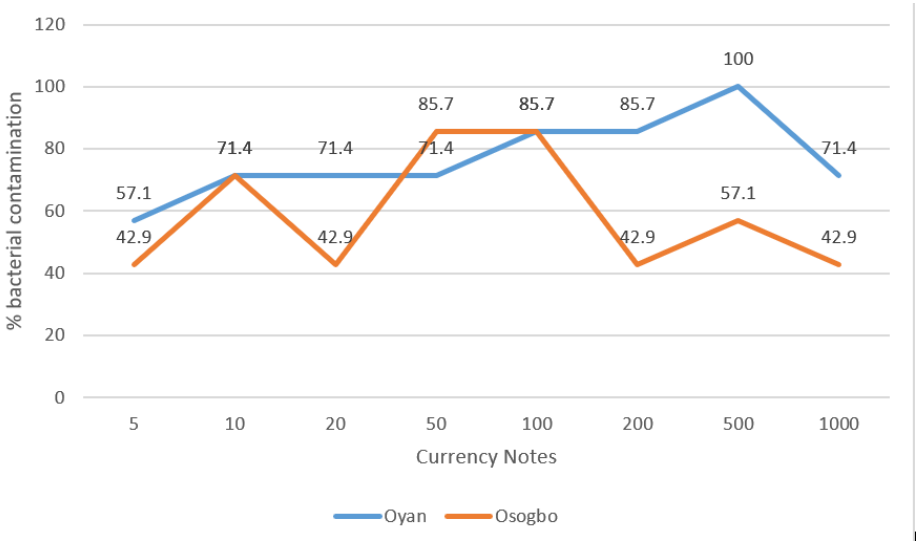


**Fig. 1. Prevalence of currency contamination in Oyan and Osogbo**

**Table 2. Occurrence of Bacterial Isolates on different currency dominations**

| Bacterial Isolate | Variable (Notes) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **5** | **10** | **20** | **50** | **100** | **200** | **500** | **1000** |
| *Escherichia coli* | 0 | 0 | 0 | 1(7.1) | 0 | 0 | 2(14.3) | 1(7.1) |
| *Klebisella sp* | 2(14.3) | 6(42.9) | 3(21.4) | 5(35.7) | 4(28.6) | 5(35.7) | 6(42.9) | 2(14.3) |
| *Proteus mirablis* | 2(14.3) | 0 | 0 | 2(14.3) | 0 | 1(7.1) | 1(7.1) | 1(7.1) |
| *Pseudomonas aeruginosa* | 0 | 0 | 1(7.1) | 0 | 0 | 0 | 0 | 0 |
| *Staphylococus aureus* | 3(21.4) | 4(28.6) | 4(28.6) | 3(21.4) | 8(57.1) | 3(21.4) | 2(14.3) | 4(28.6) |
| NBG | 7(50.0) | 4(28.6) | 6(42.9) | 3(21.4) | 2(14.3) | 5(35.7) | 3(21.4) | 6(42.9) |

*Key: No bacterial growth (NBG)*

The distribution of bacterial isolates across various Nigerian currency denominations shows that *Klebsiella sp* was the most frequent bacterium, particularly on N10, N200, and N500 notes (42.9% each), while *Escherichia coli* was found on N50, N500, and N1000 notes at lower frequencies (7.1%-14.3%), and *Staphylococcus aureus* was most prevalent on N100 notes

(57.1%), with no-bacterial growth (NBG) more common on lower-value notes like N5 and N10 (Table 2).

The fungal isolates on Nigerian currency notes show that *Aspergillus* sp was most common on N100 notes (50.0%) and N50 notes (42.9%), while *Candida spp.* was less frequent but more present on lower denominations such as N5 and N20 (Table 3).

The antibiotic resistance patterns of *Staphylococcus aureus* show high resistance to Ampiclox (83.3%) and Zinacef/Cefuroxime (82.9%), with moderate resistance to Augmentin (78.9%) and Gentamicin (47.4%), and low resistance to Ciprofloxacin (3.9%) and Erythromycin (8.8%), indicating these may remain effective treatment options (Table 4). *Staphylococcus aureus* shows widespread MDR characteristics, with high resistance to Penicillins (Ampiclox, 83.3%; Augmentin, 78.9%) and Cephalosporins (Cefuroxime, 82.9%; Ceftriaxone, 38.5%). Moderate resistance to Sulfonamides (Cotrimoxazole, 38.2%) and Aminoglycosides (Gentamicin, 47.4%) further supports the classification of MDR. However, resistance to Macrolides (Erythromycin, 8.8%) and Fluoroquinolones (Ciprofloxacin, 3.9%) remains low, which means *Staphylococcus aureus* does not meet XDR criteria as these classes remain effective for treatment (Table 4).

For Gram-negative organisms, *Pseudomonas aeruginosa* exhibited an alarming XDR profile, with 100% resistance to Amphenicols (Chloramphenicol), Cephalosporins (Cefuroxime, Ceftriaxone), Fluoroquinolones (Ciprofloxacin), and Aminoglycosides (Gentamicin). The only observed susceptibility is to Streptomycin and Penicillins (Augmentin), leaving very limited treatment options. Other Gram-negative organisms, including *Klebsiella* sp, *Proteus mirabilis*, and *Escherichia coli*, demonstrated clear MDR characteristics. *Klebsiella* sp showed high resistance to Amphenicols (89.2%) and Cephalosporins (Cefuroxime, 77.1%; Ceftriaxone, 82.9%), with moderate resistance to Aminoglycosides (Gentamicin, 73.3%) and Fluoroquinolones (Ciprofloxacin, 48.3%). *Proteus mirabilis* similarly exhibited MDR, with resistance to Amphenicols (93.1%), Fluoroquinolones (71.2%), and Aminoglycosides (59.3%). While *Escherichia coli* demonstrated MDR, with resistance to Cephalosporins (Cefuroxime, 78.4%; Ceftriaxone, 88.6%) and Amphenicols (73.7%), susceptibility to Penicillins and other classes indicates it does not meet XDR criteria.

## 4. DISCUSSION

This study highlights significant differences in microbial contamination and antibiotic resistance between rural and urban environments, emphasizing the impact of environmental, socioeconomic, and hygiene factors. *Klebsiella sp* was the most prevalent organism in the study. Similarly, a study by Ofoedu et al. (2021) showed that about 81.7% of currency notes were contaminated with either *Escherichia coli*, *Klebsiella sp* or *Staphylococcus* sp in varying degrees. The higher prevalence of *Klebsiella* sp

**Table 3. Occurrence of Fungal Isolates on different currency dominations**

| Fungal Isolates | Variable (Notes) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **5** | **10** | **20** | **50** | **100** | **200** | **500** | **1000** |
| *Aspergillius sp* | 2(14.3) | 3(21.4) | 2(14.3) | 6(42.9) | 7(50.0) | 4(28.6) | 5(35.7) | 1(7.1) |
| *Candida sp* | 3(21.4) | 0 | 2(14.3) | 1(7.1) | 3(21.4) | 2(14.3) | 2(14.3) | 1(7.1) |
| NFG | 9(64.3) | 11(77.5) | 10(71.4) | 7(50.0) | 4(28.6) | 8(57.1) | 7(50.0) | 12(85.7) |

*Key: No fungal growth (NFG)*

**Table 4. Percentage distribution of antibiotic resistance in Gram-positive organism**

| Antibiotics | Antibiotic Classes | *Staphylococus aureus* (n=31) |
|---|---|---|
| Ampiclox | Penicillin | 83.3 |
| Erythromycin | Macrolide | 8.8 |
| Cotrimoxazole | Sulfonamide | 38.2 |
| Ciprofloxacin | Fluoroquinolone | 3.9 |
| Gentamicin | Aminoglycoside | 47.4 |
| Zinacef/Cefuroxime | Cephalosporin | 82.9 |
| Rocephin/Ceftriaxone | Cephalosporin | 38.5 |
| Augmentin | Penicillin | 78.9 |

**Table 5. Percentage distribution of antibiotic resistance patterns in Gram-Negative organisms**

| Antibiotics | Antibiotic Classes | *Escherichia coli* (n=4) | *Proteus mirablis* (n=7) | *Klebsiella sp* (n=33) | *Pseudomonas aeruginosa* (n=1) |
|---|---|---|---|---|---|
| Chloramphenicol | Amphenicol | 73.7 | 93.1 | 89.2 | 100 |
| Streptomycin | Aminoglycoside | 33.2 | 25 | 40.4 | 0 |
| Cotrimoxazole | Sulfonamide | 45.5 | 63.2 | 22.7 | 0 |
| Ciprofloxacin | Fluoroquinolone | 53.3 | 71.2 | 48.3 | 100 |
| Gentamicin | Aminoglycoside | 81.2 | 59.3 | 73.3 | 100 |
| Zinacef/Cefuroxime | Cephalosporin | 78.4 | 65 | 77.1 | 100 |
| Rocephin/Ceftriaxone | Cephalosporin | 88.6 | 73.1 | 82.9 | 100 |
| Augmentin | Penicillin | 48.4 | 52.3 | 49.1 | 0 |

in rural areas (35.7% vs. 23.2% in urban areas) reflects poorer sanitation, limited access to clean water, and unhygienic handling of currency in rural settings. Cash-based transactions in open markets increase direct contact with contaminated surfaces, facilitating microbial transfer. Similarly, the dominance of *Aspergillus* sp in rural areas (37.5% vs. 16.1%) can be attributed to the agricultural nature of these settings, which expose currency to fungal spores present in dust and soil. These observations are consistent with findings from Ofoedu et al. (2021), who reported higher microbial loads in rural areas due to environmental conditions and socioeconomic disparities. These results/observations show the behavioral attitude to hygiene of rural residents (Edem et al., 2021).

The type and denomination of currency also influenced contamination levels. Higher-value notes (e.g., ₦100, ₦200, ₦500) showed greater bacterial and fungal contamination compared to lower denominations like N5 and N10. This is consistent with a study by Kiyevhobu et al (2023) ₦100 and ₦ 200 notes had the highest number of organisms present. Similarly, a study by Ofoedu et al. (2021) showed that ₦100 currency note appeared the most contaminated whereas ₦5 note appeared the least contaminated. This trend is likely due to the longer circulation cycles and frequent handling of higher-value notes, which increases their exposure to diverse microbial sources. *Klebsiella* sp was the most prevalent bacterium on higher denominations, likely due to its ability to persist on surfaces, while lower denominations were more likely to exhibit no bacterial growth (NBG). The frequent use of polymer notes (e.g., N5, N10) in smaller transactions may contribute to lower contamination, as polymer surfaces are less porous and easier to clean than paper notes (Prasai et al., 2010). Similarly, *Aspergillus* sp was most common on paper notes (N100), aligning with a study by Abdullahi et al. (2023) that reported ₦100 as the note with the most contamination rate and *Aspergillus niger* as the most prevalent fungi in the study. The reason for this observation may be due to poor water quality and high humidity in rural areas, which facilitate the growth of fungi like *Aspergillus* sp. These fungi can contaminate Naira notes through contact with hands and surfaces that have been exposed to contaminated water, as water sources often serve as reservoirs for fungal spores, including *Aspergillus* sp (Mbong et al., 2023).

The sampled naira notes were found to be highly contaminated with resistant bacterial isolates, particularly those exhibiting multidrug resistance (MDR) and extensively drug resistance (XDR). This study underscores the alarming prevalence of antibiotic resistance on naira notes, posing a significant public health challenge. Resistance is categorized into three key types: MDR (resistance to at least one antibiotic in three or more classes), XDR (resistance to all but two or fewer antibiotic classes), and pandrug resistance (PDR, resistance to all antibiotics across all classes) (Akinjogunla et al., 2024; Almakrami et al., 2024). *Staphylococcus aureus* demonstrated high levels of MDR in this study, with pronounced resistance to commonly used antibiotics such as Penicillins (Ampiclox, 83.3%; Augmentin, 78.9%) and Cephalosporins (Cefuroxime, 82.9%; Ceftriaxone, 38.5%). These findings suggest the diminished efficacy of these first-line antibiotics in treating S. aureus infections. Despite this, low resistance rates were observed for Macrolides (Erythromycin, 8.8%) and Fluoroquinolones (Ciprofloxacin, 3.9%), suggesting their continued utility as alternative treatments. Similarly, a study carried out in Kaduna, the north-western region of Nigeria, by Obajuluwa et al. (2024) reported 60.8%, 17.7% and 1.3% of bacterial isolates to be MDR, XDR and PDR, respectively. The situation for Gram-negative bacteria is particularly concerning, with *Pseudomonas*

*aeruginosa* exhibiting an XDR profile. The pathogen displayed 100% resistance to Cephalosporins, Amphenicols, Fluoroquinolones, and Aminoglycosides. These resistance levels reflect the organism's robust adaptive mechanisms, including efflux pumps, enzymatic breakdown of antibiotics, and biofilm formation, which collectively render many therapeutic options ineffective. The limited susceptibility observed to Streptomycin and Penicillins (Augmentin) highlights the critical need for alternative treatment strategies for infections caused by this bacterium. Other Gram-negative organisms, including *Klebsiella* sp*, Proteus mirabilis, and Escherichia coli*, demonstrated consistent MDR profiles, with significant resistance to Cephalosporins and Amphenicols. This widespread resistance likely stems from the indiscriminate use of antibiotics in healthcare and agricultural sectors, which creates selective pressure favoring resistant strains. These results align with patterns observed by Otaigbe and Elikwu (2023), which discussed how inappropriate antibiotic use driven by weak regulatory frameworks contributes significantly to antimicrobial resistance in low- and middle-income countries (LMICs). Furthermore, substandard and counterfeit antibiotics, common in resource-constrained settings, exacerbate resistance by delivering subtherapeutic doses that fail to eradicate pathogens (McManus and Naughton, 2020; Zabala et al., 2022). These results underscore the antibiotic resistance patterns observed in this study, suggesting that currency notes may serve as vectors for transmitting resistant bacteria. This finding emphasizes the urgent need for stringent hygiene practices and regular disinfection of frequently handled objects to curb the spread of resistant pathogens. Additionally, comprehensive antibiotic stewardship programs are essential to regulate antimicrobial use across various sectors. Strengthened policies should aim to limit the misuse of critical antibiotics, promote the development of novel treatments, and raise public awareness about the risks of resistance. Without immediate action, the unchecked rise of antibiotic resistance could compromise the effectiveness of existing therapies, posing severe threats to global public health.

## 5. CONCLUSIONS AND PUBLIC HEALTH IMPLICATIONS

This study highlights Nigerian currency notes, particularly lower denominations and paper-based notes, as significant reservoirs of bacterial and fungal contamination, including multidrug-resistant pathogens. The findings reveal stark differences in contamination patterns between rural and urban areas, influenced by environmental, socioeconomic, and hygiene-related factors. The high prevalence of *Klebsiella* sp and *Staphylococcus aureus* with multidrug resistance on naira notes underscores the public health risks associated with their frequent handling, especially in areas with poor sanitation. To address these risks, the study emphasizes the need for improved hygiene practices, such as regular handwashing after handling currency, alongside the disinfection of frequently used items. Transitioning to durable, polymer-based notes could further reduce contamination risks due to their less porous and easier-to-clean surfaces. Additionally, robust antibiotic stewardship programs and stronger regulatory measures to curb the misuse of antibiotics and tackle counterfeit drugs are essential to combat the escalating threat of antimicrobial resistance. Immediate and coordinated efforts are critical to safeguarding public health and mitigating the spread of resistant pathogens.

## CONSENT

As per international standards or university standards, Participants' written consent has been collected and preserved by the author(s).

## ETHICAL APPROVAL

It is not applicable.

## DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

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## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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