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Assessment of Multidrug Resistant Bacteria in Paper Naira Notes

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ABSTRACT

The bacteriological quality of some Nigerian currencies in circulation was investigated for total bacterial count and kinds of bacterial species present. The currency notes studied had high bacterial counts: ranging from 1.5×10^4 to 3.0×10^4 cfu/ml. Five bacterial species were isolated: *Escherichia coli, Staphylococcus aureus, Proteus mirabilis, Streptococcus sp. and Klebsiella sp. Escherichia coli* and *Streptococcus* spp were had the highest prevalence in the study (22.5%) while *Proteus mirabilis* was the least prevalent of the bacterial isolates (15%). The Antibiotic susceptibility pattern suggests that some of the isolates were multiple antibiotic resistant. The health effects of the found organisms are described, and recommendations are given to ensure safe management of the notes. The naira notes are not cleaned or disinfected before being passed from person to person. Therefore, they could serve as channels for the spread of infectious diseases (that is, acts as formites). As a result, there is a high risk of contracting an infection after coming into touch with soiled naira notes. The bacteria's reported multi-drug resistance serves to further highlight the importance of the notes for public health. Our research has demonstrated that the currency in use in Ekpoma may be contributing to the proliferation of bacteria that are resistant to antibiotics. We therefore advise against engaging in behaviors that increase the risk of contracting an infection from handling currency or contamination, and we urge against sloppy hygiene standards when handling currency or immediately after.

Keywords: Money, Naira, Bacteria, Antibiotics, Resistance, Currency, Multidrug

INTRODUCTION

The idea of money originated in the human mind. Bartering involved the

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direct exchange of one good for a certain amount of another good before the invention of money. In the barter economy, people give items away either for their own consumption or in exchange for other things they want. However, the barter system is problematic because it required a lot of effort on the part of the participants to try and exchange things for services (Kemka *et al.*, 2013) [1].

Contrary to exchanges relying on a twofold coincidence of wants, most daily currency transactions include the passage of money through many hands in the form of notes and coins (Ogunleye, 2005) [2]. The Nigerian Central Bank has issued naira notes in a variety of denominations (CBN). Through commercial banks, they are made available to the general population. There are now eight naira note denominations available: Paper notes are N100, N200, N500, and N1000 whereas latex notes are N5, N10, N20, and N50. The most widespread and frequently used notes in daily monetary transactions are the N5, N10, N20, N50, N100, and N200 naira notes. They are widespread, particularly among the general public, but the wealthy and businesses typically utilize the N500 and N1000 notes (Okon *et al*., 2003) [3].

The spread of the bacteria among the handlers was caused by people handling the notes who left some of their body flora on the notes. This has been linked to major health risks like lungs' function being compromised (Osim and Esin, 1996) [4]. Dust, soil, water, microorganisms on the handlers' hands, skin, etc., the saliva frequently used when counting the notes, and wounds can all be linked to the contamination of the notes.

Keeping Nigerian naira notes in brassieres, socks, pockets, under rugs, or even squeezing them in your hand commonly introduces microorganisms to the notes. Naira notes have been shown to contain *Citrobacter* sp., *Mycobacterium lapiae*, *Salmonella* sp., *Shigella* sp., *Escherichia coli*, *Staphylococcus aureus*, and *Pseudomonas aeruginosa* (Haque, 2003) [5]. The majority of them are part of the skin's natural flora, although some, like *S. aureus* and *P. aeruginosa*, can be opportunistic pathogens. This implies that some infectious organisms might be able to formites in the notes.

The transfer of contagious diseases via contact with insects and paper money is a very real possibility (Pope *et al*., 2002) [6]. Fomites are non-living organisms that are capable of entangling, housing, and spreading contagious pathogens. Paper money is a redeemable form of currency that is commonly contaminated. Money is stored under a variety of environmental and personal sanitary conditions and handled by people with various health and hygienic standards (Ghamdi *et al*., 2011) [7].

The growth of bacteria on these notes is also aided by packing them in dark, wet settings in leather, cotton, or polythenes bags. By isolating the pathogenic bacteria on their unique growing media and then identifying them using the polyphasic approach, it is possible to detect the presence of particular bacteria on these notes. But this is too laborious. So, the most typical approach is to look for an indicator. Many environmental tools act as vehicles in the transmission of microbiological entities from the environment to humans. These transmission mechanisms have a significant impact on many people's health in developing nations, where infection rate is a common indicator of local sanitation and hygiene standards (Anderson, 1991) [8].

In Nigeria, the currency notes are used for purchasing uncooked meat from the market, ready to eat food, milk, drugs and charcoal at a local store are used in all varieties of trade. Many Nigerians do not care how dirty their fingers are when touching money. Because of this, individuals like the artisan with oily, dusty, and dirty hands, the butcher with bloody hands, the street vendor with wet, oily hands, the teacher with chalky, inky hands, etc., will simply pick up or obtain Nigerian currency notes with their unclean hands, resulting in the contamination of the notes with microorganisms. Most people don't carry cash with them, and squeezing bills is frequent, especially among bus drivers and their conductors, market vendors, motorcycle riders, butchers, restaurant owners, and meat vendors, among others. Men regularly tuck cash into their stockings, while women typically tuck it under their sweaty brassiere. Market vendors also squeeze cash into their soiled pockets (Mensah *et al*., 2002) [9].

Bacteria are incredibly adaptable and may thrive in harsh conditions. Their ability to cling to surfaces and their capacity to process biofilms are two of their most crucial survival strategies (multicellular aggregates). Colony-forming units (CFU) per cm2 of a banknote are used to calculate the amount of bacterial cells on a certain banknote. A coin can hold up to 103 CFU cm2, whereas a banknote can carry up to 106 CFU cm2. According to studies, polymer-based banknotes often have a lower bacterial count than cotton-based "paper"

banknotes. Numerous physicochemical characteristics of polymers may be to blame for this. It has been established that the influenza virus may have a role in the spread of this illness on banknotes. Other strains may be active for up to 17 days, while one strain, H3N2, can remain contagious on banknotes for up to 3 days (Vriesekoop *et al.*, 2010) [10]. Numerous pathogens connected to tonsillitis, pneumonia, gastro enteritis, throat infection, urinogenital tract infection, and lung abscess have been described (Saeed and Rasheed, 2011) [11].

Surface charge, surface roughness, stiffness, and hydrophobic characteristics are elements that affect how well bacteria and other microorganisms adhere to surfaces like paper money (Vriesekoop *et al*., 2010) [10]. Microbial contamination can spread either directly through hand-to-hand contact or indirectly through food or other inanimate things like cars that have been used to transport the contamination (Rote *et al*., 2010) [12]. If this paper money is tainted with dangerous bacteria, these microbes could spread and pose a risk to your health (Ahmad *et al.*, 2010) [13].

Droplets from sneezing, coughing, touching other objects with infected hands, or being placed on unclean surfaces can contaminate paper currency (Oyero & Emikpe, 2007) [14]. Poor or Negative money handling procedures, such as spraying during ceremonies, when such notes may be crushed when they fall to the ground, could be the source of contamination (Ogo *et al.*, 2004) [15]. The rate of food-related public health incidents is also increased by the immediate interaction of food and money (Food Science Australia, 2000) [16]. Such reports are available for Egypt (EI-Dars & Hassan, 2005) [17], India (Singh *et al.*, 2002) [18], and other countries. With their hands covered in blood and animal excrement, meat vendors solicit payment from customers in slaughterhouses and markets. Currency notes become virulent when they are in the hands of bus drivers, fish and meat vendors, and other such people. Different microorganisms are found on banknotes (Barro *et al*., 2006) [19]. When it comes to shifting the majority to cash and coins, the situation in eateries is similar (FSA, 2002) [20].

The notes will act as a vehicle delivering bacteria to contaminate the hands of the next user because people who live in unclean settings and perform unhygienic activities, such as using saliva to count paper notes, will contaminate them with bacteria (Sushil Kumar *et al*., 2011) [21]. A higher surface area of paper money makes it a disease breeding habitat (Ayandele & Adeniyi, 2011) [22]. It is mandatory for anyone working in the medical field, the food and catering business, and the banking industry to wash their hands after handling cash. The handling of coins and banknotes spreads millions of bacteria from person to person every day. Hands should be completely cleansed and dried before handling food and after handling money as a basic precaution. In most impoverished nations, there are few studies on the microbiological contamination of money. Lack of information may be a factor in why there are no public health regulations governing how money is used, handled, and circulated (Ghamdi *et al.*, 2011) [7]. *Staphylococcus aureus, Escherichia coli, -haemolytic Streptococcus, Acetobacter spp, Bacillus spp, Salmonella spp, Enterobacter spp, Pseudomonas spp*, fungus, viruses and eggs, larvae of worms, parasites, and helminthes are among the microorganisms frequently found on banknotes. Some bacteria linked to banknotes may cause opportunistic infections, while others are harmful and frequently cause food poisoning (Vriesekoop *et al.*, 2010) [10].

Paper currency can be contaminated by microbes in developed nations as well. Numerous US investigations have documented the contamination of paper money and coins with harmful microorganisms such *Staphylococcus aureus, Klebsiella, Enterobacter* spp., and *Escherichia coli*. Public health officials are very concerned about the contamination of objects by pathogenic bacteria because contaminated objects can act as sources of disease transmission (Ghamdi *et al.*, 2011) [7]. *Mycobacterium tuberculosis, Vibrio cholerae, Bacillus species, Corynebacterium* spp., *Staphylococcus aureus*, and *Micrococcus* spp. were among the bacteria involved. Environmental organisms like Gram-Positive bacteria, particularly *Bacillus* spp., and those originating from human normal skin flora like *Staphylococcus aureus* are the most common pollutants of money (Xu *et al*., 2005; Igumbor *et al.*, 2007) [22,23]. According to studies by Umeh *et al.* (2007) [24] and Hosen *et al.* (2006) [25], 89.8% of Nigerian currency notes in circulation have microbial contamination, while a study by Hugo *et al.* (1983) [26] discovered that 100% of currency notes in circulation have bacterial contamination, and they isolated Coagulase Negative *Staphylococci* (23.4%), *Staphylococci aureus* (8.4%), *Escherichia coli* (5.6%), *Bacillus* spp (Igumbor *et al.*, 2007) [23]. For the study and to assess the multidrug resistant bacteria in the paper naira notes in

Ekpoma, Edo State, several occupational groups and sites (Banks, Market, Restaurants and Bar, Fuel/Gas stations, and Bike (okada) riders) have been enrolled based on the statement of difficulties.

MATERIALS AND METHODS

Area of Study

The administrative center of Edo State's Esan West Local Government Area, Ekpoma, served as the study's location. With a land area of 17,450 square kilometers and a population of 3.1 million, Edo state is located in Nigeria's South-South geopolitical zone between longitude 06o 04IE and 06o 43IE and latitude 05o 44IN and 07o 34IN. In the semi-urban town of Ekpoma, the main professions are farming, trading, public service, and education (World Gazzetter, 2007) [27].

Study Population / Sample Size

Different occupational groups (Banks, Market women, Restaurants and Bar and Fuel/Gas (filing station) stations were randomly selected in Ekpoma to be used in this study. Forty (40) paper naira notes of different denominations (N100, N200, N500 and N1000) were randomly collected from the different occupational groups and sampled.

Sample Collection

Forty (40) paper naira notes of different denominations (N100, N200, N500 and N1000) comprising of 20 old notes and 20 new notes were randomly collected from the different occupational groups and sampled.

Research Design

This study was a descriptive/analytical study. It was designed to evaluate the multidrug resistant bacteria present in paper naira notes in Ekpoma, Edo State. Sample of notes were collected by exchanging notes from various group enrolled in the study. Each naira note collected was taken for bacteriological analysis to the Microbiology laboratory of St Kenny Research Consult, Ekpoma, Edo State using standard methods. Results were presented in tables.

Sample Analysis/Methods

Each currency note was soaked in 10ml of normal saline and serial dilution was carried out from the stock solution. The dilution of 10-3, 10-5 and 10-7 were then analysed for total bacteria by plating 1 ml of each suspension on nutrient agar using pour plate method (Collins, 1989) [28]. For 24 hours, the plates were incubated at 37°C. Representative colonies of bacterial isolates were selected and purified by subculturing on selective (MacConkey agar) and enriched media (CLED). After incubation, plates were examined for growth. These sub-cultured plates were then used in the identification and characterization of the organisms (Ayandele & Adeniyi, 2011) [21]. Microorganisms were recognized on the basis of macroscopic, microscopic and differential biochemical tests. The Catalase test, Indole test, Oxidase test, Citrate test, and Coagulase test were among the various biochemical tests used. On the basis of macroscopic, microscopic, and differential testing, microorganisms were identified.

Physical Examination: The physical conditions of the naira notes were taken and recorded, e.g. dirty, wrinkled, odourous, toured, clean, fairly, etc.

Antibiotics Susceptibility Test: In vitro susceptibility tests of the bacterial isolates to antibiotics were done using disc diffusion technique. Zero point one (0.1) ml of each bacterial isolates prepared directly from an overnight broth culture and adjusted to 0.5 McFarland Standard (NCCLS, 2004) [29] was inoculated using sterile pipette onto each of the nutrient agar media. The commercially available discs containing the following antibiotics: Penicillin (Pen, 10ug), Ceftazidime, (Caz, 30ug), Streptomycin (Stp, 30ug) Ciprofloxacin (Cpf, 5ug), Gentamycin (Gen, 10ug), Ofloxacin (Ofl, 5ug) Ceftriaxone (Cef, 30ug) and Cotrimoxazole (Cot, 30ug) of oxoid products were aseptically placed on the surfaces of the sensitivity agar plates using a sterile forceps and gently pressed to ensure even contact. The plates were incubated at 37ºC for 24 hours , the zones of inhibition after incubation were observed, and the diameters of inhibitory zones were measured in millimeters (mm) using a ruler. According to the manufacturer's standard zone size interpretative manual, the measurement was interpreted as sensitive and resistant. The appraisal of the data was thought to be sensitive to the intermediate measurements.

RESULTS

Table 1 shows the physical conditions of the naira notes sampled. The physical conditions observed were; odour, dirt, wrinkle and tearing. The N 100 notes had Smelly odour, dirty, wrinkled and most of them were toured, while the N 200 notes were dirty, wrinkled and most of them were toured, the N 500 notes had Smelly odour, were fairly dirty and wrinkled and the N 1000 notes were fairly clean and wrinkled.

Bacteria isolated and percentage prevalence from the study was shown in table 2. The organisms isolated are; *Staphylococcus aureus* (20.0%), *Escherichia coli* (22.5%), *Streptococcus* spp (22.5%), *Proteus mirabilis* (15.0%) and *Klebsiella* spp (20.0%). *Escherichia coli* and Streptococcus spp had the highest percentage prevalence while *Proteus mirabilis* was the least prevalent.

Table 3 shows the organisms isolated from the study according to locations sampled. From the naira notes sampled from the bank, *Escherichia coli* and *Streptococcus* spp were isolated, naira notes sampled from the filing station, *Streptococcus* spp, *Proteus mirabilis* and *Klebsiella* spp were isolated, from those samples from market women, *Escherichia coli* and *Streptococcus* spp were isolated while naira notes sampled from restaurants and bar, *Escherichia coli, Staphylococcus aureus* and *Klebsiella* spp were isolated.

Table 4 shows the bacteria isolated from different denominations (both old and new notes). In the old notes, from the ₦ 100 and ₦ 200notes (6) sampled each, 12 organisms were isolated which made them the naira notes with the highest number of organisms present followed by the ₦ 1000 (4 sampled) notes which had 7 organisms while the ₦ 500 notes (4 sampled) had 6 organisms isolated from them making it the naira note with the least number of organisms isolated. Among the new notes sampled, the ₦ 200 notes and ₦ 1000 notes had 2 and 1 organism present in them respectively.

Table 5 shows the total viable count of bacteria in the naira notes. The mean total viable bacterial count for ₦ 100 and ₦ 200 notes is the same and higher than others (3.0 x 10^4 cfu/ml). The ₦1000 notes had a count of 2.4 x 10^4 cfu/ml while the ₦500 notes had a mean viable count of 1.5 x 10^4 cfu/ml which happens to be the least count in this study. Among the New notes, the mean variable count of ₦200 note is 1.2 x 10^4 cfu/ml, the mean variable count of ₦1000 note is 1.0 x 10^4 cfu/ml and there was no organism isolated in the ₦100 and N500 notes. In comparison of the old notes and new notes, the mean variable counts of the old notes were higher than that of the new notes.

The distribution of antibiotic sensitivity pattern of bacterial isolates is shown in table 6. The cultural characteristics and biochemical analysis of bacterial isolates is represented in table 7.

Table 1: Physical conditions of the old naira notes sampled.

Naira Note (₦)	No. of Sample	Smelly odour	Dirty	Wrinkled	Torn
100	6	+	+++++	++	++
200	6	-	+++++	++	++
500	4	++	+++	++	-
1000	4	-	++	++	-

KEY: + = Present; - = Not present

Table 2: Percentage prevalence of bacterial isolates.

Organisms	No Isolated	Percentage Prevalence (%)
Staphylococcus aureus	8	20
Escherichia coli	9	22.5
Streptococcus spp	9	22.5
Proteus mirabilis	6	15
Klebsiella spp	8	20
TOTAL	40	100

Table 3: Bacteria isolated from the study according to location of sample.

Locations Sampled	Organisms Isolated
Bank	*Escherichia coli* *Streptococcus* spp
Filing Station	*Klebsiella* spp *Streptococcus* spp *Proteus mirabilis*
Market women	*Escherichia coli* *Streptococcus* spp
Restaurant and Bar	*Escherichia coli* *Staphylococcus aureus* *Klebsiella* spp

Table 4: Bacteria isolated from different denominations.

Old Naira Note	**₦100** **N = 6**	**₦200** **N = 6**	**₦500** **N = 4**	**₦1000** **N = 4**	**Total No. of Organisms Isolated**
Staphylococcus aureus	3/6	2/6	1/4	2/4	8
Klebsiella spp	2/6	3/6	1/4	1/4	7
Proteus mirabilis	1/6	2/6	1/4	1/4	5
Streptococcus spp	3/6	2/6	1/4	2/4	8
Escherichia coli	3/6	3/6	2/4	1/4	9
TOTAL	**12**	**12**	**6**	**7**	**37**
New Naira Notes	**₦100** **N = 6**	**₦200** **N = 6**	**₦500** **N = 4**	**₦1000** **N = 4**	
Staphylococcus aureus	0/6	1/3	0/2	1/4	2
Klebsiella spp	0/6	0/6	0/4	0/4	0
Proteus mirabilis	0/6	0/6	0/4	0/4	0
Streptococcus spp	0/6	1/6	0/4	0/4	1
Escherichia coli	0/6	0/6	0/4	0/4	0
TOTAL	0	2	0	1	3

Table 5: Total viable count of naira note contamination.

	Mean viable count (cfu/ml)			
Naira Notes	**₦100**	**₦200**	**₦500**	**₦1000**
New notes	-	1.2×10^4	-	1.0×10^4
Old notes	3.0×10^4	3.0×10^4	1.5×10^4	2.4×10^4

Table 6a: Antibiotic Sensitivity Pattern of Bacteria Isolates from the new notes (₦200 and ₦1000).

Antibiotics (Gram Positive Disc)	₦200		₦1000
	Staph aureus	***Streptococcus* spp**	***Staph aureus***
Erythromycin	S	**S**	**S**
Gentamicin	S	S	S
Ciprofloxacin	R	R	S
Norfloxacin	R	S	S
Streptomycin	S	R	R
Rifampicin	R	R	R
Ampiclox	S	R	R
Chloramphanicol	S	S	R
Levofloxacin	R	R	S
Amoxil	S	S	R

KEY: S = Sensitive; R = Resistance

Table 6b: Antibiotic Sensitivity Pattern of Bacteria Isolates from the old notes (₦100, ₦200, ₦500 and ₦1000).

Antibiotics (Gram Positive &Negative Disc)	**₦100**					**₦200**					**₦500**					**₦1000**				
	SA	***SS***	***KS***	***PM.***	***EC***	***SA***	***SS***	***KS***	***PM.***	***EC***	***SA***	***SS***	***KS***	***PM.***	***EC***	***SA***	***SS***	***KS***	***PM.***	***EC***
Erythromycin	S	S	NT	NT	NT	S	R	NT	NT	NT	R	S	NT	NT	NT	S	R	NT	NT	NT
Gentamicin	S	S	R	S	R	R	S	S	S	R	R	S	R	S	R	S	S	R	S	R
Ciprofloxacin	S	R	R	R	R	S	S	S	R	R	R	R	R	S	R	S	R	R	R	R
Norfloxacin	S	R	NT	NT	NT	S	R	NT	NT	NT	S	R	NT	NT	NT	S	R	NT	NT	NT
Streptomycin	R	S	R	R	S	R	R	S	R	S	R	S	R	S	R	R	S	R	R	S
Rifampicin	R	R	NT	NT	NT	S	S	NT	NT	NT	R	R	NT	NT	NT	R	R	NT	NT	NT
Ampiclox	R	S	NT	NT	NT	R	S	NT	NT	NT	R	S	NT	NT	NT	R	S	NT	NT	NT
Chloramphenicol	R	S	NT	NT	NT	R	S	NT	NT	NT	S	S	NT	NT	NT	R	S	NT	NT	NT
Levofloxacin	R	R	NT	NT	NT	S	R	NT	NT	NT	R	R	NT	NT	NT	R	R	NT	NT	NT
Amoxil	R	S	NT	NT	NT	R	S	NT	NT	NT	R	S	NT	NT	NT	R	S	NT	NT	NT
Augmentin	NT	NT	R	S	R	NT	NT	R	S	R	NT	NT	R	S	R	NT	NT	S	S	R
Ceporex	NT	NT	R	R	R	NT	NT	R	R	R	NT	NT	R	R	R	NT	NT	S	S	R
Tarivid	NT	NT	S	S	R	NT	NT	S	S	R	NT	NT	R	S	R	NT	NT	S	S	R
Septrim	NT	NT	S	R	R	NT	NT	R	R	S	NT	NT	S	R	R	NT	NT	S	R	R
Reflacin	NT	NT	R	S	S	NT	NT	S	S	S	NT	NT	S	S	S	NT	NT	S	S	S
Naliolixic acid	NT	NT	R	S	R	NT	NT	S	S	R	NT	NT	R	S	R	NT	NT	R	S	R
Ampicillin	NT	NT	S	R	R	NT	NT	R	R	R	NT	NT	S	R	R	NT	NT	S	R	R

KEY: S = Sensitive; R = Resistance; SA – *Staphylococcus aureus*; PM – *Proteus mirabilis*; NT = Not tested; SS – *Streptococcus* spp; EC – *Escherichia coli*

Table 7: Cultural Characteristics and Biochemical Analysis of Bacterial Isolates.

Isolates	Cultural characteristics				Biochemical analysis								Sugar Fermentation				Probable Microorganism
	Shape	Elevation	Consistency	Colour	Gram	Catalase	Coagulase	Indole	Motility	Oxidase	Citrate	Urease	Glucose	Maltose	Sucrose	Lactose	
1	Cocci in Cluster	Spherical	Moist	Golden yellow in NA	+	+	+	_	_	_	+	+	A	_	A/G	_	*Staphylococcus aureus*
2	Rod	Convex	Mucoid	Rose Pink in MCA	_	+	_	+	+	_	_	_	A/G	A/G	A	A/G	*Escherichia coli*
3	Rod	Raised	Mucoid	Light Pink in MCA	_	_	_	_	_	_	+	+	A/G	A	A	_	*Klebsiella* spp
4	Cocci in Chains	Spherical	Moist	White in NA	+	+	_	_	_	_	+	+	A	_	A/G	_	*Streptococcus* spp
5	Bacilli	Raised	Mucoid	Cream in MacConkey	_	+	_	_	_	+	+	_	A	A/G	A	A/G	*Proteus mirabilis*

KEY: + = Positive; NA = Nutrient agar; A = Acid production; - = Negative; MCA = MacConkey agar; G = Gas

DISCUSSION

Everywhere in the environment, there are microorganisms, some of which are dangerous to human life and others which are not. The microorganisms on the notes indicate that the necessary circumstances for their presence have been met, according to their presence (Brock *et al.*, 1994) [30]. This makes me wonder how secure our circulating naira notes are. Since dirty notes are typically damp, bacteria can grow well on them. They offer hospitable circumstances, including substrate obtained from the human body, dust from the surroundings, and handling-related substrate (Haque, 2003) [5]. We examined a total of 20 samples of Nigerian paper currency, including 4 notes with different denominations (N100, N200, N500, and N1000). Physical conditions for the various denominations were documented (table 1). 13 (65%) of the 20 samples of naira notes were found to be infected with various bacterial species. Most samples were contaminated with many bacterial species (Tables 4). Our study's demonstration of the isolation of these bacteria from currency suggests that cash may be a significant means of microbial agent transmission in the population, posing a risk to public health. Our study's currency contamination rate is lower than that of other developing nations' currencies, including the 94% reported in the United States (Pope *et al.*, 2002) [6], the 75% reported in Nepal (Lamichhane *et al.*, 2009) [31], the 72.3% reported in Saudi Arabia (Suaad & Laila, 2011) [32], and the 100% recently reported in Ghana (Tagoe *et al.*, 2011) [33] and Pakistan (Sabahat & Humaira, 2011) [34]. These variations demonstrate that microbiological contamination of cash is a widespread issue and that sanitary procedures and handling of currency vary widely across regions.

Keeping money under body surfaces, not washing hands properly after using the restroom, wetting fingers with saliva while counting money, coughing and sneezing on hands while handling money, placing or storing money on unclean surfaces during transactions, and spraying during ceremonies are a few behavioral practices at our study site that may lead to currency contamination. Paper money (notes) is made of cotton and linen and provides a wide surface area that can serve as a breeding environment for bacteria that can survive there for prolonged periods of time. Additionally, the uneven surface of banknotes makes it easier for various kinds of microorganisms to stick to them. These elements facilitate note colonization.

Seven of the ten new currency ('mint') samples used as controls had no signs of microbial development. It's possible that these samples contained picky organisms and that the

media and/or growth conditions used were not suitable for isolating them. We propose usage and handling as potential sources of contamination of Nigerian naira notes currently in circulation as this money had not been in use.

It was discovered that the amount of pollution was correlated with the type of currency (Table 4 and 5). Our results agree with recent reports (Nagesh *et al.*, 2010; Ahmed *et al.*, 2010; Tagoe *et al.*, 2011; Sabahat & Humaira, 2011) [33-36]. For various daily transactions, lower denominations are exchanged between hands more frequently than higher amounts. Lower denominations are more susceptible to contamination because of the higher rate of exchange. Additionally, lower denominations of currency tend to be handled improperly more often than greater ones. In contrast to Sabahat and Humaira's (2011) [34] findings, which did not indicate that any particular currency was particularly prone to contamination, we found that the N100 and N200 notes had the highest levels of contamination (100%) (Tables 4 and 5). This could be because they account for the majority of daily cash transactions. The elevated bacterial loads also indicate risk, particularly when coupled with unsanitary behaviors like intermittent finger moistening by touching the tongue's tip while counting money. Our research shows that smaller denominations contain the most infectious agents, especially given that they are traded more frequently than higher denominations. However, no note denomination was immune to contamination because we found microbial growth in every note denomination we studied.

Additionally, we noticed that the source and physical characteristics of the cash were related to currency contamination (Table 1). The physical characteristics of cash may provide a clue as to its antiquity. Another significant element that affects the likelihood of germs on currency has been proposed as age (Vriesekoop *et al.*, 2010; Al-Ghamdi *et al.*, 2011) [7,10].

The highest levels of bacteria isolate contamination were found on currency taken from filing cabinets, restaurants, and pubs. Food, whether cooked or raw, may include bacteria that can be transmitted through money either directly or indirectly. Microorganisms can be transferred from money to food if necessary hygiene procedures aren't followed. Therefore, the practice of food vendors in the research region of handling food and money simultaneously could result in the transfer of harmful bacteria to food. Hand washing must be repeated before handling food if money is handled in between hand washing and handling food. The discovery of microbial contamination in money from all sources is extremely concerning and suggests that contaminated money may constitute a health risk, especially to people with impaired immune systems, both in the community and in hospitals. To lower the chance of contracting an infection from money, improved personal hygiene standards are strongly encouraged.

The naira notes contained *Staphylococcus aureus* (20.0%), *Escherichia coli* (22.5%), *Streptococcus* spp. (22.5%), *Proteus mirabilis* (15.0%), and *Klebsiella* spp. (20.0%) among other potentially harmful bacteria. Our research demonstrates that the most common contaminants of Nigerian naira notes circulating in the study region are *Escherichia coli* and *Streptococcus* spp. But the discovery of gram-positive and gram-negative bacteria during isolation suggests that it might be acting as a repository for harmful pathogens. These microorganisms are a typical part of the mucous membranes and skin's flora. *S. aureus* pathogens are well known (Archer, 1998) [37]. According to research by Kumar, *et al.* (2009) [38], *S. aureus* may live for eight days on paper notes. This pathogen's protracted existence on money enables transmission. The majority of the bacteria found in this investigation belong to the human flora. This shows that the main source of microorganisms on naira notes is likely to be people. When left in locations where they come into contact with the skin directly, the notes could have become colonized. A sophisticated ecosystem of microbes, both resident and transient, can be found on the skin. From 10^3 cfu/cm^2 in dry places to more than 10^7 cfu/cm^2 in moist areas, the amount of bacteria on the skin surface varies (Brock *et al.*, 1994) [30]. The presence of *Proteus mirabilis, Klebsiella* sp., and *E. coli* points to faecal contamination (Galvani, 1974) [39]. These germs may have been spread by cross-contamination from offal or by contaminated water used to wet the fingers during counting.

Additionally common in the natural world and a well-known human colonizer is *Staphylococcus aureus. S. aureus* are typically not harmful, but when they enter deeper body tissues or damaged skin, they can frequently cause infections (pyogenic infections). Exfoliation of the top layer of skin, impetigo, carbuncles, and food intoxication are also connected to it (Brock *et al.*, 1994; Jensen *et al.*, 1997)

[30,40]. It is easily spread from the notes to people and can start an infection. *S. aureus*-caused soft tissue infections are relatively common in the community. Methicillin-resistant *Staphylococcus aureus* has changed over the past 40 years from a manageable annoyance to a serious societal concern (Neel & Ragini Deshpande, 2012) [41]. S. aureus is a significant nosocomial pathogen to watch out for because it might be found in nasal or skin flora (Adegoke & Komolafe, 2009) [42]. *S. aureus* can cause a wide range of illnesses, from non-life-threatening conditions like bacteremia, meningitis, pneumonia, endocarditis, osteomyelitis, sepsis, and toxic shock syndrome to serious conditions like pimples, cellulitis, boils (furuncles), impetigo, carbuncles, folliculitis, scalded skin syndrome, and abscesses (TSS). Skin, bone, joint, soft tissue, respiratory, endovascular, and wound infections are also common. It is still one of the top five causes of nosocomial infections and frequently results in postoperative wound infections (Bowersox, 1999) [43]. *S. aureus* may survive on canines, horses, cats, and even cause bumble foot in chickens (Hanselman *et al.*, 2009) [44], among other animals (Burton *et al.*, 2008) [45]. One of the primary causes of mastitis in dairy cows is *S. aureus* (Cenci-Goga *et al.*, 2003) [46].

E. coli and *P. mirabilis*, two enteric pathogens, were recovered from the samples examined. *E. coli* were widely dispersed in money of all different denominations. Their discovery in currency is a sign of fecal contamination, unsanitary working environments, and poor personal hygiene habits among currency workers. Therefore, handling money and food at the same time should be avoided unless proper hygiene is followed or food handling equipment is employed in between the two procedures. One of these bacteria that is utilized to indicate the presence of fecal contamination in water is *E. coli.* It ferments lactose, producing acid and gas in the process. The presence of *E. coli* in food or water samples serves as an indicator of fecal contamination, and it is also advised that other dangerous enteric bacteria may also be present. Numerous researches have noted that bacteria can spread from money notes to people through eating (Lamichhane *et al.*, 2009; Ministry of Health, 2007; Reither *et al.*, 2007) [31,47,48]. Our research suggests that the Nigerian naira, which is always in circulation, serves as a vehicle for the spread of human pathogenic germs. Despite the fact that *E. coli* is typically thought of as an opportunistic pathogen, investigations have identified the pathogenic strain O157:H7 from money (Jiang & Doyle, 1999; Ehwarieme, 2012) [49,50]. According to Jiang X, *et al.* (1999) [49], this particular strain of *E. coli* may survive in money for up to eleven days, which makes it possible for it to spread to people.

The most prevalent strain of *Streptococcus* is pericoronitis, a gingival infection. Due to their ability to synthesize dextrans from glucose, streptococci can attach to fibrin-platelet aggregates at injured heart valves. This mechanism explains how they might cause subacute valvular heart disease after entering the bloodstream, such as after a dental extraction (Patterson, 1996) [51].

Members of the Enterobacteriaceae that are clinically significant include *Klebsiella* spp and *E. coli*. Urinary tract and wound infections are linked to *Klebsiella* spp (Prescott *et al.*, 2008) [52]. Some *E. coli* strains are known to produce heat-stable enterotoxins (WHO, 1984; Jensen *et al.*, 1997) [38,53]. Nasopharynx infections frequently involve *Klebsiella* spp. It is not just limited to people; it affects all living things, including animals and other natural environments like soil, sewage, and surface water (Brisse & Verhoef, 2000) [54]. It spreads disease throughout the planet. There are numerous infections that can be contracted when they affect various body organs like the liver, urinary tract, or lungs (Wen-Chien, 2002) [55]. Colonization of the notes can also be caused by habit, such as salivating on one's fingers while counting money. Environmental sources can also colonize an area.

P. mirabilis emits a strong fishy smell and moves in swarms (Belas, 1996) [56]. In both soil and water, *P. mirabilis* can be found as a free-living bacterium. Additionally, the bacterium is typically found in the human gastrointestinal tract (Coker *et al.*, 2000) [57]. *P. mirabilis* infection may potentially be to blame for kidney and bladder stone formation. As the stones form, the bacteria colonize them, making them more resistant to antibiotic action (Pearson *et al.*, 2008) [58]. When the bacteria go to the urethra and bladder, *Proteus mirabilis* causes the most typical infection. The mildest urethritis symptoms are frequent urination and pyuria. Back discomfort, a constricted look, urgency, hematuria, suprapubic pain, an increase in urine frequency, and pyuria are some of the symptoms of cystitis. When germs move from the lower urinary tract, pyelonephritis may result. The following are signs of pneumonia: fever, chills, chest discomfort, rales, and cough. *P. mirabilis* infection can result in prostatitis, which in men can cause fever, chills, and a painful prostate. Except in severe situations, broad-

spectrum penicillin or cephalosporin can be used to treat *Proteus mirabilis* infections (Esipov *et al.*, 1998) [59].

Also, it can be deduced from tables 4 and 5 that the old naira notes spread carry more bacteria than the new naira notes which means the longer in circulation the more contaminated the notes.

Most of the antibiotics examined were usually effective against isolated bacteria. The most successful medications were erythromycin, gentamicin, augmentin, tarivid, and reflacin since they were efficient against the majority of isolates (Table 6). Norfloxacin, streptomycin, ampiclox, amoxil, septrim, ampicillin, and chloramphenicol were additional beneficial medications. Rifampicin, levofloxacin, ciprofloxacin, and ceporex were inactive medications because they had poor susceptibilities. Each organism had resistant strains.

From this study, we encourage the patronage of electronic payment methods which will help in curbing or reducing the spread of diseases and infections via the naira notes.

CONCLUSION

The naira notes are not cleaned or disinfected before being passed from person to person. Therefore, they could serve as channels for the spread of infectious diseases (that is, acts as formites). As a result, there is a high risk of contracting an infection after coming into touch with soiled naira notes. The bacteria's discovered multi-drug resistance serves as additional evidence of the notes' importance to public health. Money plays a significant role in the spread of drug-resistant germs in the community, as evidenced by the isolation of multidrug resistant bacteria from currency notes.

It was discovered that the Nigerian banknotes in use were tainted with a variety of bacteria. Therefore, care should be taken when handling paper money. Because the Nigerian naira is used by one of the biggest countries in Africa with one of the greatest populations, our findings have broad implications for public health. Multidrug-resistant *Staphylococcus aureus* are widely dispersed in the study area, according to earlier research. Our findings provide additional evidence of the prevalence of drug-resistant microbes in the study environment, with probable transmission routes including currency. To determine the significance of cash in pathogen transmission, molecular studies showing a relationship between isolates from currency and those of clinical origin must also be conducted. As a result, it is important to follow hygienic precautions like thoroughly washing your hands with soap after using an ATM and to avoid putting cash in your socks, shoes, or under the carpet. Additionally, we should refrain from putting money in our mouths, biting off the ends of currency notes, and using saliva when counting money. Additionally, suppliers of ready-to-eat food should receive training on how to prevent potential cross-contamination between money notes and the food they sell.

The potential of infection from bacteria found on the notes should be taken into consideration when handling them, especially by individuals who place them in their brassiere or another region where there is intimate contact with the skin. Additionally, you should stop wetting your finger with saliva while counting naira notes because this practice increases the risk of transferring bacteria from the notes to your mouth. Notes that have been tampered with or are dirty should occasionally be removed from circulation.

Our research has demonstrated that the use of local currencies could help resistant microbes proliferate across Ekpoma. We, therefore, advise against engaging in behaviors that increase the risk of contracting an infection from handling currency or contamination, and we urge against sloppy hygiene standards when handling currency or immediately after. Electronic credit cards or plastic (or polymer-based) that could be quickly washed to reduce contamination as found in other nations might be adopted for all transactions to reduce the need of cash and, thus, the chance of exposure to contaminated currency. The general people should be made aware of the potential health risks associated with money notes as sources of infection. It is advised that the central bank of Nigeria enforce regulations against improper handling of Nigerian currency in order to aid in preventing the spread of these infections. Notes that have been tampered with or are dirty should occasionally be removed from circulation.

Money that has been tampered with or worn out needs to be routinely removed from circulation because it is the most polluted. To maintain the quality and longevity of currency, policies on proper handling should be implemented. Some recommendations for use of paper money and coins are as under:

1. It is suggested that regular disinfection of currency deposited in banks with ultraviolet light, fumigation or formalin vapors should be done.
2. The CBN should put in place a retrieval system, which ensures that notes do not remain in circulation for too long.
3. Money handlers should generally improve on their habit and ensure that the notes are not abused or mishandled. These could go a long way in checking the spread of infections through naira notes as formites.
4. It is advised to change the paper currency into plastic/ polymer-based currency notes which could be easily washed to reduce contamination.
5. It is recommended that more awareness campaign and seminars should be created both in rural and urban areas because it is only our identity in terms of transaction.

CONFLICT OF INTEREST

The authors declare no conflicts of interest. The authors alone are responsible for the content and the writing of the paper.

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