USED NIGERIAN CURRENCY NOTES AS POTENTIAL SOURCES OF INFECTION IN CALABAR, NIGERIA

Otu-Bassey, I. B. [1], Ibeneme, E. O.[1,2]*, Udomfuh, N. B. [1],
[1]Department of Medical Laboratory Science, Faculty of Allied Medical Sciences, University of Calabar, Calabar-Nigeria
[2]Dr. Lawrence Henshaw Memorial Specialist Hospital Reference Laboratory, Calabar, *Nigeria*
***Author for Correspondence:** +234-803-372-5219 / ibeneme.eo@gmail.com

ABSTRACT
Background: Currency notes when not used and in circulation, remain clean and fresh but when in use and have changed hands, may be soiled and liable to tear and microbial contamination. As unrelated to human health as it seems, money could serve as a vehicle in the transmission of pathogenic microbial organisms as well as disease if handled un-hygienically during its transit.
Aim: This study was therefore aimed to investigate the potentials of the Nigerian currency notes as vehicle for the transmission of microbial agents of infection in Calabar.
Methodology: A cross sectional study was carried out between May and September, 2017 to examine 200 randomly selected used Nigerian currency notes for bacteria and fungi of medical importance. Organisms were isolated using standard swabbing, direct microscopy and cultural techniques and identified using various biochemical techniques.
Results: Overall, 154 (77%) samples tested positive for potential bacterial pathogens, with *Staphylococcus aureus* taking the lead in prevalence (36%), followed by *Pseudomonas aeruginosa* (13.5%), *Escherichia coli* (11.5%) *Klebsiella aerogenes* (9.5%) and *Proteus mirabilis* (6.5%). Fungal isolates had a total of 147 (73.50%) with *Aspergillus niger* ranking highest (30.50%) in prevalence, followed by *Aspergillus fumigatus* (19.50%), *Candida albicans* (10%), *Blastomyces dermatitidis* (7.5%), and *Penicillium* spp (6%). The polymer notes recorded insignificantly higher bacterial and fungal organisms than the paper notes (p>0.05). The 50 naira note was the most (86.76%) while 5, 500, and 1000 naira notes were the least contaminated (50.0%) each.
Conclusion: The study has demonstrated a high rate of bacterial and fungal contamination of the Nigerian currency notes in Calabar. They may play a role in the spread of diseases in Calabar, hence adequate hygiene measures in the handling of money as well as the enforcement of cashless economy policy is suggested.
Key Words: Currency notes, contamination, pathogenic microbes, polymer, Calabar

INTRODUCTION
Currency notes are widely exchanged daily, for goods and services, by many people in communities all over the world (Allan *et al.*, 2018; Muguongo *et al.*, 2019; Tosin *et al.*, 2019), which expose these banknotes to microbial contamination as a result handling and storage, thereby making them potential sources of microbial infection to other people, more especially the immuno-compromised (Abd Alfadil *et al.*, 2018; Moses *et al.*, 2018). Banknotes, the most frequently used and circulated substance in the world, are usually contaminated with various microbes as they are handled by people of diverse health and hygienic standards and are stored under varying environmental and personal hygienic conditions (Mbajiuka *et al.*, 2014; Tosin *et al.*, 2019).
Contamination of banknotes may occur generally from the public in communities, hospitals (Moses *et al.*, 2018) and food-sales outlets, or during transactions, storage or production (Allan *et al.*, 2018; Moses *et al.*, 2018).

During handling and transactions, contamination from skin, wounds, nasal secretions and aerosols, and the anal region, are some of the main sources of contamination of banknotes (Moses *et al.*, 2018; Agholor *et al.*, 2020). Improper handling may be as a result of handlers coughing, sneezing onto hands and touching the notes: improper storage may come in the way of placement in or on dirty surfaces (Imarenezor *et al.*, 2018; Moses *et al.*, 2018). Practices which are unhygienic such as wetting fingers with saliva prior to counting notes (Abd Alfadil *et al.*, 2018; Imarenezor *et al.*, 2018; Moses *et al.*, 2018) and handling currency notes with filthy and stained fingers by market traders, automobile mechanics, meat-sellers and so on, may also introduce an array of bacteria to the notes (Imarenezor *et al.*, 2018); these could have a great impact on public health in a developing country like Nigeria, where microbial infection is ubiquitous and access to adequate healthcare is beyond the majority of citizens (Abd Alfadil *et al.*, 2018).

This study, therefore, aims to determine the extent of bacterial and fungal contamination of Nigeria currency notes in circulation in Calabar, Nigeria.

MATERIALS AND METHODS

Study Area

The areas of study were Calabar South and Calabar Municipality Local Government Areas (LGA) of Cross River State, Nigeria.

Sampling technique and sample collection

A random sampling technique was employed to obtain the various denominations of the Naira notes of the polymer and paper currency form. A total of 200 currency note samples were collected through the process of buying products and obtaining balance from traders in market places, meat sellers in abattoirs, beggars, taxi drivers, pump attendants in petrol stations and bankers. All samples were swabbed with pre-labelled, sterile swab sticks pre-soaked in sterile peptone water; the samples were then transported to the University of Calabar Teaching Hospital (UCTH) laboratory for microbial analysis.

Bacteriological analysis of samples

Each sample swab was soaked in 3-5 mL of sterile peptone water in a test tube and incubated at 37^{o}C for 3-5 hours. The stock suspension for each sample was then cultured onto blood agar (BA), chocolate agar (CHOC) and MacConkey agar (MAC) plates and also enriched in Selenite F broth; all cultures were incubated at 37^{o}C for 18-24 hours. The enriched culture in Selenite F broth was then sub-cultured onto Salmonella-Shigella agar (SSA) after incubation at 37^{o}C for 18 hours. The bacterial colonies on the agar plates were identified using Gram reaction, colonial and morphological appearance, and standard biochemical tests (oxidase, indole, coagulase, DNAse, urease, lysine and ornithine decarboxylase, beta-galactosidase, hydrogen sulphide production, methyl red, citrate and carbohydrate fermentation) (Franco-Duarte *et al*., 2019).

Mycological analysis of samples

Each sample swab was soaked in 3-5 mL of sterile peptone water in a test tube and incubated at 37^{o}C for 3-5 hours. The stock suspension for each sample was then cultured onto Sabouraud Dextrose agar (SDA) and incubated at 37^{o}C for 24-48 hours. Fungal colonies were morphologically identified by viewing the slide smears of the colonies, stained with lactophenol blue (Sangeetha and Thangadurai, 2013) and confirmed with standard fungal biochemical tests such as carbon and nitrogen utilization, carbon fermentation and enzyme activity (caseinase, cellulase, gelatinase, glucosidase,fatty acid esterase, lipase, urease) (Paterson and Bridge, 1994).

RESULTS

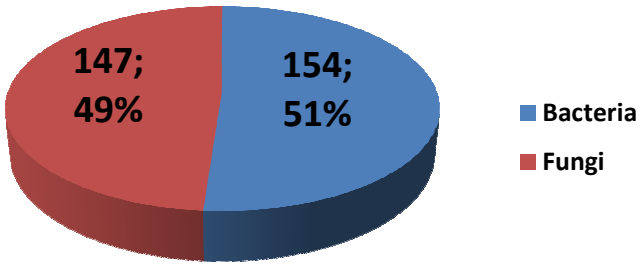

Figure 1: Occurrence of microbes on currency notes
Results from microbial analysis of currency notes established a higher prevalence of bacteria (51.0%; 154/301) than fungi (49.0%; 147/301) (Figure 1).

Table 1: Distribution of bacterial and fungal pathogens on used Nigerian currency notes in relation to note texture

Currency note texture	No. examined	No. (%) positive for Bacteria	Fungi	Chi-square Value	Significance
Polymer	128	104 (81.3)	99 (77.3)	$X^2 = 3.626$, $p>0.05$	NS
Paper	72	50 (69.4)	48 (66.7)	$X^2 = 2.697$, $p>0.05$	NS
Total	**200**	**154 (77.60)**	**147 (73.50)**		

NS – not significant

Polymer-type notes, compared with paper-type notes, harboured a higher number of bacteria (104/128; 81.3% and 50/72; 69.4 respectively) and fungi (99/128; 77.3% and 48/72; 66.7% respectively) (Table 1). These differences were not statistically significant ($X^2 = 3.626$, $p>0.05$ and $X^2 = 2.697$, $p>0.05$ respectively).

Table 2: Distribution of potential bacterial pathogens on used Nigerian currency notes based on denominations

Currency denomination	Number examined	No (%) +ve for bacterial pathogen *S. aureus*	*Proteus mirabilis*	*Klebsiella aerogenes*	*E. coli*	*P. aeruginosa*	Total
₦5	12	3 (25.00)	1 (8.33)	2 (16.67)	2 (16.67)	1 (8.33)	9 (75.00)
₦10	22	12 (54.54)	1 (4.55)	1 (4.55)	2 (9.09)	1 (4.55)	17 (77.27)
₦20	26	9 (34.61)	2 (7.70)	3 (11.53)	4 (15.38)	2 (7.69)	20 (76.92)
₦50	68	31 (45.59)	4 (5.88)	5 (7.35)	6 (8.82)	12 (17.64)	58 (85.29)
₦100	28	7 (25.00)	1 (3.57)	3 (10.71)	4 (14.29)	6 (21.42)	21 (75.00)
₦200	24	6 (25.00)	2 (8.33)	2 (8.33)	3 (12.50)	3 (12.50)	16 (66.67)
₦500	10	3 (30.00)	1 (10.00)	1 (10.00)	1 (10.00)	1 (10.00)	7 (70.00)
₦1000	10	1 (10.00)	1 (10.00)	2 (20.00)	1 (10.00)	1 (10.00)	6 (60.00)
Total	**200**	**72 (36.00)**	**13 (6.50)**	**19 (9.50)**	**23 (11.50)**	**27 (13.50)**	**154 (77.00)**

$X^2=3.626$, $p>0.05$

Out of the 200 used Nigerian currency notes examined, 154 (77.00%) harboured various potential bacterial pathogens, including *Staphylococcus aureus*, which ranked highest with 36.0% prevalence, followed by *P. aeruginosa* (13.5%), *E. coli* (11.5%), *K. aerogenes* (9.5%) and *Proteus mirabilis* (6.5%). The denomination of Naira note most contaminated with bacteria among the used currency notes examined, was the 50 Naira note (85.3%; 58/68), closely followed by the 10 Naira notes(77.3%; 17/22) (Table 2). The distribution of bacterial pathogens on used Nigerian currency notes by denominations was not statistically significant (X^2=3.626, p>0.05).

Table 3: Distribution of pathogenic fungi from the Nigerian currency notes based on denominations

Currency denomination	Number examined	No (%) +ve for fungal pathogen					Total
		Aspergillus niger	*Aspergillus fumigatus*	*Candida albicans*	*Blastamyces dermatitidis*	*Penicillium*spp	
₦5	12	2 (16.67)	1 (8.33)	1 (8.33)	1 (8.33)	1 (8.33)	6 (50.00)
₦10	22	11 (50.00)	2 (9.09)	1 (4.54)	1 (4.54)	1 (4.54)	16 (72.73)
₦20	26	8(30.77)	4 (15.38)	3 (11.53)	2 (7.70)	1 (3.85)	18 (69.23)
₦50	68	24 (35.29)	19 (27.94)	6 (8.82)	6 (8.82)	4 (5.88)	59 (86.76)
₦100	28	8 (28.57)	7 (25.00)	3 (10.71)	2 (7.14)	1 (3.57)	21 (75.00)
₦200	24	5 (20.83)	4 (16.67)	4 (16.67)	1 (4.17)	2 (8.33)	16 (66.67)
₦500	10	2 (20.00)	1 (10.00)	1 (10.00)	1 (10.00)	1 (10.00)	5 (50.00)
₦1000	10	1 (10.00)	1 (10.00)	1 (10.00)	1 (10.00)	1 (10.00)	5 (50.00)
Total	**200**	**61 (30.50)**	**39 (19.50)**	**20 (10.00)**	**16 (7.50)**	**12 (6.00)**	**147 (73.50)**

X^2=2.697, p>0.05

Of the 200 used Nigerian currency notes examined, 147 (73.5%) harboured various fungal pathogens, including *Aspergillus niger* (61/200; 30.5%), *Aspergillus fumigatus* (39/200; 19.50%), *Candida albicans* (20/200; 10%), *Blastomyces dermatitidis* (16/200; 7.5%) and *Penicillium* spp. (12/200; 6.0%). Among the denominations examined, the highest rate of fungal contamination was observed on the 50 Naira notes (86.8%; 59/68) followed by the 100 Naira notes (75.0%; 21/28) and the 20 Naira notes (69.2%; 18/26) (Table 3). The distribution of fungal pathogens on used Nigerian currency notes by denominations was not statistically significant (X^2=2.697, p>0.05).

DISCUSSION

Bacterial and fungal contaminations of currency notes have been documented in Nigeria (Umeh *et al.*, 2007; Awe *et al.*, 2014; Mbajiuka *et al.*, 2014; Yakubu *et al.*, 2014; Sani *et al.*, 2016; Tosin *et al.*, 2019) as well as in other parts of the world (Adinortey *et al.*, 2011; Al-Ghamdi *et al.*, 2011; Mukharjee *et al.*, 2017; Abd Alfadil *et al.*, 2018; Elsharief *et al.*, 2018); this study corroborates these findings.

In the present study, there were more bacteria isolated from currency notes than fungi. Bacteria are known to be more prevalent on human skin than fungi (Byrd *et al.*, 2018). This fact could have accounted for the greater number of bacterial isolates than fungal isolates. Most bacteria encountered in this study are normal flora of the human skin. This suggests that humans are the major source of bacteria found on Naira notes: possibilities are that the notes could have been colonized when placed in areas where they make direct contact with the skin, which harbours a complex ecosystem of transient and/or resident microorganisms (Awe *et al.*, 2010; Skowron *et al.*, 2021). The number of bacteria on an area of skin surface ranges from 10^3cfu/cm^2 in dry areas, to more than 10^7cfu/cm^2 in moist areas (Skowron *et al.*, 2021). In addition, dirty notes are usually moist and thereby provide a good surface for bacterial growth (Alemu, 2014).

Reports from other parts of Africa, such as Libya, Ghana, and Sudan (Adinortey *et al.*, 2011; Abd Alfadil *et al.*, 2018; Elsharief *et al.*, 2018) and from Saudi Arabia (Al-Ghamdi *et al.*, 2011) as well, revealed that bank notes provide a large surface area for the proliferation of pathogenic microbes, which may cause human diseases such as meningitis, tuberculosis, diarrhoea, septicaemia and urinary tract and gastro-intestinal infections (Tosin *et al.*, 2019).

In the present study, currency notes made of polymer harboured more bacteria and fungi when compared with paper-type currency notes. Although some studies observed that polymer-type currency notes often have lower bacterial count when compared with the cotton-based, paper-type currency notes (Allan *et al.*, 2018), which might be as a result of various physicochemical parameters of polymers (Vriesekoop *et al.*, 2010; Allan *et al.*, 2018). In recent times, many nations are adopting the plastic polymer made currency (Allan *et al.*, 2018) since they are stronger and probably last longer in circulation (Alemu, 2014). The polymer notes, in this study, could have acquired more bacterial and fungal load and as a result of longer duration of circulation and higher rates of handling in cash transactions. Also, the smaller denominations which are polymer-type are much more handled than the larger paper-type denominations, by petty traders who care less about hygienic handling of currency notes (Adinortey *et al.*, 2011); Alemu (2014) observed this phenomenon in journal articles reviewed.

Bacteria of the Enterobacteriaceae family were more diversely predominant on currency notes tested in this study; although of all individual bacteria isolated, *Staphylococcus aureus* was the most dominant. *S. aureus* are usually normal, harmless bacteria living on human skin, but once they gain entry into damaged skin or deeper body tissues, they are often able to cause pyogenic infections, from the mild peeling of superficial skin layer (exfoliation), impetigo, carbuncles, to the severe, such as food intoxication and deep-seethed systematic infections (Awe *et al.*, 2010). Nose rubbing, coughing and sneezing on hands, while exchanging money (Al-Ghamdi *et al.*, 2011; Tosin *et al.*, 2019), as well as placing currency notes in or close to underwear or underpants, which are close to damp skin areas (Leonard and Olajumoke, 2016), could inadvertently result in contamination of currency notes. Infection with *S. aureus* always result in major problems in hospitals, but in the past few decades the incidences of community-acquired *S. aureus* infection have increased tremendously (Al-Ghamdi *et al.*, 2011). Paper currency has recently been identified as a mode of transmission of community-acquired *S. aureus*. Since staphylococci have developed resistance to many antibiotics, the spread of antibiotic resistant strains by paper currency is almost inevitable (Al-Ghamdi *et al.*, 2011; Aminu and Yahaya, 2018). Next to *S. aureus* in prevalence, in this study, was *Pseudomonas aeruginosa*.

It is a free-living bacteria and one of three *Pseudomonas* species responsible for opportunistic infections in immuno-compromised individuals (Moradali *et al.*, 2017). It may cause eye and skin infections, as well as external otitis (Awe *et al.*, 2010).

In this study, *Aspergillus* species and *Candida* species were the most dominant fungi, accounting for about 50% of all fungi isolated from currency notes. Both organisms were more dominant in lower denomination notes which are polymer-based, than in paper-based currency notes. This could be as a result of wider circulation of the lower denomination currency notes, which are more handled by petty traders who have little or no regard for proper handling and storing of currency notes (Adinortey *et al.*, 2011; Alemu, 2014). Polymer notes also absorb moisture poorly, hence retaining more surface film of moisture capable of promoting the growth of fungi. *Rhizopus*, *Penicillium*, *Aspergillus* species, and yeasts were reported in several studies (Adinortey *et al.*, 2011; Mbajiuka *et al.*, 2014; Girma, 2014), including *Fusarium* (Sharma and Sumbali, 2014; Girma, 2014), *Trichoderma* species (Yakubu *et al.*, 2014; Girma, 2014), Sani *et al.* (2016) observed that *Rhizopus* species was the most predominant fungi in their study, while Adinortey *et al.* (2011) reported same to be the least predominant fungi.

Aspergillus species are commonly found on old paper notes and even on brand new minted notes; *Aspergillus niger* seem to be the most predominant fungi. It is less likely to cause human disease, but aspergillosis and acute pneumonia usually results whenever many spores are inhaled (Schuster *et al.*, 2002; Sharma and Sumbali, 2014). The fungus may also colonize cavities within the lungs and invade all parts of the body, and almost always results in death in immunocompromised patients (Campbell and Steward, 1980; Khin *et al.,* 1989). It can also cause serious lung diseases as well as otomycosis (Ozcan *et al.,* 2004; Ozhak-Baysan *et al.,* 2010). *Candida* species infection can lead to serious endocarditis (Halawa *et al.,* 2011; Madhavan *et al.,* 2011).

CONCLUSION

This study clearly showed that Nigerian currency notes are contaminated with bacteria and it highlights the potential for paper-based as well as polymer-based notes money to spread pathogenic bacteria and fungi in the Nigerian community.

There is therefore the need to intensify the education on currency note handling to reduce the potential risks of transfer of pathogen between persons. Improvement of personal hygiene standards is strongly recommended to reduce the risk of infection. The Central bank of Nigeria (CBN) should improve on existing cashless systems to reduce the use of currency notes. Dirty and mutilated currency notes should be withdrawn from circulation periodically. These could go a long way in reducing the spread of infections through naira notes.

Conflict of interest declaration

The authors declare no conflict of interest.

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