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Assessment of bacterial isolates associated with mobile phones of meat sellers in selected markets in Benin city, Edo State, Nigeria

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Abstract

Mobile phones are essential components used to enhance social life and aid different professions. Swab samples were obtained from ninety-six (96) meat sellers' mobile phones in four (4) major markets; Edaiken, New Benin, Oba and Ogida in Benin City, over a period of four months. Mobile phones were sampled in the morning (8am-10am) and evening (4pm-6pm) between September, 2018 and December, 2018. Samples were immediately transported to the laboratory for microbiological processing and analysis using standard methods. The isolates were enumerated and identified, and antibiotics susceptibility test was carried out before and after plasmid curing. The study revealed that the mean total heterotrophic bacterial counts ranged from 1.07 ± 0.22 x 10^4 CFU/mL in New Benin market to 5.60 ± 0.12 x 10^4 CFU/mL in Edaiken market. The mean total coliform counts ranged from 0.60 ± 0.15 x 10^4 CFU/mL in Ogida Market to 4.63 ± 0.61 x 10^4 CFU/mL in Oba Market. The total staphylococcal counts ranged from 0.27 ± 0.09 x 10^4 CFU/mL in Oba market to 3.00 ± 0 ± 1.30 x 10^4 CFU/mL in New Benin market. *Staphylococcus epidermidis*, *Bacillus* spp, *Staphylococcus aureus*, *Klebsiella* sp., *Pseudomonas aeruginosa*, *Escherichia coli* and *Enterococcus* sp. were recovered. All the bacterial isolates had multiple antibiotic resistance index greater than the minimum limit of 0.2, indicating that the isolates are of significant public health concern. *Escherichia coli*, *Klebsiella* spp, *Pseudomonas aeruginosa*, *Staphylococcus aureus* and *Bacillus* spp all had multiple plasmids, according to the plasmid profile study. The existence of bacterial isolates linked to human diseases on the phones of meat vendors highlight their potential as fomites, which could lead to disease outbreaks resulting in infections with serious public health implications.

Keywords: Antibiotics susceptibility, Assessment, Markets, Meat sellers, Mobile phones, Plasmids.

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INTRODUCTION

Mobile phones are electronic devices use for communication. It was founded in Europe in 1982 with the goal of increasing communication (Neubauer *et al*., 2005). Initially, majority of mobile phones produced were very large to be permanently put in cars as car phones (Ekhaise *et al*., 2008). Mobile phones are vital business and social accessories, yet they are regularly exposed to microbial infected environments (Akinyemi, 2009). Due to the accomplishments and benefits derived from mobile phones, humans do not consider the potential health risk these phones pose to them (Tagoe *et al*., 2011). Many users neglect personal cleanliness and also share their phones with other people. This exposes the phones to a wide range of germs, making it an excellent transmittable tool for the microorganisms that are on the phone surfaces (Ibrahim *et al*., 2013). All mobile phones are held in the hand and germs which reside on human hands as their natural microflora or those picked up from the environment can contaminate the phones (Al-Abdalall, 2010). It is possible that harmful bacteria could be transferred from human hands to mobile phones (Kusumrungum *et al*., 2003). Ekrakene and Igeleke (2007) states that the continual handling of the phones and their increased temperature during usage makes it an ideal habitat for breeding by microorganisms. They can be contaminated by a variety of sources, including human hands and skin, purses and the environment. These sources are pathways for microbes to colonize phones, resulting in both mild and acute diseases (Soto *et al*., 2006). Furthermore, because mobile phones are carried by people to different environments where microorganisms abound, they may act as fomites (Bhoonderowa *et al*., 2014).

Mobile phones, provide a great breeding environment for microorganisms, with increased temperatures and humidity (Srikanth *et al.,* 2009; Tambe and Pai, 2012). In locations where the amount of germs present is anticipated to be high, such as market places, mobile phone usage has increased substantially. This could increase pathogen transmission and make disease containment more challenging (Butcher and Ulaeto, 2005). The mobile phone comes into intimate contact with likely contaminated parts of the human body; mouth, ears, nose and hands during usage (Elkholy and Ewees, 2010). There is emerging evidence that polluted surfaces play a key role in the propagation of antibiotic-resistant microorganisms (Weinstein and Hota, 2004). In addition, studies show that those who use contaminated cellphones have a higher risk of contracting infectious infections (Khan and Shaikh, 2012). Meat contamination can occur due to intrinsic microflora in normal animal tissues, air, and surroundings, improper slaughtering practices, handling and processing circumstances (Bell, 1997; Kozaèinski *et al*., 2006). Following slaughtering, several bacteria are introduced at various stages of the meat processing process, which contaminate the meat. Furthermore, hand washing may not be frequently done during the daily activities hence increasing the risk of germ transmission via mobile phones (Schulz *et al*., 2003). The essence of assessing the bacterial load of mobile phones is to promote and create awareness about the hygiene practices of phone users (Lubwama *et al*., 2021). This study was carried out to identify bacterial isolates found on meat sellers' phones in Benin City, Edo State, Nigeria.

MATERIALS AND METHODS

Collection of samples

The samples for the study were from the mobile phones of meat sellers using sterile swab sticks by firmly wiping the surface of the phones. Samples were collected in the morning (8am - 10am) and in the evening (4pm- 6pm) once in a month from September 2018 to December, 2018. They were immediately transported to the laboratory for microbiological analysis (Cheesbrough, 2000; Amala and Ade, 2015).

Enumeration and identification of the bacterial isolates*:*

The swabs were each immersed separately in peptone water contained in a test tube so as to revive the organisms, 1mL of the peptone water was used to inoculate individually, freshly prepared media (nutrient, MacConkey and mannitol salt agar) and thereafter incubated at 37^{o}C for 24 h. After incubation the colonies were enumerated while the discrete bacterial colonies were then sub-cultured on sterile plates containing nutrient agar for proper identification (Cheesbrough, 2000; Anyadoh-Nwadike *et al*., 2011). Mannitol salt and MacConkey agar were used to selectively isolate and culture *Staphylococcus* spp. and coliform respectively. The pure bacteria isolates were confirmed using

cultural, morphological and some biochemical tests which included: coagulase, urease, catalase, oxidase, indole and citrate utilization tests (Cheesebrough, 2000).

Antibiotics susceptibility of the bacterial isolates

Kirby-Bauer disc diffusion method was used and a standardized inocula was achieved using the direct colony method. A pure colony of the bacterial isolate was used to form a suspension of 1mL sterile normal saline, which was adjusted to a 0.5 McFarland standard equivalent, then 0.1mL of the bacterial inoculum suspension was smeared across the whole surface of sterile Mueller-Hinton agar plates to inoculate them. The plates were air-dried for 15 min. before being incubated at 37°C for a period of 24 h. The zones of inhibition of growth were measured and evaluated using approved guidelines (Julien *et al.,* 2014; CLSI, 2017).

Plasmid profiling and curing

Plasmid profiling liquid cultures were grown to saturation overnight at 37^{o}C in 3-5 mL LB + ampicillin or LB + carbenicillin liquid and spun down ~1.5 mL of culture in a microfuge tube for 15 sec at maximum speed. Cells were suspended in 200µL STET buffer, by gently pipetting up and down (or by vortexing). Twenty microliters (20 µL) lysozyme solution was added, mixed briefly by quick vortex or inversion and immediately placed at 100^{o}C for 3 min. and then removed promptly. Tubes were cooled down for a few minutes on bench top, spun at top speed for 20 min. and the gooey precipitate/pellet was removed with a wooden toothpick and discarded. Equal volume of 100 % isopropanol was added to each tube (~250-300µL) and mixed well, before being placed on ice or at 4^{o}C for at least 30 min. Precipitated nucleic acids (DNA+RNA) was spun down at top speed for 15 or 20 min. The supernatant was discarded, and the pellets were rinsed in 70% ethanol, vortexed, and spun for a few minutes. Ethanol and dry pellet were aspirated and pellet was re-suspended in 50-200 µL TE. Volume of 1-5 µL per restriction digest was used. Ribonuclease was added. Miniprep DNA was stored at -20^{o}C. The bacteria were injected into a 10 mL nutrient broth containing 100 g/ml of the mutagen (acridine orange). Each mutagen-exposed culture was plated on nutritional media, inoculated then incubated at a temperature of 37°C for 24 h after inoculation (Sheikh *et al.,* 2003).

RESULTS

Results of the total heterotrophic bacterial counts of mobile phones of meat sellers (Table 1) reveal that the sampled mobile phones from Edaiken market, in the evening had the highest total heterotrophic bacterial count (5.60 ± 0.12 x 10^4 cfu/mL) in October 2018, while New Benin market in the morning, recorded the least total heterotrophic bacterial count (1.07 ± 0.22 x 10^4 cfu/mL) obtained in December 2018. The findings of the coliform count of meat dealers' mobile phones are shown in Table 2. Samples from mobile phones of meat sellers in Oba market, collected in the evening (4.63 ± 0.61 x 10^4cfu/ mL) had the highest total coliform count recorded in the month of September, 2018 while samples from Ogida market collected in the morning, had the least coliform count of 0.60 ± 0.15 x 10^4 CFU/mL in the month of December, 2018. The highest bacterial count was recorded from samples obtained in the evening (4pm- 6pm).

In Table 3 the results of the total Staphylococcal counts on mobile phones of meat sellers reveals that the highest Staphylococcal count was recorded from mobile phones of meat sellers in New Benin market, in the evening (3.00 ± 0.40 cfu/mL) obtained in October, 2018. In December 2018, samples obtained in the morning from Edaiken Market had the lowest Staphylococcal counts (0.27 0.09 cfu/mL). Table 4 shows the result of the cultural, morphological, and biochemical characteristics features of the bacterial isolates. The identified isolates are *Staphylococcus aureus, Escherichia coli, Pseudomonas aeruginosa, Klebsiella* spp., *Staphylococcus epidermidis, Bacillus* spp. and *Enterococcus* spp. Table 5 shows the frequency of occurrence. *Staphylococcus aureus* had the highest frequency of occurrence (21.6 %) and *Enterococcus* sp. recorded the lowest frequency of occurrence (3.1 %).

Table 1: Total Heterotrophic Bacteria Counts of Mobile Phones of Meat Sellers in Sampled Markets (September to December 2018) in Benin City

Sampling locations	September	October	November	December
	x 10^4 CFU/mL			
Oba Market (Morning)	4.27±0.79	4.63±0.24	3.63±0.78	2.73±1.63
Oba Market (Evening)	4.97±0.12	4.53±0.84	4.27±0.87	3.50±1.61
Ogida Market (Morning)	3.47±0.92	2.87±0.10	3.33±1.01	2.17±0.44
Ogida Market (Evening)	4.37±0.62	3.00±0.10	3.90±1.09	2.67±0.44
New Benin Market (Morning)	3.93±1.12	3.97±1.45	3.67±1.29	1.07±0.22
New Benin Market (Evening)	5.02±0.85	4.70±0.78	4.87±0.47	1.27 ±0.37
Edaiken Market (Morning)	3.52±0.92	4.87±0.15	3.57±0.74	1.23±0.15
Edaiken Market (Evening)	4.47±1.13	5.60±0.12	4.10±0.60	1.87±0.32

Values are expressed as Mean ±Standard Error of duplicate experiments.

Table 2: Coliform Counts of Mobile Phones of Meat Sellers in Sampled Markets (September to December, 2018) in Benin City.

Sampling Locations	September	October	November	December
	x 10^4 CFU/mL			
Oba Market (Morning)	3.67±0.45	3.03±0.49	2.57±1.18	1.77±0.15
Oba Market (Evening)	4. 63±0.61	3.90±0.40	4.20±1.05	1.97±0.32
Ogida Market (Morning)	2.53±0.32	1.60±0.32	0.77±0.46	0.60±0.15
Ogida Market (Evening)	2.73±0.32	2.20±0.55	0.93±0.17	1.57±0.75
New Benin Market (Morning)	2.33±0.67	1.40±0.47	1.53±0.58	2.27±0.37
New Benin Market (Evening)	3.27±0.52	3.23±0.38	2.33±0.47	2.70±0.97
Edaiken Market (Morning)	3.53±0.62	2.97±0.92	2.40±1.35	1.63±0.13
Edaiken Market (Evening)	4.30±0.46	4.37±0.37	3.47±0.95	2.13±0.35

Values are expressed as Mean ±Standard Error of duplicate experiments.

Table 3: Total Staphylococci counts of mobile phones of meat sellers in sampled markets (September to December, 2018) in Benin City.

Sampling Locations	September	October	November	December
	x 10^4 CFU/mL			
Oba Market (Morning)	1.90±0.87	1.37±0.61	1.50±0.72	0.30±0.12
Oba Market (Evening)	2.93±0.87	2.67±0.29	2.40±1.10	0.80±0.23
Ogida Market (Morning)	0.90±0.15	1.07±0.13	0.53±0.18	0.47±0.37
Ogida Market (Evening)	1.80±0.36	2.13±0.09	1.17±0.71	0.80±0.44
New Benin Market (Morning)	1.00±0.15	2.00±0.15	1.53±0.35	0.87±0.58
New Benin Market (Evening)	1.77±0.23	3.00±0.40	1.90±0.27	0.32±0.13
Edaiken Market (Morning)	0.70±0.25	1.00±0.15	0.47±0.42	0.27±0.09
Edaiken Market (Evening)	2.40±0.35	2.27±0.20	1.60±0.99	0.80±0.15

Values are expressed as Mean ±Standard Error of duplicate experiments.

Table 4: Cultural, morphological and biochemical characteristics of the bacteria isolates

	Bacterial isolates						
Cultural	A	B	C	D	E	F	G
Shape	Circular	Circular	Irregular	Irregular	Circular	Circular	Circular
Colour	Golden yellow	White	Greenish blue	Grey white	Grey white	Yellow	Cream
Opacity	Opaque	Translucent	Translucent	Opaque	Opaque	Opaque	Translucent
Elevation	Raised	Raised	Raised	Flat	Raised	Raised	Flat
Morphological							
Gram stain	+	-	-	+	-	+	+
Shape	Cocci	Rods	Rods	Rods	Rods	Cocci	Cocci
Arrangement	Clusters	Single	Single	Single	Clusters	Clusters	Single
Motility	-	+	+	+	-	-	-
Biochemical							
Catalase	+	+	+	+	+	+	-
Oxidase	-	-	+	-	-	-	-
Indole	-	+	-	-	-	-	-
Urease	+	-	-	-	+	+	-
Citrate	+	-	+	+	+	-	-
Coagulase	+	-	-	-	-	-	-
H_2S	-	-	-	-	-	+	-
Sugar Fermentation							
Lactose	+	+	-	-	+	+	+
Sucrose	+	+	-	-	+	+	+
Glucose	+	+	-	+	+	+	+
Probable Isolates	*Staphylococcus aureus*	*Escherichia coli*	*Pseudomonas aeruginosa*	*Bacillus* spp.	*Klebsiella* spp.	*Staphylococcus epidermidis*	*Enterococcus* spp.

Key: + , positive; -, negative

The antibiotic resistance pattern of the bacterial isolates is presented in Table 6. At least three of the antibiotics used were resistant to all of the bacterial isolates tested. All drugs were completely resistant in *Escherichia coli*, *Klebsiella* sp., *Pseudomonas aeruginosa*, *Staphylococcus aureus*, and *Bacillus* sp. *Staphylococcus epidermidis* were susceptible to cotrimoxazole, ampicillin, rocephin, ciprofloxacin and streptomycin. *Enterococcus* spp. were susceptible to some of the antibiotics used including pefloxacin, gentamicin, ampicillin, amoxicillin, ciprofloxacin, streptomycin. One hundred percent (100%) of the bacterial isolates had a multiple antibiotic resistance (MAR) index greater than the acceptable limit of 0.2, indicating that the isolates were of significant public health concern. The results of the antibiotics sensitivity testing of the bacterial isolates after curing are presented in Table 7. Even after curing, the bacterial isolates were found to be resistant to some of the antibiotics used (cotrimoxazole, pefloxacin, rocephin, and ampicillin). *Pseudomonas aeruginosa* and *Klebsiella* spp., on the other hand, were found to be resistant to ciprofloxacin and amoxicillin. *Staphylococcus*

aureus and *Bacillus* spp. were sensitive to gentamicin, rocephin, and erythromycin after curing. Plate 1 shows the results of the agarose gel electrophoresis of plasmids harbored by the bacterial isolates. It was revealed that, the bacterial isolates possessed multiple plasmids. The molecular size of the plasmids obtained varied but were all above 3kbp.

Table 5: Frequency of occurrence of the bacteria isolates (%)

Isolates	**Occurrence (%)**
Staphylococcus aureus	21 (21.6)
Pseudomonas aeruginosa	19 (19.6)
Staphylococcus epidermidis	18 (18.6)
Escherichia coli	17 (17.5)
Bacillus spp.	13 (13.4)
Klebsiella spp.	6 (6.2)
Enterococcus spp.	3 (3.1)
Total	97 (100)

Table 6: Antibiotic resistance pattern of bacterial isolates

Gram -ve	No.	CMX	CHL	SFX	CIP	AMX	AMC	GEN	PEF	OFX	STR
E. coli	17	5(29.4)	7(41.2)	4(23. 5)	3(17. 6)	7(41.2)	2(11.8)	2(11.8)	2(11.8)	3(17. 6)	5(29.4)
P. aeruginosa	19	7(36.8)	6(31. 6)	8(42.1)	4(21.1)	5(26.3)	2(10. 5)	2(10. 5)	3(15.8)	4(21.1)	5(26.3)
Klebsiella spp.	6	2(33.3)	1(16.7)	1(16.7)	2(33.3)	3(50)	1(16.7)	1(16.7)	1(16.7)	1(16.7)	1(16.7)
Gram +ve		PEF	GEN	AMP	CXM	AMX	CRO	CIP	STR	CMX	E
S. aureus	21	7(33)	5(23.8)	4(19)	7(33.3)	3(14.3)	7(33.3)	4(14.3)	4(19)	2(9. 5)	5(23.8)
Bacillus spp.	13	4(30.8)	1(7.7)	4(30.8)	6(46.2)	2(15.4)	4(30.8)	3(23.1)	4(30.8)	2(15.4)	3(23.1)
Enterococcus spp.	3	0(0)	0(0)	0(0)	1(33.3)	0(0)	2(66.7)	0(0)	0(0)	1(33.3)	1(33.3)
Staphylococcus epidermidis	18	2(11.1)	1(5. 6)	0(0)	1(5.6)	2(11.1)	0(0)	0(0)	0(0)	1(5.6)	2(11.1)

KEY: OFX = ofloxacin, CMX = cotrimoxazole, SFX= sparfloxacin, CIP = ciprofloxacin, AMX = amoxicillin, AMC =amoxicillin + clavulanic acid, CXM = cefuroxime, PEF= pefloxacin, STR = streptomycin, GEN =gentamicin, CRO = ceftriaxone, E = erythromycin, AMP =ampicillin, CHL= chloramphenicol. R - Resistance, I = Intermediate and S – Susceptible

Table 7: Antibiotic sensitivity testing of bacterial isolates after curing

Gram -ve	CMX	CH	SFX	CIP	AMX	CRO	GEN	PEF	OFX	STR	MAR Index
E. coli	S	S	R	S	S	S	R	R	S	R	0.4
P. aeruginosa	S	S	S	S	S	R	S	R	R	R	0.4
Klebsiella spp.	R	R	S	S	S	R	S	S	S	S	0.3
Gram +ve	PEF	GEN	AMP	CXM	AMX	CRO	CIP	STR	CMX	E	MAR Index
S. aureus	R	S	S	R	S	S	R	S	R	S	0.4
Bacillus spp.	S	S	R	S	R	S	S	R	S	S	0.3

KEY: OFX = ofloxacin, CMX = cotrimoxazole, SFX= sparfloxacin, CIP= ciprofloxacin, AMX = amoxicillin, CXM = cefuroxime, PEF= pefloxacin, STR = streptomycin, GEN =gentamicin, CRO = ceftriaxone, E = erythromycin, AMP =ampicillin. R - Resistance, I = Intermediate and S – Susceptible MAR index ≥ 0.2 (public health significance).

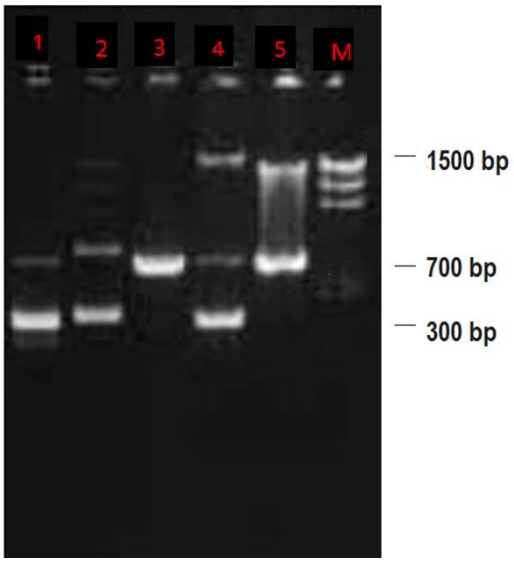

Plate 1: Agarose Gel Electrophoresis of Plasmids Harboured by the Bacterial Isolates
lane 1: *Escherichia coli* (plasmid present), lane 2: *Pseudomonas aeruginosa (*plasmid present), lane 3: *Klebsiella* spp. (plasmid present), lane 4: *Staphylococcus aureus* (plasmid present), lane 5: *Bacillus* spp. (plasmid present).

Discussion

Mobile phones are indispensable component of modern civilization. However, due to the intimate character of humans and the proximity of mobile phones to sensitive parts of the body (faces, hands, mouth and ears) during use, they serve as reservoirs of bacteria that could lead to diseases (Karabay *et al*., 2007; Kilic *et al*., 2009). Some of the bacteria found on mobile phones surfaces were shown to be potentially harmful to humans, according to the research. These isolates when present in a vulnerable host could have major health implications. High bacterial contamination was reported on the mobile phones investigated in the current study. Other researchers have reported mobile phones as a major source of bacterial infection in Ghana (Tagoe *et al.,* 2011), Nigeria (Ilusanya *et al.,* 2012), India (Kumar and Aswathy, 2014), and Egypt (Selim and Abaza, 2015). Pathogens can remain infectious on fomites or surfaces for a long time after exposure, depending on the environment. Pathogens can also aggressively colonize these surfaces in humid conditions, changing a reservoir from passive to active state. In addition, biofilm formation by bacterial isolates on a surface might influence and affect the survival rate of other microbes present there (Hassan *et al.,* 2004). Sampled mobile phones from Edaiken Market, in the evening recorded the highest total heterotrophic bacteria counts ($5.60 \pm 0.12 \times 10^4$ cfu/mL) while samples from New Benin Market, sampled in the morning had the least total heterotrophic bacteria counts ($1.07 \pm 0.22 \times 10^4$ cfu/mL). The total heterotrophic bacterial counts exceeded the recommended permissible limit for bacterial surface contamination and this could result to serious public health consequence. The bacterial counts recorded in the evening were found to be greater than those obtained in the morning. It could be inferred that the mobile phones would have picked up more bacteria from the hands and the environment all through the day considering the amount of handling. The high bacterial isolates load on these phones may be due to a number of reasons that contribute to their

contamination. A large number of bacterial isolates can be found in raw meat and bacterial isolates from the soil, animal feed, water, dung, animal's natural flora and digestive systems, are all found on the meat. Knives, air and hands, and meat sellers' clothing could all be intermediate sources of contamination (Leung *et al*., 2015). Depending on how it is handled, these germs can multiply throughout transportation or even at the retail point. Butchers and meat handlers in poor nations rarely follow meat safety regulations and instead work according to their own preference. For optimal meat storage, most meat vendors lack freezers or refrigerators. Meat Vendors that do not have proper storage facilities have a higher microbial load in their meat, according to studies (Iheagwara and Okonkwo, 2016).

It was observed that the majority of meat vendors do not practice hand cleaning, neither do they practice frequent and proper hand washing with soap and running water. The business is also, yet to fully embrace the concept of cleanliness and basic sanitary measures, largely due to their poor understanding of infection control practices. The lack of understanding of meat sellers about safety rules, as well as their inadequate sanitary and personal hygiene practices, was also highlighted by Adesokan and Raji's (2014). As a result, cross contamination between mobile phones and handlers could occur, turning these phones into veritable reservoirs of bacteria that could cause diseases. These meat sellers deal with money on a regular basis, hence, cross contamination between mobile phones and money is a possibility. Furthermore, the majority of meat vendors do not clean or disinfect their cellphones. During this research, 100% of the volunteers stated that they had never cleaned (decontaminated) their gadgets. Cleaning for the bulk of them consisted of just wiping their phones on their clothes and sleeves. It's probable that dry cleaning using a piece of cloth don't prevent contamination of mobile phones, but rather promote its spread. Other factors that may have influenced bacterial proliferation include educational level, cell phone use, and pollution.

Staphylococcus aureus, *Staphylococcus epidermidis*, *Bacillus* spp., *Pseudomonas aeruginosa*, *Escherichia coli*, *Enterococcus* spp. and *Klebsiella* spp., Some of these isolates may have made their way to the phone via the skin and from hand to hand transmission. The bacterial isolated in this study have been linked to a variety of human diseases, including nosocomial and community-acquired illnesses. The most common bacterial agent discovered was *Staphylococcus aureus*. Famurewa and David (2009) isolated *Staphylococcus aureus* as the most commonly encountered bacteria, with a frequency of occurrence of 32.9 %. According to Akinyemi *et al.* (2009), this could be owing to the organisms' ability to proliferate in warm environments.

Bacterial isolates examined were all resistant to at least three of the antibiotics used, according to the antibiotic resistance pattern. Multiple Antibiotic Resistance (MAR) index is a low-cost method for determining the relative incidence of antibiotic-resistant microorganisms in the environment. When the index exceeds 0.2, it is an indication of a source of contamination where antibiotics are often administered (Krumpernam, 1983; Osundiya *et al*., 2013: Idemudia and Ekhaise, 2019). All of the examined bacterial isolates had multiple antibiotic resistance to the antibiotics tested, with a multiple antibiotic resistance index which were above 0.2. Antibiotic use and bacterial susceptibility should be closely monitored to avoid the development of resistance (Doron and Davidson 2011).

Plasmid profile analysis was carried out on bacteria isolates that exhibited 100% resistance to all the antibiotics employed and it was revealed that *Klebsiella* spp., *Pseudomonas aeruginosa, Escherichia coli, Bacillus* spp. and *Staphylococcus aureus* possess multiple plasmids. The bacteria isolates were found to be resistant to some of the antibiotics even after curing. However, *Escherichia coli, Pseudomonas aeruginosa*, *Klebsiella* spp. became sensitive to ciprofloxacin and amoxicillin after curing. *Staphylococcus aureus* and *Bacillus* spp. also became sensitive to gentamicin, rocephin and erythromycin. This implies that the resistance capacity of the organisms were plasmid mediated. The molecular size of the plasmids obtained varied but were all above 3kbp. Plasmid curing is a determinate for antibiotic resistance mediation by eliminating or destroying the bacteria plasmids (Trevors, 1986; Adeyemo and Onuilude, 2015).

CONCLUSION

The mobile phones accessed were found to be highly contaminated by bacterial isolates which were resistant to most of the antibiotics used in the study. The MAR index which was greater than

0.2 indicates that the source of contamination is an environment where antibiotics are often used. This implies that mobile phones have the ability to act as a fomite; objects capable of carrying infections, hence the study is of public health importance as it enlightens people on proper handling of their mobile phones.

CONFLICT OF INTEREST

Authors have no competing interests to declare.

Author contributions

IIB wrote the original draft of the manuscript, EII carried out the bench work and collated the data. IEE performed the study review. EFO participated in the study design, supervised the study, and reviewed the manuscript. All authors read and approved the final version of the manuscript

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