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Research article

Mobile devices and accessories are reservoir for drug-resistant bacteria among university Students: a cross-sectional study

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ABSTRACT

The use of mobile phones and earplugs among students have become popular and are easy route for drug-resistant bacteria. This study aimed to determine the bacterial contamination on mobile phones and earplugs with their antibiotic resistance pattern among University students in Lagos, Nigeria. A total of 100 phone and earplug swab samples were collected. The samples were cultured on different appropriate growth media. Bacterial identification was done according to the standard bacterial procedures for identification. A total of 196 bacterial isolates were recovered from both devices and further subjected to antibiotic susceptibility testing against 11 commonly used antibiotics using disc diffusion method. This study revealed that mobile phones and earplugs had bacterial contamination of 48.5% and 51.5% respectively. Eleven bacterial species were identified which included *Klebisella pneumoniae* (27%), *Staphylococcus aureus* (15.8%), *Enterobacter aerogenes* (12.8%), *Proteus mirabilis* (9.7%), *Escherichia coli* (7.7%). The resistance pattern varied with 128 bacterial isolates highly resistant to cotrimoxazole (65.3%). Furthermore, 24.5%, 26.0% and 6.6% were multidrug-resistant, resistant to third generation cephalosporin among *Enterbacteriaceae* and methicillin-resistant *Staphylococcus aureus* respectively. This study's findings shows mobile phones and earplugs of university students were contaminated with drug-resistant pathogenic bacteria. Therefore, frequent or constant use of these devices, sharing and keeping of long nails is discouraged to control the spread of drug-resistant pathogenic bacteria.

Keywords: Mobile Devices, Earplugs, Methicillin-Resistant, Drug-Resistant Bacteria.

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INTRODUCTION

Mobile devices have increasingly become a crucial part of students' lives for communication, entertainment and/or academic purposes worldwide [1]. A global estimate of mobile phone user is 5.11 billion [2]. Mobile phones and accessories are relatively abundant in Nigeria due to their multipurpose functionality. There is a significant proportion (25 - 40 million) of mobile phone users of which 49% are students [2]. Earplugs have grown increasingly popular in recent times and aid in noise pollution reduction most especially in public places [3].

The mobile phone can serve as a source of transmission of pathogenic bacteria in a population and subsequently, drug-resistant bacteria which are a threat to human health could emerge [4]. There has been an upsurge in the use of earphones among young adults in recent years, as well as a high incidence of sharing among students [5]. Studies have shown its possible health implications; not limited to pathway for invasion by microorganisms into the ear canal skin [6]. The mobile devices and accessories are frequently contaminated with bacteria. Consequently, due to their widespread usage by diverse group of people, bacterial cross-contamination has increased.

Antimicrobial resistance continues to rise which in most cases results from the inappropriate use of anti-microbials [7]. Most times, bacteria acquire resistance to "commonly- used" antibiotics resulting to complicated or chronic infection [8]. Examples of isolated drug resistant bacteria from mobile devices include: *Staphylococcus aureus* resistant to Benzyl penicillin [9], *Escherichia coli*, *Streptococcus pyogenes*, *Salmonella* spp., *Pseudomonas aeruginosa* and *Shigella* spp. demonstrated 100% resistant to Ampicillin and Cefuroxime [10]. Risk factors that promote the contamination of drug-resistant bacteria include; the excessive use of broad spectrum antibiotics. The hygiene habit between teenagers and young adults has also been identified as possible risk factors [11].

Mobile devices and accessories may serve as reservoirs for a variety of microorganisms and subsequently; exogenous source of infection among students; especially in hot-humid climatic regions of the world [12]. Report on the contamination of students' mobile devices and accessories with bacteria and the possible occurrence of drug-resistant bacteria is limited globally [11]. Some mobile devices harbors diversity of drug-resistant bacteria when frequently used in close proximity to contaminated body parts. Such proximity can aid transmission of drug-resistant bacteria. In Nigeria, studies on universities students' mobile phones has reported a significant incidence (62%) of mobile phones colonized by drug-resistant bacteria with existing report only on multi-drug resistance [13]. Similar studies on continuous earplugs usage among adolescents and young adults are rare in the literature. Moreover, there are limited information on the class of drug-resistant bacteria isolated from both mobile devices and accessories. Methicillin-resistant *Staphylococcus aureus* and resistance to third generation cephalosporin by *Enterbacteriaceae* have mostly been reported from hospital settings in Nigeria [14, 15]. Thus, there is the need to monitor the prevalence of drug-resistant bacteria isolated from mobile phone and earplugs of university students in Lagos, Nigeria.

MATERIALS AND METHODS

Procurement of Drugs and Chemicals

All the drugs and chemicals (media) used in this study has been procured from Liofilchem s.r.l., Italy and Oxoid, Cambridge, United Kingdom respectively.

Study Area and Design

This cross-sectional study was done at the main campus of Caleb University, Lagos, Nigeria. This private-owned University is located in Ikorodu-Itokin Road, Lagos with over 4,000 students. Caleb University has a highly vegetative environment with cultural diversity. This study was done from February – June, 2022.

Sample Collection

Informed consent was given prior to sample collection which allowed the sampling of mobile phones and earplugs. A questionnaire about the student's device (mobile phone and earplug) usage habits and other relevant data was retrieved. A total of 100 swab samples were randomly collected from 50 mobile phones and 50 earplugs of students across different Departments of the University. The Samples were collected using moistened sterile cotton swabs. The sterile swab sticks were previously moistened in 2ml of 1% sterile saline solution. The sterile swab sticks were gently rolled over the surface of the earplugs and mobile phones.

Identification and Isolation of Bacteria

The phone and earplug swabs were inoculated onto the following media plates (Oxoid, Cambridge, UK): Blood agar, Mac Conkey agar, Mannitol salt agar and Eosin methylene blue agar; aerobically incubated for 24 hours at 37°C. After incubation, discrete colonies were sub-cultured on a freshly prepared Nutrient agar to obtain pure culture.

The bacterial isolates were identified via morphological description of colonies, gram staining, and biochemical tests- catalase test, motility test, urease test, citrate test, sugar fermentation test, indole test, and heamolysis test.

Antimicrobial Susceptibility Test of Isolated Bacteria

Antimicrobial susceptibility testing was done for all isolated bacteria using the modified Kirby-Bauer Disc Diffusion method on Muller Hinton agar (Oxoid, Cambridge, UK). The agar was inoculated with the test organism and antibiotic discs were aseptically mounted. Standard for inoculum was 0.5 McFarland standard. The susceptibility pattern of each bacterial isolate was analysed and interpreted using the clinical and laboratory standards institute's standard criteria [16]. The antibiotics tested included: Amoxicillin-Clavulanic acid (30µg), Tetracycline (30µg), Ceftriaxone (30µg), Ciprofloxacin (5µg), Erythromycin (15 µg), Cefotaxime (30 µg), Imipenem (10 µg), Gentamicin (10 µg), Cotrimoxazole (50 µg), Ceftazidime (30 µg), Cefoxitin (30 µg) (Liofilchem s.r.l., Italy). The degree of susceptibility of the test isolate to each antibiotic was determined by measuring the zone diameter of inhibition in millimeters.

Analysis of Data

Data analysis was done using SPSS version 21.0 (SPSS Inc. Chicago). Descriptive statistics was used to represent number and percentage. Chi-square was used to establish association between predisposing factors and bacteria isolated from the mobile devices and earplugs. Statistical significant association was established when P-value < 0.05

RESULTS & DISCUSSION

Prevalence of Bacteria from Mobile Devices and Accessories

To the best of our knowledge, this study provides the first documented findings to assess, determine the prevalence and associated risk factors of mobile phone and earplug contamination by drug-resistant pathogenic bacteria in student community of Lagos, Nigeria. The prevalence of bacteria on the mobile phones and earplugs was 48.5% (95/196) and 51.5% (101/195) respectively. Table 1 shows the prevalent bacteria isolated from both the mobile phones and earplugs varied..

Table 1: Prevalence of bacteria isolates from mobile devices and accessories

Bacterial isolates	Mobile phones n (%)	Earplugs n (%)	Total n (%)
Klebsiella pneumoniae	29 (30.5)	24 (23.8)	53 (27.0)
Proteus mirabilis	8 (8.4)	11 (10.9)	19 (9.7)
Staphylococcus aureus	20 (21.1)	11 (10.9)	31(15.8)
Klebsiella oxytoca	17 (17.9)	1 (1.0)	18 (9.2)
Enterobacter cloacae	1 (1.1)	12 (11.9)	13 (6.6)
Enterobacter aerogenes	3 (3.2)	22 (21.8)	25 (12.8)
Citrobacter spp.	2 (2.1)	4 (4.0)	6 (3.1)
Staphylococcus epidermidis	6 (6.3)	2 (2.0)	8 (4.1)
Escherichia coli	1 (1.1)	14 (13.9)	15 (7.7)
Micrococcus spp.	7 (7.4)	0 (0.0)	7 (3.6)
Aerobacter spp.	1 (1.1)	0 (0.0)	1 (0.5)
Total (%)	**95**	**101**	**196**

The top four highest was *K. pneumoniae* (27% (53/196)), *S.*

aureus (15.8% (31/196)), *Enterobacter aerogenes* (12.8% (25/196)) and *P. mirabilis* (9.7% (19/196)). Both mobile phones and earplugs had proportion of *K. pneumoniae* 29% and 24% respectively and *S. aureus* 20% and 11% respectively. Nevertheless, low proportion of *Enterobacter cloacae* (6.6% (13/196)) *Staphylococcus epidermidis* (4.1% (8/196)), *Micrococcus spp.* (3.6% (7/196)) and *Citrobacter spp.* (3.1% (6/196)) were found from both mobile phones and earplugs whereas *Micrococcus spp.* and *Aerobacter spp.* was isolated only from mobile phones. A statistical significant association was found between variables (frequent and constant usage of mobile phones and earplugs, keeping of long nails, sharing of mobile phones and earplugs and indiscriminate use of antibiotics) and bacterial contamination of mobile phones and earplugs ($p < 0.05$) as shown in Table 2

Table 2: Predisposing factors for the colonization of bacteria on mobile devices and accessories (n = 100) among university students

Variables	N (%)	N (%) isolated bacteria	P-value
Keeping of long nails	33 (33)	39 (20)	0.038*
Frequent and constant usage of mobile phones and ear plugs	72 (72)	71 (36.2)	0.021*
Sharing of mobile phones and earplugs	66 (66)	67 (34.2)	0.019*
Indiscriminate use of antibiotics	51 (51)	13 (6.6)	0.042*
Frequent use of alcohol based hand sanitizers	63 (63)	6 (3.1)	0.068

KEY: *- statistically significant association ($p < 0.05$)

A significant number of studies have revealed the prevalence of bacterial contamination of mobile phones and earplugs and other accessories [1,17-19]. Here, the overall prevalence of bacterial contamination was 100% among mobile phones and accessories. With 48.5% and 51.5% for mobile phones and earplugs respectively. Study by Sepehri et al., (2009) in India reported somewhat similar data for mobile phones of 40.6%. Contrary to studies reported from Nigeria, Ghana, Iran, Slovakia, Italy with higher rates of 62%, 83.3%, 78.4%, 92%, 86% respectively [19-23]. There is paucity of global information on bacterial contamination of earplugs belonging to students; however, this study finding of 51.5% bacterial contamination rate of earplugs contradict higher documented rates of 68% reported in Manipal among college students with frequent and constant use of earphones [24]. These discrepancies can be due to difference in methodology, frequency of cleaning devices, hand-washing practice and public awareness of disease transmission.

In this study, the most prevalent was *K. pneumoniae* (27% (53/196)), *S. aureus* (15.8% (31/196)), *Enterobacter aerogenes* (12.8% (25/196)) and *P. mirabilis* (9.7% (19/196)) and least with *Enterobacter cloacae* (6.6% (13/196)) *Staphylococcus epidermidis* (4.1% (8/196)). Similarly, study done by Koscova et al. [26] with a high prevalence (33%) of *K. pneumoniae* among mobile devices in Slovakia. Though, there have been findings with low contamination rate of 17.2%, 15.4% and 3.5% in Malaysia, Nigeria and Saudi Arabia respectively for *Klebsiella pneumoniae* [17,19,26]. This bacterium is a major cause of both hospital and community-acquired infections. In concordance to our findings, report of 16.2% for *Staphylococcus aureus* in Saudi Arabia. Contrary to our findings, studies with higher colonization rate of 20%, 54.1% and 56.0% for *Staphylococcus aureus* have been reported in Nigeria, India and Nepal respectively [19,27,29]. Although, *Staphylococcus aureus* is a normal flora of the skin as well as nasal region; it is also notorious for causing infections ranging from folliculitis, boils, sepsis, ear and blood stream infection [30]. The existence of *E. aerogenes* and *E. cloacae*; gram-negative rods thus suggests the likelihood of faecal contaminants on mobile phones and earplugs. In contrast to our study, higher rate have also been reported [17]. Another causative agent of bacterial sepsis. Interestingly, *Proteus mirabilis* was among the top four most prevalent bacteria (9.7% (19/196)). *P. mirabilis* have not been reported from neither mobile phones nor earplugs of university students according to previous studies [22, 24]. However, *P. vulgaris* which was not detected in this study have been reported from mobile phones in Malaysia with a 2.5% prevalence [17]. Nevertheless, Al-Abdalall [26] reported a low prevalence (3.66%) of *P. mirabilis* among mobile phones users in the city of Dammam, Saudi Arabia. This is in contrast to our findings. *P. mirabilis* is a normal flora of a healthy human intestine consequently; it can be found in faeces. Faecal contamination of mobile phones and accessories is possible with poor hygiene after defecation in perspective.

Antibiotic Susceptibility Test Result

One hundred and ninety-six (196) pathogenic isolated bacteria from both mobile phones and earplugs were subjected to antibiotic susceptibility testing against 11 antibiotics. The susceptibility showed *S. aureus* (16%) susceptible to gentamicin, ciprofloxacin, ceftriaxone, ceftazidime, *E. coli* (2%) was sensitive to tetracycline, gentamicin and ciprofloxacin, 30% of *Klebsiella pneumoniae* (30%) was sensitive to ciprofloxacin and gentamicin. *Proteus mirabilis* (8%) was sensitive to gentamicin, cefoxitin and tetracycline. Bacterial isolates from both mobile phones and earplugs showed high degree of resistance to cotrimoxazole (65.3%), tetracycline (55.6%), gentamicin (53.6%), erythromycin (53.1%) and amoxicillin-clavulanic acid (52.0%); moderate resistance to cefoxitin (47.0%), ciprofloxacin (46.4%) and lower resistance to ceftazidime (36.7%), imipenem (35.2%), cefotaxime (30.1%) and ceftriaxone (26.0%). High resistance was observed for erythromycin (44.2%) and gentamicin (76.2%) among bacteria isolated from mobile phone swabs and earplug swabs respectively as shown in Table 3 - 4. Whereas, the least resistance was observed for the third generation cephalosporin: cefotaxime (9.5%) and ceftriaxone (35.6%) among bacteria isolated from mobile phone swabs and earplug swabs respectively. In this study, *Klebsiella pneumoniae* and *Proteus mirabilis* had the highest resistance to cotrimoxazole 52.8% vs. 89.5%.

Table 3: Antibiotic susceptibility profile of isolated bacteria from earplug swabs (n=50)

Antibiotics	KP(n=24) N (%)	PM(n=11) N (%)	SA(n=11) N (%)	EC*(n=14) N (%)	CS(n=4) N (%)	SE(n=2) N (%)	EA(n=22) N (%)	EC(n=12) N (%)	Total(n=101) N (%)
AMX	18(75)	4 (36.4)	2(18.2)	11(78.6)	1(25)	-	22(100)	10(83.3)	68 (67.3)
CAZ	9(37.5)	2 (18.2)	2(18.2)	9(64.3)	1(25)	-	15(68.2)	8(66.7)	46 (45.5)
CRO	5(20.8)	1(9.1)	1(9.2)	6(42.9)	1(25)	-	14(63.6)	8(66.7)	36 (35.6)
CLO	15(7.7)	11 (100)	7(63.6)	12(85.7)	4(100)	1(50)	22(100)	12(100)	85 (84.2)
FOX	14(7.1)	9(81.8)	7(63.6)	8(57.1)	3(75)	1(50)	10(45.5)	9(75)	61 (60.4)
E	14(7.1)	3 (27.3)	2(18.2)	10(71.4)	1(25)	-	22(100)	10(83.3)	62 (61.4)
IMI	6 (25)	1 (9.1)	-	7(50)	1(25)	-	19(86.4)	11(91.7)	45 (44.6)
TE	13(54.2)	11(100)	8(72.7)	10(71.4)	4(100)	1(50)	18(81.8)	10(83.3)	76 (75.2)
CIP	10(41.7)	9(81.8)	7(63.6)	9(64.3)	4(100)	1(50)	15(68.2)	12(100)	67 (66.3)
CN	13(54.2)	10(90.9)	4(36.4)	11(78.6)	4(100)	1(50)	22(100)	12(100)	77 (76.2)
CTX	7 (29.2)	2(18.2)	1(9.2)	10(71.4)	1(25)	-	20(90.9)	9(75)	50 (49.5)

KEY:

AMX- Amoxicillin-Clavulanic acid, E- Erythromycin, TE- Tetracycline, IMI- Imipenem, CN-Gentamicin, CAZ- Ceftazidime, CLO- Cotrimoxazole, FOX- Cefoxitin, CRO- Ceftriaxone, CIP- Ciprofloxacin, CTX- Cefotaxime.

KP- *Klebsiella pneumoniae*, PM- *Proteus mirabilis*, SA- *Staphylococcus aureus*, EC*- *Escherichia coli*, CS- *Citrobacter* spp., EC- *Enterobacter cloacae*, EA- *Enterobacter aerogenes*, SE-*Staphylococcus epidermidis*.

Table 4: Antibiotic susceptibility profile of isolated bacteria from mobile phone swabs (n=50)

Antibiotics	KP(n=29) N (%)	EC(n=1) N (%)	SA(n=20) N (%)	KO(n=17) N (%)	PM(n=8) N (%)	MS(n=7) N (%)	EA(n=3) N (%)	CS(n=2) N (%)	Total(n=95) N (%)
AMX	9(31.0)	1(100)	6(30)	6(35.3)	7(87.5)	3(42.9)	1(33.3)	1(50)	34 (35.8)
CAZ	7(24.1)	1(100)	2(10)	5(29.4)	6(75)	3(42.9)	1(33.3)	1(50)	26 (27.4)
CRO	5(17.2)	1(100)	1(5)	5(29.4)	-	3(42.9)	-	-	15 (15.8)
CLO	13(44.8)	1(100)	10(50)	8(47.1)	6(75)	3(42.9)	1(33.3)	1(50)	43 (45.3)
FOX	10(34.5)	1(100)	5(25)	6(35.3)	4(50)	3(42.9)	1(33.3)	1(50)	31 (32.6)
E	13(44.8)	-	10(50)	8(47.1)	6(75)	3(42.9)	1(33.3)	1(50)	42 (44.2)
IMI	8(27.6)	-	7(35)	5(29.4)	4(50)	-	-	-	24 (25.3)
TE	12(41.4)	-	9(45)	6(35.3)	3(37.5)	3(42.9)	-	-	33 (34.7)
CIP	6(20.7)	-	5(25)	5(29.4)	3(37.5)	3(42.9)	1(33.3)	1(50)	24 (25.3)
CN	7(24.1)	-	7(35)	6(35.3)	3(37.5)	3(42.9)	1(33.3)	1(50)	28 (29.5)
CTX	-	-	-	5(29.4)	2(25)	2(28.6)	-	-	9 (9.5)

KEY:

AMX- Amoxicillin-Clavulanic acid, E- Erythromycin, TE- Tetracycline, IMI- Imipenem, CN-Gentamicin, CAZ- Ceftazidime, CLO- Cotrimoxazole, FOX- Cefoxitin, CRO- Ceftriaxone, CIP- Ciprofloxacin, CTX- Cefotaxime.

KP- *Klebsiella pneumoniae*, PM- *Proteus mirabilis*, SA- *Staphylococcus aureus*, EC- *Escherichia coli*, CS- *Citrobacter* spp., EA- *Enterobacter aerogenes*, SE- *Staphylococcus epidermidis*, KO- *Klebsiella oxytoca*, MS- *Micrococcus* spp.

In this study, bacterial isolates from both mobile phones and earplugs showed the highest degree of resistance to cotrimoxazole (65.3%). Comparable is the report by Khadka et al., (2018) with the highest resistance to cotrimoxazole among college students in Kigali, Rwanda. Similarly, report from two different studies in Bangdalesh [12,32] had high resistance to tetracycline and cotrimoxazole likewise our study. Furthermore, among the isolates *Enterobacter aerogenes* was 92% resistant to amoxicillin-clavulanic acid. On the contrary, from this study, previous studies tested *Enterobacter aerogenes* against amoxicillin. Amoxicillin-clavulanic acid is a renowned combination therapeutic agent of semi-synthetic antibiotic, amoxicillin and a β-lactamase inhibitor, potassium clavulanate [7]. The varying resistance pattern observed may have resulted from the difference in geographic locations or the inappropriate use of antibiotics by students as reported by Tagoe et al., (2011) in Cape Coast on antibiotic use.

Distribution of Drug-resistant Pathogenic Bacteria

The prevalence of drug-resistant bacteria was 57.1%. Table 5 shows the distribution of characteristics of resistance: multi-drug resistance, resistance to third generation cephalosporin among *Enterbacteriaceae* and methicillin-resistant *Staphylococcus aureus* was 24.5%, 26.0% and 6.6% respectively. Multi-drug resistance was found among *Proteus mirabilis, E. coli, K. pneumoniae, K. oxytoca, Enterobacter aerogenes* and *Citrobacter spp.* with prevalence of 10%, 2%, 20%, 12%, 2% and 2% respectively. The antibiotics with demonstrated multi-drug resistance were erythromycin, cotrimoxazole, ceftazidime, tetracycline, cefoxitin, ceftriaxone and imipenem. The *S. aureus* isolated from the student's mobile phones showed a significant resistance to Cefoxitin. These isolates are described as methicillin-resistant *Staphylococcus aureus*. Resistance to third generation cephalosporins (ceftazidime and cefotaxime) was observed among the members of *Enterobacteriaceae; K. pneumoniae, E. coli, Proteus mirabilis, K. oxytoca* in this study.

Isolates from earplug swabs: *Escherichia coli* and *Klebsiella pneumoniae* were multi-drug resistant to amoxicillin-clavulanic acid, cefotaxime, ciprofloxacin, gentamicin, imipenem and tetracycline.

Table 5: Characteristics of the drug-resistant bacteria isolated from mobile devices and accessories

Characteristics	Mobile phones N (%)	Earplugs N (%)	Total N (%)
Multi-drug Resistance	22 (23.2%)	26 (25.7)	48 (24.5)
Third generation cephalosporin resistance among *Enterobacteriacae*	21 (22.1%)	30 (29.7)	51(26.0)
Methicillin-resistant *Staphylococcus aureus*	6 (6.3)	7 (6.9)	13 (6.6)
TOTAL	**49 (51.6)**	**63 (62.4)**	**112 (57.1)**

In recent times, drug-resistant bacteria have increasingly become a global public health challenge leading high morbidity and/or mortality rate. If not closely monitored could result to a global crisis with difficult-to-treat diseases at the fore front. Here, multi-drug resistant had prevalence of 24.5%. A similar multi-drug resistant prevalence of 21.4%% has been reported in Nepal [29]. In contrast, higher multi-drug resistant prevalence data of 90.54%, 45.4% has been documented among university students in Bangladesh and Ghana respectively [12, 21]. In this study, multi-drug resistance was found among *E. coli, K. pneumoniae, K. oxytoca, Enterobacter aerogenes* and *Citrobacter spp.* which concordant previous studies in Rwanda and Ethiopia [31,33] though, a significantly low prevalence (9%) of multi-drug resistance have been reported in Rwanda. Interestingly, only six and seven methicillin-resistant *Staphylococcus aureus* were found to be isolated from the mobile phones and earplugs of the university students in this study. The prevalence of 6.6% for methicillin-resistant *Staphylococcus aureus* in this study is supported by a low prevalence of 4% and 5.9% reported in Southern Brazil and Saudi Arabia respectively [26,34]. On the other hand, high prevalence have been reported by few researchers [29,31]. Another interesting aspect of this work is the emergence of third generation cephalosporin resistance among *Enterbacteriaceae.* Here, a relative prevalence of 26.0% was documented. This does not corroborate with previous findings in Rwanda and Nigeria [31,35]. Indeed, difference in prevalence data is a reflection of the different geographical study area and the methodologies applied. Our results reveals the possibility of mobile phones and earplugs to contribute as source of different pathogenic bacteria most especially drug-resistant. Consequently, it is imperative to provide information either to university students or the general population on effective prevention and control approaches that will curtail the spread of these drug-resistant pathogenic bacteria. The hypothesis that these mobile phones and accessories could be a reservoir for drug-resistant pathogenic bacteria like multi-drug resistant *Klebsiella* spp. *Enterobacter* spp., third generation cephalosporin resistant *Proteus mirabilis* and methicillin-resistant *Staphylococcus aureus* among university students was supported by findings from this study.

CONCLUSION

The mobile phones and earplugs of university students were highly contaminated with disease- causing bacteria. These bacteria had varied drug-resistant characteristics: multidrug resistant, resistance to third generation cephalosporin and methicillin-resistant *Staphylococcus aureus.* Consequently, mobile phones and earplugs could aid the transmission of drug-resistant bacterial pathogens. Therefore, frequent or constant use of mobile phones and earplugs, sharing of mobile phones and earplugs as well as keeping of long nails is strongly discouraged to control the spread of these drug-resistant pathogenic bacteria.

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