Asian Journal of Research in Biosciences

Volume 6, Issue 2, Page 112-124, 2024; Article no.AJORIB.1560

Prevalence of Bacteria Associated with Mobile Phones of Inpatients in Some Hospitals in Ardo-Kola Metropolis, Nigeria

Emmanuel Allahnanan [a], Samuel Kennedy Banja [a], Waetsi Nya Yusufu [a*] and Fred Grace Wayas [a]

[a] Department of Biological Sciences, Taraba State University, Jalingo, Nigeria.

Authors' contributions

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

Article Information

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://prh.globalpresshub.com/review-history/1560

Original Research Article

Received: 01/02/2024
Accepted: 04/04/2024
Published: 08/04/2024

ABSTRACT

Mobile phones are carried everywhere thus coming in contact with various surfaces. Inpatients' mobile phones may contain potential nosocomial causing microbes to the inpatient, family members, and the general public. Thirty-two (32) inpatient phones were chosen at random from three study areas to see if they could function as formites and contain bacteria that could be transferred. First Referral Hospital Sunkani, Primary Healthcare Kofai and Lafiya clinic ATC) in Ardo Kola Local Government, Taraba State were the study area. The goal of this study was to determine the prevalence of bacterial contamination on inpatients' phones and to identify bacterial isolates. A swab sample from each inpatient's phone (using a moist sterile swab), as well as a self-administered questionnaire, was retrieved. Samples were cultured in nutrient, blood and macConkey's agar using the streak method, bacteria were identified using Gram staining and a few biochemical assays (indole, citrate utilization, catalase, oxidase, coagulase, and urease test). The

**Corresponding author: Email: waetsinya@gmail.com;*

overall prevalence of mobile phone contamination with one or more bacteria was 90.6 percent, with the most common bacteria isolates being *Staphylococcus aureus* (46.9%) and *Escherichia coli* (34.4%), and the least common bacteria isolates being *Klebsiella spp*. (12.5%) and *Enterococcus spp*. (12.5%). As a result, using various methods to control the growth of bacteria, such as restricting mobile phone use in hospitals and implementation of proper hand washing hygiene, is necessary to shed bacterial burden and reduce contamination.

Keywords: Nosocomial; prevalence; inpatients; mobile phones; formites.

1. INTRODUCTION

"A mobile phone (also known as a cell phone, cellular phone or a hand phone) is a gadget that allows users to make and receive phone calls over a radio link while roaming about a wide geographical area" [1]. Since the first mobile phones hit the market, mobile phone technology has made significant strides. The introduction of smart phones in 1994 with touch screen displays and advanced mobile operating systems combining the features of SMS for text messaging and MMS for sending and receiving photos, email, internet access, video chatting, and entertainment features marked the beginning of the integration of many features into mobile phones in addition to the standard voice function [2-4]. Mobile phones are becoming among the most important accessories for both social and professional life. Mobile phones are handled frequently and held close to the face, while being typically kept in bags or pockets. Instead of a keypad with individual keys and multiple nooks and crannies, many of these devices have touch screens with a single smooth surface.

Microbiological standard in hygiene is necessary for a healthy life. However, unhealthy practices are being observed in both the developing and developed world. On ways to lessen infection on mobile phones, however, there is comparatively little counsel. In addition to increasingly being a necessary tool for communication, mobile devices have the potential to spread pathogenic microbes [5]. This can be done by its frequent contact with hands [6], since a vast majority of mobile phones are hand held [3]. "There is plenty of information regarding hospital acquired infection and the role of mobile phones in harboring bacteria responsible for such infections and research has shown that mobile phones could constitute a major health hazard" [7-14] since healthcare associated infections (HAIs) have increased significantly during the last decade. These infections remain a major cause of morbidity and mortality, which in turn leads to an increase in health care cost and also new health care hazards for inpatients and the community [15]. Mobile phones are used in the hospital without restriction and the majorities of Health care workers (HCWs) neither clean their mobile phones regularly nor wash hands after using their mobile phones [16,17]. "Public telephones as well as cell phones can act as reservoirs to a wide variety of bacterial species, many of which have the potential to be pathogenic" [18,4].

Mobile devices used in healthcare facilities are particularly interesting, as they have been involved in the spread of nosocomial infections [19-21]. The mouthpiece of public telephones has been linked to high levels of microbial contamination, though the earpiece and handles can also support microbial species. With the drop in use of public payphones and cell phones with buttons and keyboards, indirect contamination from person to person has decreased, however it has been discovered that personal mobile phones are more prone to microbiological contaminations [22]. "The hands and gloves of healthcare workers readily acquire the pathogens after contact with contaminated hospital surfaces and equipment, and then transfer these organisms to subsequently touched patients and devices" [23,24].

"The majority of bacterial species found on phone surfaces are members of the normal flora of the skin and body, due to the constant contact with the hands and face. The normal flora of the skin includes about 10 bacterial species with the most being *Staphylococcus epidermidis* and *Corynebacteria"* [25]. "In addition, bacteria found in the mouth and the upper respiratory tract can also spread through aerosols and droplets that are released while breathing or talking into the phone's mouthpiece" [26]. "Many species are resistant to desiccation and can persist on phone surfaces for weeks, with gram-negative bacteria usually persisting longer than their gram-positive counterparts" [27]. Due to the frequent usage of mobile phone, heat generated by the phone

creates an ideal temperature that supports the growth of bacteria. There is relatively little guidance, however, on how to reduce contamination on mobile phones.

"Healthcare-associated infections remain a leading and high-cost problem of global health systems despite improvements in modern therapies" [18,28,29]. "Nosocomial infections constitute a major problem globally with major social, economic, moral, and personal effects that increase morbidity and mortality of hospitalized patients" [24]. "It is estimated that between 5% and 10% of patients admitted to hospitals acquire HAI, but recent data suggest that this figure is on the rise" [12,17,4,24,30]. Since mobile phones (MPs) are rarely cleaned after handling, it is thought that variations in personal hygiene and behaviors may increase the risk of cross-contamination between healthcare professionals and patients. After contact between healthcare professionals and patients, these could spread bacteria, including numerous resistant strains, and can be a source of bacterial cross-contamination. There may be a chance of patient and healthcare worker cross contamination, according to research on infections linked to the provision of healthcare. However, there is paucity of information available regarding the frequency of bacteria on hospital patients' mobile phones in Ardo-kola, Taraba State, Nigeria. This study is aimed at determining the degree of bacterial contamination of personal mobile phones of inpatients across some hospitals in Ardo-kola metropolis.

2. MATERIALS AND METHODS

2.1 Study Area

The study was conducted in Sunkani and ATC in Ardo kola Local Government Area of Taraba State, Nigeria. Ardo-kola Local Government is located at latitude 8.7557°N and longitude 11.2524°E). The economic activity of this community is mostly Farming, Fishing, Artisan and few civil servants. Social amenities such as good roads, pipe-borne water and electricity are lacking.

2.2 Study Sites

The study was conducted in three different sites chosen at random in Ardo-kola metropolis namely First Referral Hospital Sunkani, Lafiya Clinic, and primary healthcare Kofai, kasuwan Bera.

2.3 Sample Size

A total of 32 swab samples of mobile phones were collected randomly from inpatients among three hospitals in the study area.

2.4 Data Collection

Socio-demographic characteristics of the participants: A self-administrated questionnaire was distributed to collect information about the socio-demographic characteristics (age, gender and profession), use of mobile phones as well as habit of cleaning of mobile phones.

2.5 Sample Collection

The mobile phone was first held with the aid of sterile gloves. Sterile cotton swab moistened with the sterile (0.85%) normal saline solution was rotated over the surface of both sides of the mobile phone. The cotton swabs were transferred immediately to the Biology Laboratory in the Department of Biological Sciences, Taraba State University within Two to three hours of collection to prevent drying.

2.6 Media Preparation for Microbial Analyses

Nutrient agar and MacConkey agar were prepared according to the manufacturer's specification and sterilized in an autoclave for 15 minutes at 121°C. Blood agar was prepared from Nutrient agar using sheep blood. The Media were allowed to cool and was poured into sterilized Petri dishes. The media was then incubated overnight at 37°C to check for sterility.

2.6.1 Isolation of bacteria

The swab samples were directly inoculated on Nutrient Agar, Blood Agar and MacConkey's Agar in a biosafety cabinet and inoculating loop was flamed with a Bunsen burner using streak plate method. The plates were incubated at 37^{o}C for 24 hours and then examined for bacterial growth.

2.6.2 Identification of bacteria

The plates that had growth were selected for identification of isolated bacteria. Preliminary identification of bacteria was made based on cultural and morphological characteristics, gram reaction, colony characteristics, haemolysis on blood agar, changes in physical appearance in

differential media and biochemical tests according to Cheesbrough [31] Criuckshank et al. [32]. The isolated colonies were picked using sterile wire loop and sub cultured on MacConkey and Nutrient agar. The inoculated media were incubated aerobically at 37^{o}C for 24 hours and then examined.

2.6.3 Gram staining

This was done to differentiate organisms based on the structure of their cell walls as Gram positive (tough outer cell of peptidoglycan), or Gram negative (having two layers of membranes, with a thin layer of peptidoglycan sandwiched between them). Smear was done from isolate by sterile loop, small portion from colony was taken and drops of normal saline on a clean dry slide then mix and spread in circular manner. The slide was left to air dry and fixation was done by gentle heat. Crystal violet was added to smear for 1 minute, and then washed by tap water, Logul's iodine was added for 1 minute, then washed by tap water, Acetone alcohol was added for seconds and washed by tap water. Finally, the smear was covered with Saffranin for 2 minutes, and washed by tap water, the smear was left to air dry, and a drop of oil immersion was added and examined under microscope using objective lens x100. Gram positive appeared Blue/Purple color and Gram negative appeared red color [33].

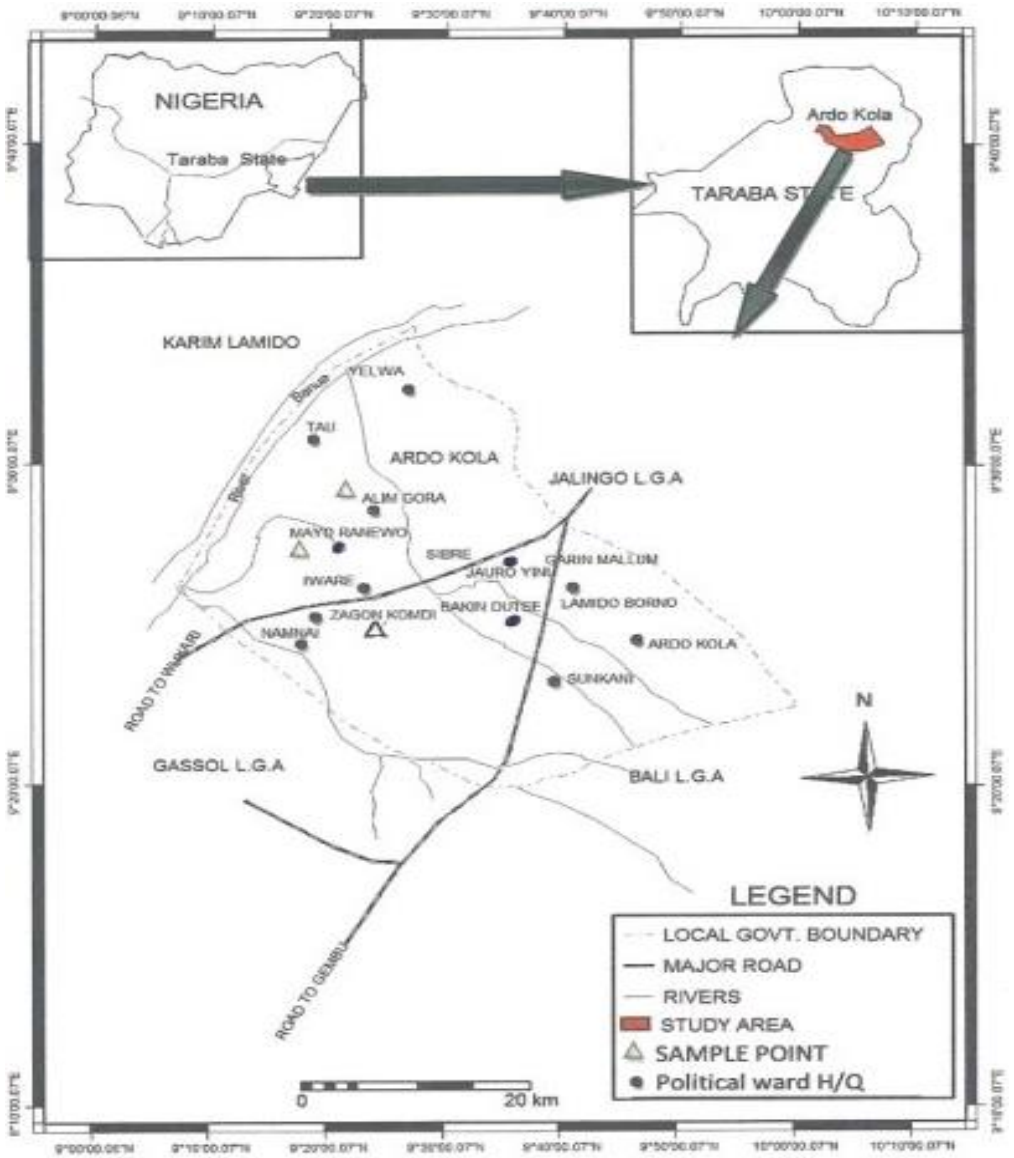

Fig. 1. Map of Nigeria showing study area

2.7 Biochemical Tests

Group of tests done to identify bacteria included the following:

2.7.1 Indole test

A sterilized test tube containing 4 ml of tryptophan broth was taken. The tube was inoculated aseptically by taking the broth from 18 to 24 hrs of culture. The tube was incubated at 37°C for 24-28 hours. 0.5 ml of Kovac's reagent was added to the broth culture. Presence of Pink colour indicated positive and no change in colour indicated negative. A tube was not inoculated which served as control substance [34].

2.7.2 Citrate utilization test

Simmons citrate agar was inoculated slightly on the slant by touching the sterile wire loop to a colony that is 18 to 24hrs old. It was incubated at 35^{O}C to 37^{O}C for 18 to 24hrs. Positive growth was visible on the slant surface and the medium was an intense Prussian blue while negative trace or no growth was visible on the medium which remain deep forest green colour. A tube was not inoculated which served as control [35].

2.7.3 Catalase test

This was carried out by putting a drop of hydrogen peroxide on a clean slide. With a sterile inoculating loop, a colony of organism was picked and allowed to be in contact with the hydrogen peroxide. Presence of bubbles indicates positive reaction while absence of bubbles indicates negative reaction [34].

2.7.4 Oxidase test

Fresh growth was removed from the agar plate using a non-metallic instrument such as a sterile plastic inoculating loop. The oxidase test strip was moistened slightly with oxidase reagent and the growth was rubbed into the moistened paper of the strip. If the microbe has cytochrome oxidase, it will add electrons to the reagent, changing it from its colorless appearance to a deep indigo blue in a matter of 10-20 seconds. Waiting any longer than this increases the likelihood that the reagent turns blue due to natural chemical changes caused by exposure to air. If the color does not turn blue within 20 seconds, the test is negative for the presence of oxidase [34].

2.7.5 Coagulase test

This was used to identify *Staphylococcus aureus*, which produces the coagulase enzyme that causes plasma to clot by converting fibrinogen to fibrin. *Staphylococcus aureus* produces two forms of coagulase: bound and free. The slide test is to detect bound coagulase and the tube test is to detect free coagulase. Free coagulase involves the activation of plasma coagulase-reacting factor (CRP), which is a modified or derived thrombin molecule, to form a coagulase CRP complex. This complex in turn reacts with fibrinogen to produce the fibrin clot. A drop of sterile distilled water was placed on each end of a sterile slide. A colony of the test organism was emulsified on each spot to make two thick suspensions. The slide test was adopted and a loop-full of plasma was added to one of the suspensions and mixed gently. The slide was examined for clumping or clotting of the organisms within 10 seconds. Plasma was not added to the second suspension, which served as control substance [34].

2.7.6 Urease test

This was carried out to detect the production of urease to breakdown urea to ammonia and carbon-dioxide. Urea agar base was used for this test. It was prepared and sterilized according to manufacturer's instruction. Urea and the indicator were also added as specified. The medium after sterilization was allowed to cool and gel and then the isolates were inoculated and labeled accordingly. They were inoculated at 37°C for 24hrs and observed. There was color change from orange to pink for the urease positive organisms and orange to yellow for the urease negative isolate and this was recorded appropriately. A tube was not inoculated which served as control substance [33].

2.8 Statistical Analysis

Data obtained was subjected to the Statistical Package for Social Sciences (SPSS) version 23 for data analysis. The Pearson Chi-square test was used to determine prevalence.

3. RESULTS

Bacteria species isolated in the order of most prevalent were *Staphylococcus species* (46.9%), *Escherichia coli* (34.4%), *Coagulase-Negative Staphylococcus* (CoNS) and *Pseudomonas*

species (18.8%), *Streptococcus species* (15.6%) *Enterococcus species* and *Klebsiella species* (12.5%) being the least prevalent (Fig. 2).

Table 1 describes the prevalence for the different phone screen types and shows that the keypad phones recorded higher prevalence of, 100.0% (17/17) than soft-screen mobile phone, 80.0% (12/15) with a slight but statistically non-significant difference (χ^2=3.752; P>0.05). An overall prevalence of 90.6% (29/32) was recorded in the swab samples examined from all inpatients.

The isolated bacteria from keypad phones includes *Staphylococcus aureus* 58.8% (10/17)*, E.coli* 35.3% (6/17), CoNS 23.5% (4/17), *Pseudomonas spp* 23.5% (4/17), *Streptococcus spp* 23.5% (4/17), *Klebsiella spp* 23.5% (4/17) and *Enterococcus spp* 17.6% (3/17) whereas the bacteria isolated from soft-screen phones are *Staphylococcus aureus* 33.3% (5/15)*, E.coli* 33.3% (5/15), CoNS 13.3% (2/15), *Pseudomonas spp* 13.3% (4/15), *Streptococcus spp* 6.7% (1/15), *Klebsiella spp* 0.0% (0/15) and *Enterococcus spp* 6.7% (1/15). It was noted that *Klebsiella spp* recorded a higher prevalence of 3.5% (4/17) in keypad phones than soft-screen mobile phones 0.0% (0/15) with a statistically significant difference (χ^2=4.034; P<0.05) as can be seen on Table 2.

Table 3 describes sex related prevalence and showed that mobile phones from female recorded a higher prevalence of 100.0% (24/24) than male, 62.5 (5/8) with significant difference (χ^2=9.931; P<0.05) as seen below.

Table 4 shows the frequency of bacteria isolated based on sex of inpatients. The isolated bacteria species from mobile phones of male inpatients are *Staphylococcus aureus* 37.5% (3/8)*, E. coli* 25.0% (2/8), CoNS 12.5% (1/8), *Pseudomonas spp* 0.0% (0/8), *Streptococcus spp* 0.0% (0/8), *Klebsiella spp* 0.0% (0/8) and *Enterococcus spp* 12.5% (1/8). The bacteria isolated from mobile phones of female inpatients are *Staphylococcus aureus* 50.0% (12/24)*, E. coli* 37.5% (9/24), CoNS 20.8% (5/24), *Pseudomonas spp* 25.0% (6/24), *Streptococcus spp* 20.8% (5/24), *Klebsiella spp* 16.7% (4/24) and *Enterococcus spp*12.5% (3/24). It was noted that *Pseudomonas species* recorded higher prevalence of 25.0% (6/24) among females than males 0.0% (0/8) with a statistically non-significant difference (χ^2=2.462; P>0.05).

Table 1. Percentage prevalence of bacteria for different phone screen types

Kind of MP	No of MP sampled	Prevalence rate (%)
Keypad	17	17(100.0)
Softscreen	15	12(80.0)
Total	32	29(90.6)

(χ^2=3.752; P>0.05)
Key: MP: Mobile Phone

Table 2. Occurrence of isolated bacteria for different phone screen types

Kind of phone	Bacteria (%) N=32						
	S. aureus	***CoNS***	***E. coli***	***Klebsiellaspp***	***Pseudomonas spp***	***Enterococcus spp***	***Streptococcus spp***
Keypad	10(58.8)	4(23.5)	6(35.3)	4(23.5)	4(23.5)	3(17.6)	4(23.5
Softscreen	5(33.3)	2(13.3)	5(33.3)	0(0.0)	2(13.3)	1(6.7)	1(6.7)

(χ^2=4.034; P<0.05)
Keys: S. aureus: Staphylococcus aureus; E. coli: Escherichia coli; CoNS: Coagulase-Negative Staphylococcus; Spp: Species

Table 3. Percentage prevalence of bacteria based on sex

Sex	No of MP sampled	Prevalence rate (%)
Male	8	5(62.5)
Female	24	24(100.0)
Total	32	29(90.6)

(χ^2=9.931; P=0.002)
Key: MP: Mobile Phone

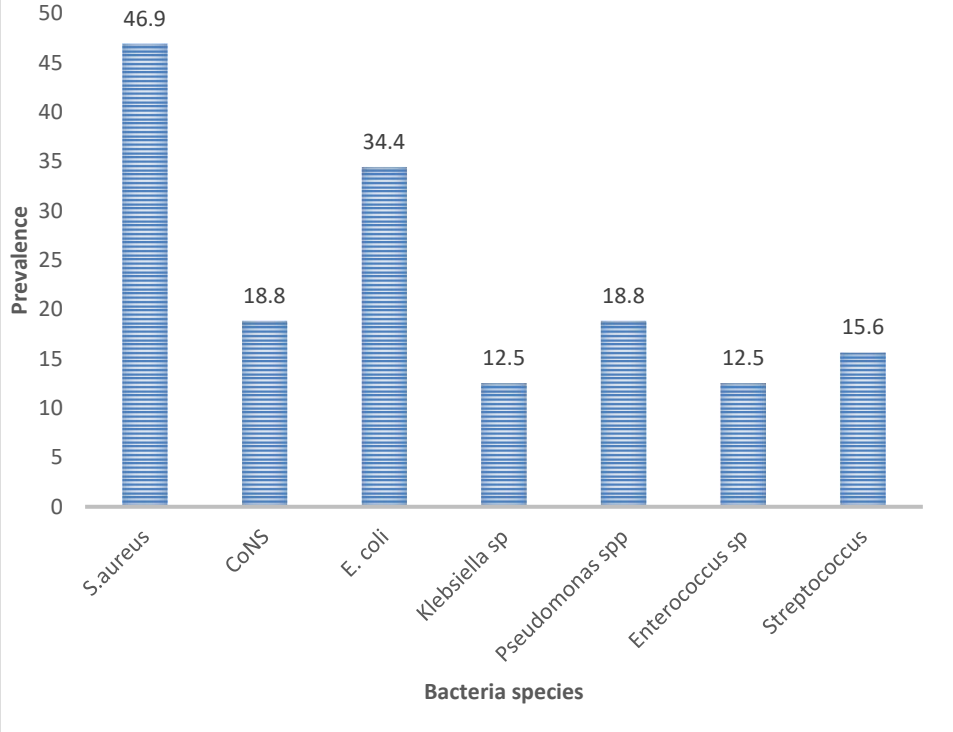

Fig. 2. Frequency of mobile phones bacteria isolate

Keys:S. aureus: Staphylococcus aureus; E. coli: Escherichia coli; CoNS: Coagulase-Negative Staphylococcus

Table 5 describes Age related prevalence which varied between 87.5%-92.3%, with age group 46-60 having the lowest prevalence of 87.5 (7/8) and the age group 15-30 years having the highest 92.3% (12/13) with a statistically non-significant difference of (χ^2=0.136; P>0.05).

The isolated bacteria species for the age group 15-30 are *Staphylococcus aureus* 46.3% (6/13), *E. coli* 53.8% (7/13), CoNS 7.7% (1/13), *Pseudomonas spp* 7.7% (1/13), *Streptococcus spp* 30.8% (4/13), *Klebsiella spp* 0.0% (0/13) and *Enterococcus spp* 15.4% (2/13). The isolated bacteria species for the age group 31-45 are *Staphylococcus aureus* 45.5% (5/11), *E. coli* 27.3% (3/11), CoNS 36.4% (4/11), *Pseudomonas spp* 36.4% (4/11), *Streptococcus spp* 9.1% (1/11), *Klebsiella spp* 27.3% (3/11) and *Enterococcus spp* 9.1% (1/13). The isolated bacteria for the age group 46-60 are *Staphylococcus aureus* 50.0% (4/8), *E. coli* 12.5% (1/8), CoNS 12.5% (1/8), *Pseudomonas spp* 12.5% (1/8), *Streptococcus spp* 0.0% (0/8), *Klebsiella spp* 12.5% (1/8) and *Enterococcus spp* 12.5% (1/8). It was noted that *Staphylococcus aureus* recorded an overall higher prevalence in all age groups with a statistically non-significant difference (χ^2=0.043; P>0.05) as seen on Table 6.

Table 7 shows a profession related prevalence which observed that civil servant and student recorded higher prevalence, 91.7% (11/12) than farmers, 87.5% (7/8) with a statistically non-significant difference (χ^2=0.123; P>0.05).

The isolated bacteria species for the civil servant profession were *Staphylococcus aureus* 33.3% (4/12), *E. coli* 16.7% (2/12), CoNS 41.8% (5/12), *Pseudomonas spp* 41.7% (5/12), *Streptococcus spp* 8.3% (1/12), *Klebsiella spp* 16.7% (2/12) and *Enterococcus spp* 8.3% (1/12). The isolated bacteria species from the phones of inpatients who are farmers were *Staphylococcus aureus* 50.0% (4/8), *E. coli* 25.0% (2/8), CoNS 12.5% (1/8), *Pseudomonas spp* 0.0% (0/8), *Streptococcus spp* 25.0% (2/8), *Klebsiella spp* 25.0% (2/8) and *Enterococcus spp* 12.5% (1/8). Student inpatients had the following bacteria isolated from their phones, *Staphylococcus aureus*58.3% (7/12), *E. coli* 58.3% (7/12), CoNS 0.0% (0/12), *Pseudomonas spp* 8.3% (1/12), *Streptococcus spp* 16.7% (2/12), *Klebsiella spp* 0.0% (0/12) and *Enterococcus spp* 16.7% (7/8). It was noted that CoNS recorded higher prevalence of 41.7.0% (5/12) among civil servants, 12.5% (1/8) in farmers than student 0.0% (0/8) with a statistically significant difference (χ^2=7.111; P<0.05) as shown in Table 8.

Table 4. Occurrence of isolated bacteria for sex in the study

Sex	Bacteria (%) N=32						
	S. aureus	***CoNS***	***E. coli***	***Klebsiella spp***	***Pseudomonas spp***	***Enterococcus spp***	***Streptococcus spp***
Male	3(37.5)	1(12.5)	2(25.0)	0(0.0)	0(0.0)	1(12.5	0(0.0
Female	12(50.0)	5(20.8)	9(37.5)	4(16.7)	6(18.8)	3(12.5)	5(30.8)

Keys: S. aureus: Staphylococcus aureus; E. coli: Escherichia coli; CoNS: Coagulase-Negative Staphylococcus

Table 5. Percentage prevalence of bacteria for age groups

Age	No of MP sampled	Prevalence rate (%)
15-30	13	12(92.3)
31-45	11	10(90.9)
46-60	8	7(87.5)
Total	32	29(90.6)

(X^2=0.136; P>0.05)
Key: MP: Mobile Phone

Table 6. Occurrence of isolated bacteria for age groups

Age group	Bacteria (%) N=32						
	S. aureus	***CoNS***	***E. coli***	***Klebsiella spp***	***Pseudomonas spp***	***Enterococcus spp***	***Streptococcus spp***
15-30	6(46.3)	1(7.7)	7(53.8)	0(0.0)	1(7.7)	2(15.4)	4(30.8)
31-45	5(45.5)	4(36.4)	3(27.3)	3(27.3)	4(36.4)	1(9.1)	1(9.1)
46-60	4(50.0)	1(12.5)	1(12.5)	1(12.5)	1(12.5)	1(12.5)	0(0.0)

Isolates
S. aureus: Staphylococcus aureus
E. coli: Escherichia coli
CoNS: Coagulase-Negative Staphylococcus

Table 7. Percentage prevalence of bacteria isolates per profession

Profession	No of MP sampled	Prevalence rate (%)
Civil servant	12	11(91.7)
Farmer	8	7(87.5)
student	12	11(91.7)
Total	32	29(90.6)

(χ^2=0.123; P>0.05)
Key: MP: Mobile Phone

Table 8. Occurrence of isolated bacteria per profession

Profession	Bacteria (%) N=32						
	S. aureus	***CoNS***	***E. coli***	***Klebsiella spp***	***Pseudomonas spp***	***Enterococcus spp***	***Streptococcus spp***
Civil servants	4(33.3)	5(41.7)	2(16.7)	2(16.7)	5(41.7)	1(8.3)	1(8.3)
Farmer	4(50.0)	1(12.5)	2(25.0)	2(25.0)	0(0.0)	1(12.5)	2(25.0)
Student	7(58.3)	0(0.0)	7(58.3)	0(0.0)	1(8.3)	2(16.7)	2(16.7)

Isolates
S. aureus: Staphylococcus aureus
E. coli: Escherichia coli
CoNS: Coagulase-Negative Staphylococcus

4. DISCUSSION

Mobile phones are indispensable tools of communication, both at home and at work; they are always picked, dropped or pocketed thereby, having the potential of acquiring microbes from the handlers and the environment. Mobile phones as inanimate objects had been shown to

possess the potential for the survival of microorganisms, some bacteria can survive for months, viruses such as *Corona, Coxackie* and *Influenza* can persist for few days; and Herpes virus can persist for a week [27].

The study showed an overall high prevalence of bacterial contamination. The result in this study confirmed the findings of other studies which reported high prevalence of bacterial contamination among inpatients in hospitals: Brady et al. [36] reported 84.3%, Vinod et al. [37] reported 83.9%. Isolation of bacteria from electronic devices, such as handheld computers and personal digital assistants, has shown these devices to be potential modes of transmission of nosocomial pathogens. The high rate of bacterial colonization of mobile phones of inpatients suggests that their regular exposure to the bacteria in the hospital environment, contact with surfaces, patients, and infected materials may influence the rate of colonization [38]. The rate of contamination of mobile phones was also reported to be higher in the following studies: Ulger et al. [11] reported 95%, Akinyemi et al. [39] reported 91%. Studies that reported findings of lower bacterial contamination of mobile phones were published by Sepehri et al. [40] at 33% and Arora et al. [9] with 41%. The observed variation might be due to the difference in adherence to infection prevention guidelines or frequency of cleaning mobile phones during working hours, hand washing practices, the pattern or policy of mobile use in the hospital and awareness of health professionals and inpatients about the role of a mobile phone in microbial transmission.

The phone screen type related prevalence showed that keypad mobile phones had higher prevalence compared to soft-screen mobile phones with Slight but non-significant difference ($\chi^{2=}3.752$; $P>0.05$) which agrees with the report of Pal et al. [41]. The higher prevalence in keypad phones is probably as a result of keypad phones having many crevices that are conducive for microbial growth and the difficulties associated with cleaning keypad phones with alcohol as it can easily damage the phone.

This study also revealed a statistically significant higher prevalence in mobile phones of females as compared to males with a significant difference ($\chi^2=9.931$; $p<0.05$) which disagrees with the findings of Husam [42] with males (85.0%) and females (80.0%). The findings of this study also disagree with the findings of Chaman et al. [43] which did not show any significant correlation between gender and mobile phone bacterial contamination. The variations seen in the current study might be as a result of personal hygiene level and public awareness or geographical location. Females are considered to use mobile phones more often than their male counterparts and the higher prevalence in females might be as a result of improper sanitary practices such as eating and chatting, defecating and chatting/answering phone calls, and patterns of mobile phone use example in bathrooms, toilet, and the surfaces where these phones are kept could potentially serve as a route for microbial contaminations. It was observed that in both male and female *Staphylococcus aureus* was the most frequent bacteria isolated which agrees with the findings of Husam [42] who reported the frequency of occurrence of *Staphylococcus aureus* in male as (50.0%) and female (40.0%). *S. aureus* is not only a disease-causing organism but also plays it role as commensal colonizing mainly nasal passages and skins which might reasonably explains it higher occurrence in both genders. The occupation related prevalence showed civil servants inpatients and student inpatient have high rates of microbial contaminations with a statistically non-significant difference ($\chi^2=0.123$; $P>0.05$) and this could be as a result of indispensability of mobile phone usage across all profession, lack of awareness on the potential of mobile phones in transmitting microbes. Other reasons might be lack of personal and community hygiene as easy cross contaminations can occur as mobile phones carrying bacteria are exchanged between friends, families and colleagues. *E. coli* and *Staphylococcus aureus* were the most frequent bacteria isolates amongst students. *Staphylococcus aureus* had the most occurrences amongst farmers whereas CoNS with a statistically significant difference ($\chi^2=7.111$; $P<0.05$) and *Pseudomonas species* were the most frequent isolated bacteria amidst civil servants. The high occurrence of *E. coli,* CoNS, Pseudomonas and *Staphylococcus aureus* could be as a result of Poor personal hygiene or contamination from already contaminated sites in the hospital setting, although, the presence of *Enterococcus* might indicate fecal contamination.

The study also revealed a statistically non-significant difference ($\chi^2=0.136$; $P>0.05$) with high prevalence of bacterial contamination in all Age groups. Patients in younger age categories were more likely to possess a mobile phone both

inside and outside the hospital, but there was no gender association. This is probably as a result of poor hygienic measures across all age groups and gender.

In this study, the bacteria isolates are *Staphylococcus aureus, E. coli*, CoNS, *Pseudomonas spp*, *Streptococcus spp*, *Klebsiella spp* and *Enterococcus spp*. *Staphylococcus species* was the most frequently encountered bacteria isolate and this could probably be as a result of its predominance on different parts of the human body as normal flora and may be indicative of poor hand hygiene following interaction with other hospitalized patients or physicians. Studies conducted by Datta et al. [44] and a study by Sadat et al. [12] showed *Staphylococcus species* was their leading isolate. These results are similar to findings of Lindberg et al. [45], as they reported high percentage occurrences of *Staphylococci* on computer keyboards and other surfaces. Another study concluded that *Staphylococcus species* was the most frequently encountered bacterial agent, probably because this type of bacteria propagates in optimum temperatures, as phones are kept warm in pockets, handbags and brief cases [39]. “In addition, the high occurrence rate of *Staphylococcus species* was estimated to contribute 40-50% to nasal carriers in humans” [46]. The implication of this observation is that the possibility of being infected with bacterial pathogens simply by using other people’s mobile phones especially when immune-compromised is high. The high prevalence of *E. coli* (34.4%) signifies fecal contamination of hands through bed pans or poor personal hygiene; this stresses the need for better sanitary measures amongst inpatients and hospital workers interacting with them. Poor personal hygiene or contamination from already contaminated site may account for the presence of this organism especially with the lack of standard public rest rooms in most of the Ardo Kola metropolis where open defecation is still rampant. “Infections by *E coli* ranges from gastro-entritis, UTI, wound infections, the presence of *E. coli* is a direct indicator that other Enterobacteriaecae could be carried on mobile phones as also noted” [7,8]. “The isolation of the recalcitrant bacteria, *Pseudomonas species* (18.8%) which had defiled the activities of many antiseptic and germicides used in disinfecting hospitals was of concern and public health interest. *Pseudomonas species* is metabolically versatile, ubiquitous in both terrestrial and aquatic environs” [47]. Findings have shown that *Pseudomonas species* is very recalcitrant to manage in infections [48]. The presence of this organism on mobile phones of inpatients calls for serious public health attention as antimicrobial resistance can emerge easily. Coagulase-negative *Staphylococcus* (CoNS) was isolated from (18.8%) mobile phones in this study. This result does not corroborate the findings of Karabay et al. [7], in which CoNS was the most frequently encountered bacterial agent isolated from 68.4% of the subjects evaluated. Brady et al. [36] had shown that “the combination of constant handling and heat generated by the phones creates a prime breeding ground for microorganisms that are normally found in our skin. This may be because these types of bacteria increase in optimum temperature and phones are perfect for breeding these germs as they are kept warm and easy to handle in pockets, handbags and brief-cases”. *Streptococcus species* in addition to streptococcal pharyngitis (strep throat), certain Streptococcus species are responsible for many cases of pink eye, [49] meningitis, bacterial pneumonia, endocarditis, erysipelas, and necrotizing fasciitis (the 'flesh-eating' bacterial infections). However, many streptococcal species are not pathogenic, and form part of the commensal human microbiota of the mouth, skin, intestine, and upper respiratory track; this with lack of personal hygiene and reduced immunity might be the probable cause of mobile phone contamination with *Streptococcus species. Klebsiella species* are ubiquitous in nature. *Klebsiellae* are opportunistic pathogens and can give rise to severe diseases such as septicemia, pneumonia, UTI, and soft tissue infection. *Enterococcus species* (12.5%) are the second leading cause of hospital acquired infections worldwide and the main leading cause in the United States contributing 20-30% of infections. They are a part of normal microbiota in female genital tract and gastrointestinal tract as well, although the presence of *Enterococcus* might indicate fecal contamination. Enterococci are involved in the blood-borne infections; UTI and wound infections consort to surgical procedures [50]. The research findings indicate that *staphylococcus aureus* and *E. coli* are the main bacterial isolates frequently associated with personal mobile phones.

“Today’s mobile phones are important devices for both the professional and social lives of their users. However, restrictions on the use of mobile phones by the Nigerian populace in certain areas of the environment where the percentage presence of bacteria is likely high (such as in

hospitals, lecture theatres, animal slaughter areas, canteens, business centres, toilets and other such places) is difficult and thus not a practical solution" [39]. "Mobile phones have become veritable reservoirs of pathogens as they touch faces, ears, lips and hands of different users of different health conditions. This infection could be reduced through identification, and control of predisposing factors, education and microbial surveillance. Most people do not understand the inherent danger in sharing phones. Sharing phones undoubtedly means cross sharing. Effective means of disinfecting cell phone should be established to reduce its potential biological hazards" [51-55].

5. CONCLUSION

It is apparent that hospital nosocomial agent reservoirs now include cell phones. In the community and in settings related to healthcare, mobile phones are often used. The research's findings suggest that both pathogenic and non-pathogenic organisms can spread via the phones used by hospital patients. These findings demonstrated that mobile phones were contaminated with a variety of microbes, and because of their intimate nature and close proximity to our bodies' most vulnerable areas—such as our faces, ears, lips, and hands—they could become veritable reservoirs of pathogens that could cause infections. The findings of this study would offer a starting point for any public awareness campaigns on the health risks of contaminated mobile phones. The findings of the study highlight the need for further research into the infectious diseases transmitted via mobile phones.

CONSENT

It is not applicable.

ETHICAL APPROVAL

It is not applicable.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Heeks R. "ICT4D 2.0: The next phase of applying ICT for international development". In Computer; 2008.
2. Ekrakene T, Igeleke CL. Microorganisms associated with public mobile phones along Benin-Sapele express way, Benin city, Edo-State of Nigeria. Journal of Applied Science Research. 2007;3(12): 2009-2012.
3. Al-Abdalall AH. Isolation and identification of microbes associated with mobile phones in Dammam in Eastern Saudi Arabia. Journal of Family Community Medicine. 2010;17(1):11-14.
4. Anupriya A, Puhalenthi K, Keerthi SJ. Microbial contamination of mobile phones in a tertiary care hospital. International Journal of Community Medicine in Public Health. 2018;25(6):2313.
5. Brady RR, Wasson A, Stirling I, McAllister C, Damani NN. Is your phone bugged? The incidence of bacterial phone to cause nosocomial infections on healthcare workers cell phone. Journal of Hospital Infection. 2006;62:123-125.
6. Kilic I, Ozaslan M, Karagoz I, Zer Y, Davutoglu V. The microbial colonisation of mobile phone used by healthcare staff. Pakistan Journal of Biological Sciences. 2009;12(11):882-884.
7. Karabay O, Kocoglu E, Tahtaci M. The role of mobile phones in the spread of bacteria associated with nosocomial infections. Journal of Infection in Developing Countries. 2007;1:72–73.
8. Tambekar D, Gulhane P, Dahikar S, Dudhane M. Nosocomial hazards of doctors mobile phones in hospitals. Journal of Medical Science. 2008;8:73-76.
9. Arora U, Devi P, Chadha A, Malhotra S. Cell phones, a modern safe house for bacterial pathogens. Journal of Medical Education and Research Science. 2009; 11(3):127–129.
10. Chawla K, Mukhopadhayay C, Gurung B, Bhate P, Bairy I. Bacterial '*cell*' phones: Do cell phones carry potential pathogens? Online Journal of Health Allied Science. 2009;8(1):1-5.
11. Ulger F, Esen S, Dilek A, et al. Are we aware how contaminated our mobile phones with nosocomial pathogens? Annals of Clinical Microbiology and Antimicrobials. 2009;8:71-89.
12. Sadat AM, Al-Omram AK, Azam Q, Bukari H, Al-Zahrani A, Al-Turki R, Al-Omram AS. Bacterial flora on cell phones of health care providers in a teaching institution. American Journal of Infection Control. 2010;38:404-405.

13. Khan HA, Baig FK, Mehboob R. Nosocomial infections: Epidemiology, prevention, control and surveillance. Asian Pacific Journal of Tropical Biomedicine. 2017;7(5):478-482.
14. Olise C, Simon OI. Fomites: Possible vehicle of nosocomial infections. Journal of Public Health and Nutrition. 2018;01(01).
15. Boev C, Kiss E. Hospital-acquired infections: Current trends and prevention. Crit Care Nurs Clin North Am. Organisation Mondiale de la Santé Pourquoi un Défi Mondial Sur les Infections Nosocomiales. Geneva, Switzerland: Organisation Mondiale de la Santé. 2016;29(1):51-65.
16. Jagadeesan Y, Deepa M, Kannagi M. Mobile phones as fomites in microbial dissemination. International Journal of Current Science. 2013;5:6-14.
17. Widerström M, Wiström J, Edebro H, Marklund E, Backman M, Lindqvist P. Colonization of patients, healthcare workers, and the environment with healthcare-associated *Staphylococcus epidermidis* genotypes in an intensive care unit: A prospective observational cohort study. BMC Infectious Disease. 2016;16(1).
18. World Health Organization. Prevention of hospital acquired infections: A practical guide, 2nd edition; 2002.
19. Badr RI, Ibrahim BH, Ali NM. Mobile phones and nosocomial infections. International Journal of Infection Control. 2012;8(2):295.
20. Angadi K, Misra R, Gupta U, Jadhav S, Sardar M. Study of the role of mobile phones in the transmission of Hospital acquired infections. Medical Journal of Dr. D. Y. Patil University. 2014;7:435-438.
21. Fauci V. "Clean care is safer care": Correct handwashing in the prevention of healthcare associated infections. Annali di igiene. 2022;28:409-415.
22. Lee JY, Chul-Gyu L, Choon-Taek C, Hee SK, Young W, Han-Sung KY, Jae J. Contamination rates between smart cell phones and non-smart cell phones of healthcare workers. ISRN Public Health 2013;6.
23. Allegranzi B, Pittet D. Role of hand hygiene in health care associated infection prevention. Journal of Hospital Infection. 2009;73(4):305-315.
24. Khashei R, Ebrahim-Saraie HS, Hadadi M, Ghayem M, Shahraki HR. The occurrence of nosocomial pathogens on cell phones of healthcare workers in an Iranian tertiary care hospital. Infectious Disorders Drug Targets. 2019;19(3):319–325.
25. Tunç K, Olgun U. Microbiology of public telephones. Journal of Clinical Infections. 2006;53:140-143.
26. Smith S, Opera I, Goodluck H, Akindolire IO, Folaranmi T, Odekeye A, Omonigbehin AA. Singapore Med Journal. 2009;7:208-211.
27. Kramer A, Schwebke I, Kamp G. How long do nosocomial pathogens persist on inanimate surfaces? A systematic review. BMC Infectious Diseases. 2006;6: 130-140.
28. Tankhiwale N, Gupta V, Chavan S, Tawade V. Nosocomial hazards of doctor's mobile phones. Journal of Medical Science. 2012;9:283–295.
29. Balapriya P, et al. Screening for nosocomial pathogens in stethoscopes, sphygmomanometers and mobile phones of health care providers in a tertiary care hospital. International Journal Current Microbiology and Applied Sciences. 2016; 5(10):91–8.
30. Foong YC, Green M, Zargari A, Siddique R, Tan V, Brain T. Mobile phones as a potential vehicle of infection in a hospital setting. Journal of Occupational and Environmental Hygiene. 2015;12(10): D232–D235.
31. Cheesbough M. District laboratory practice in tropical countries, part 2. Cambridge University Press, Madrid, Spain; 2002.
32. Criuckshank R, Duguid JP, Marmion DP, Swain P. Medical microbiology 12th edition, Churchhill L Iivingstone, Edinburgh. 2006:370.
33. Cheesbrough M. Manual of medical microbiology, low price edition. Britain Oxford Press. 2000:251-260.
34. MacFaddin JF. Biochemical tests for identification of medical bacteria. 3rd Edition, Lippincott Williams & Wilkins, Philadelphia. 2000:200.
35. MacWilliams MP. Citrate test protocol; 2009.
Available:http://www.microbelibrary.org/component/resource/laboratory-test/3203-citrate-test-protocol
Accessed 10th Sept, 2019
36. Brady RR, Hunt AC, Visvanathan A, Rodrigues MA, Graham C, Rae C, Kalima P, Paterson HM, Gibb AP. Mobile phone technology and hospitalized patients: A cross-sectional surveillance study of bacterial colonization, and patient opinions

and behaviours. Clin. Microbiol. Infect. 2011;17:830–835.
37. Vinod BK, Yahya HH, Ahmed A, Ahmed AJ, Othman MH, Magdeldin E, Anil KB. Prevalence of antibacterial resistant bacterial contaminants from mobile phones of hospital inpatients. Libyan Journal of Medicine. 2014;9(1):25451.
38. Bures S, Fishbain J, Uyehara CF, Parker J, Berg B. Computer keyboards and faucet handle as reservoirs of nosocomial pathogens in the intensive care unit. American Journal of Infection Control. 2000;28:465-471.
39. Akinyemi KO, Atapu AD, Adetona OO, Coke RA. The potential role of mobile phonesin the spread of bacterial infections. Journal of infection in Developing Countries. 2009;3:628-632.
40. Sepehri G, Talebizadeh N, Mirzazadeh A, Mir-shekari T R, Sepehri E. Bacterial contamination and resistance to commonly used antimicrobials of healthcare workers' mobile phones in teaching hospitals, Kerman, Iran. American Journal of Applied Sciences. 2009;6(5):806.
41. Pal P, Roy A, Moore G, Muzslay M, Lee E, Alder S, Wilson P, Powles T, Kelly J. Keypad mobile phones are associated with a significant increased risk of microbial contamination compared to touch screen phones. Journal of Infection Prevention. 2013;14(2):65-68.
42. Husam SA. Bacterial contamination of personal mobile phones in Iraq, Journal of Chemical, Biological and Physical Sciences. 2013;4(2):78-93.
43. Chaman R, Nargeseyan S, et al. Survey of prevalence and types of bacterial contamination of mobile phones of personnel employed in major wards of educational hospitals in Yasuj. Journal of Fundamental Applied Sciences. 2018;10 (2):449-458.
44. Datta P, Rani H, Chander J, Gupta V. Bacterial contamination of mobile phones of health care workers. Indian Journal of Medical Microbiology. 2009;27: 279-281.
45. Linberg EA, Hesselmar B, Wold A. High rate of transfer of *staphylococcus aureus from* patient skin to infant gut flora. Journal of Clinical Microbiology. 2004;42: 530– 534.
46. Uabol-Egbenni PO. Incidence of *Staphylococcus aureus* among healthy humans in Lagos and its environs. Nigerian Journal of Microbiology. 2003;17 (2):162-172.
47. Ramos JL. *Pseudomonas*, New York, Kfuwer Academic Plenum Publisher. U. S.A; 2004.
48. Marc F, Kathleen J, Susan W, et al. Edemic *Pseudomonas aeruginosa* infection in neonatal intensive care unit. Journal of Clinical Microbiology. 2000;43:1198–1204.
49. Harrington DJ, Sutcliffe IC, Chanter N. "The molecular basis of streptococcus infection and disease". Microbes Infections. 2002;4(4):501–10.
50. Fisher K, Phillips C. "The ecology, epidemiology and virulence of enterococcus". Microbiology. 2009;155(6): 1749–57.
51. Famurewa O, David O. Cell phone: A medium of transmission of bacterial pathogens. World Rural Observations. 2009;1(2):69-72.
52. Sallam HN, Ezzeldin T, et al. Defining poor responder in assited reproduction. International Journal of Fertile Women Medicine. 2005;50:115-120.
53. World Health Organisation. The burden of health care-associated infection worldwide; 2016. [Online] Available:http://www.who.int/gpsc/countrywork/burden_hcai/en
54. Yusha'u M, Bello M, Sule H. Isolation of bacteria and fungi from personal and public mobile cell phones: A case study of Bayero University, Kano (Old Campus). International Journal of Biomedical Health Science. 2010;6(1):97-102.
55. Zhao W, Yang S, Huang Q, Cai P. Bacterial cell surface properties: Role of Loosely Bound Extracellular Polymeric Substances (LB-EPS). Colloids Surf B Biointerfaces. 2015;128:600-607.

Peer-review history:
The peer review history for this paper can be accessed here:
https://prh.globalpresshub.com/review-history/1560