Phone Usage Patterns and Bacterial Contamination of Mobile Phones of Adekunle Ajasin University, Akungba-Akoko Students

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Abstract: Mobile phones have become a crucial gadget used by students for communication, research, and entertainment. Studies have indicated the colonization of phones and their potentials to spread diseases. This study evaluated the bacterial contamination on mobile phones of students attending Adekunle Ajasin University, Akungba-Akoko and assessed the phone usage patterns of the students. A total of 120 mobile phones of students from various faculties in the University were randomly selected. A sterile swab stick was used to collect samples from each mobile phone and then taken to the laboratory for microbiological analysis. A questionnaire was administered to each participant who consented to have their phone sampled. Bacterial growth was observed in 50 out of 120 phones sampled. Twenty-three isolates were obtained from the samples, and biochemical characterization showed the bacteria belonged to 13 genera, with *Staphylococcus* being the commonest. Evaluation of questionnaires showed a high rate of phone usage in toilets, with four out of five respondents reported using their phone in the toilet. The results of this study showed the phones contained potentially pathogenic bacteria and may serve as reservoirs for pathogens. Frequent cleaning and good personal hygiene are recommended for the reduction of bacterial load on these phones.

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1. Introduction

Mobile phones have become an integral part of human lives, and their use in several environments is proliferating (Anjumn *et al.,* 2011). Mobile phones mean different things to different people, but people have come to regard it as a crucial part of their lives because of their applicability in everyday living. With the recent proliferations of affordable smart phones, the use of mobile phones has been on high demand because of the top technology delivery. The number of cell phones used globally increased from less than one million to about six billion from 2000 to 2012 (World Bank, 2012). It takes only a discussion with people who recently lost their phones or have had to do without their phones for even two days to see how important the device has become. Because mobile phones do not require the use of a landline, they have become more comfortable to carry almost everywhere – even to the swimming pool, so much so that waterproof ability is now an increasing selling point of major mobile phone brands. These devices have no doubt become one of the essential tools used for communication in daily life and are commonly used everywhere.

Since mobile phones are carried almost everywhere, they are liable to come in contact with several microorganisms – both harmful and harmless ones. The use of this mobile communication technology has not only increased in institutions of higher learning, but also other areas such as healthcare and industries. This increase has garnered interest in evaluating their potential roles as a reservoir of pathogenic, opportunist bacteria, and as a source of contamination to our foods and humans in these locations (Brady *et al.,* 2006; Srivastava *et al.,* 2014). The frequent use of mobile phones in schools such as the one in the current study raises the opportunity for cross-contamination, especially if no hygienic measures and safety practices are put in place by the users (Ulger *et al.,* 2015).

Bacteria from sources such as human skin or hand, pets, bags, pockets, environment, and food particles can contaminate the surface of mobile phones. From these sources, the microorganisms can colonize the phone and potentially cause diseases that can range from mild to chronic (Brady *et al*., 2007). When pathogens are present on the surface of a mobile phone, they could be transferred to the user's skin, other surfaces, or foods, where nutrients are available and can make their survival and growth happen (Akinyemi *et al*., 2009). Bacteria isolated from mobile phones are usually normal flora of the source of contamination, but these organisms may serve as mobile reservoirs of infection while facilitating the spread of the bacteria to other locations. Furthermore, the common exchanges and sharing of mobile phones between users may directly aid the spread of potentially pathogenic bacteria in the community (Brady *et al*., 2007).

Several studies have been conducted to evaluate the bacterial population of students' mobile phones. In a survey by Kõljalg *et al.* (2017), high levels of bacteria on secondary school students' mobile phones were reported. *Enterococcus faecalis* was the most common bacteria detected, followed by *Staphylococcus aureus, Acinetobacter* sp., *Pseudomonas* sp., *Bacillus cereus*, and *Neisseria flavescens*. The authors did not identify antibiotic-resistant genes and concluded that students' mobile phones do not appear to be considerable vectors for the spread of antibiotics-resistant pathogens. However, in the study conducted by Famurewa and David (2009), out of the 150 phones screened from people from different walks of life [University lecturers (nine), undergraduate students (86), health care personnel (11), patients (four) and commercial users (40)], 124 phones were microbiologically contaminated, with all isolates resistant to more than three antibiotics. The pathogens identified were *S. aureus, P. aeruginosa, Serratia* sp., *Escherichia coli*, *Klebsiella* sp., and *Proteus vulgaris*.

Although studies have been carried out to evaluate the bacterial contamination of mobile phones in some institutions of higher learning, to the best of our knowledge stemming from extensive literature searches, none has been carried out in Adekunle Ajasin University Akungba-Akoko (AAUA). Therefore, this study was conducted to isolate and identify bacteria associated with students' mobile phones in AAUA and to evaluate the phone usage patterns of the students.

2. Material and Methods

Study Area and Design

The study was conducted on the campus of AAUA, situated in Ondo State, southwestern Nigeria.

Sampling

A total of 120 samples (60 male and 60 female) were aseptically and randomly collected from students' phones across the faculty buildings, classrooms, hall ways, libraries and relaxation centers by swabbing the entire phone with a sterile swab stick and immersed into 5ml of peptone water which was incubated overnight at 37°C (Tagoe *et al*., 2011). Also, a questionnaire was given to each user to study the age distribution, frequency of phone cleaning, usage in the toilet, frequency of hand washing and choice of the cleaning agent.

Enumeration of bacteria

Serial dilutions from the resulting growth from the nutrient broth medium were inoculated on MacConkey agar (for coliforms), and Cetrimide agar (for selective isolation of *Pseudomonas aeruginosa*) using pour plate technique and incubated at 37°C for 24 h under aerobic condition. The number of estimated Colony Forming Units (CFU) was then calculated.

Isolation of bacteria

Colonies showing good growth and characters on plates were picked and streaked on nutrient agar plates and incubated at 37°C for 24 h. Rapidly growing, visually distinct colony and morphologically different isolates were selected for further analysis.

Preservation of bacteria

Nutrient agar slopes were prepared to keep each isolate for further use: nutrient agar was prepared in a conical flack, and 15 ml was dispensed into each McCartney bottle. This was then sterilized using an autoclave at 121 °C for 15 minutes. After sterilization, the molten agar was allowed to cool and set in a sloping position to form a slant. The slants were incubated overnight to ascertain the sterility of the slant. Each pure culture was picked and placed on the surface of different agar slant and incubated at 25 °C for 24 h until growth was observed. The culture slant was then kept in the refrigerator to serve as a stock culture for biochemical identification (Fawole and Oso, 2007).

Biochemical identification

Preliminary identification of bacteria isolates was based on Gram staining and cultural characteristics. Further identification was based on a series of biochemical tests which included: catalase, oxidase, citrate, indole, coagulase, motility, glucose, lactose, sucrose, dextrose, and fructose utilization tests (data not shown).

Administration of Questionnaire

Questionnaires with the following items: age, gender, frequency of phone cleaning and usage in the toilet, frequency of hand washing and choice of cleaning agent, were administered to volunteers. Multiple answer questions were designed and each student was asked for his/ her consent to respond to the questionnaire about his/her mobile phone characteristics and usage habits, and to allow the sampling of their device's surface.

The questionnaire was filled out by each of the 120 participants in the study. All 120 respondents had been using their mobile phones continuously for at least the last 12 months.

Results

Culturing

Out of the 120 samples that were cultured, bacterial growth was observed in 50 samples (36 male and 14 female samples). Table 1 shows the distribution growth and contamination rate of both genders under study. A total of 23 isolates were obtained from the samples, which included 12 and 11 morphologically different isolates obtained from male and female samples, respectively.

Bacterial Isolates

Table 2 shows the occurrence of bacterial isolates from the mobile phones of male and female students. Organisms isolated from male students' phones included *S. aureus, P. aeruginosa*, *Actinomyces* spp, *Corynebacterium* spp, *Alcaligenes faecalis*, *Listeria monocytogenes, Micrococcus luteus, B. subtilis*, *Pseudomonas* spp, *Sporosarcina* spp, and *Aeromonas* spp. Bacteria isolated from the female students' mobile phones were similar to those isolated from male students. *Actinomyces* sp., *B. subtilis, Listeria* spp, *Klebsiella pneumoniae, Enterobacter agglomerans, S. aureus, Proteus mirabilis, Micrococcus luteus, Corynebacterium* spp and *Bacillus* spp were all isolated from the female students' phones.

In general, a total of 23 organisms with 43.8% Gram positive rod, 39.13% Gram negative rod and 17.39% Gram positive cocci were isolated from the samples. Biochemical tests indicated that a total of 13 genera were isolated which included: *Staphylococcus* (23.40% frequency), *Pseudomonas* (17.02% frequency), *Actinomyces* (10.64% frequency), *Bacillus* (8.51% frequency), *Listeria* (8.51% frequency), *Corynebacterium* (8.51% frequency), *Alcaligenes* (6.38% frequency), *Micrococcus* (6.38% frequency), *Sporosarcina* (2.13% frequency), *Aeromonas* (2.13% frequency), *Proteus* (2.13% frequency), *Enterobacter* (2.13% frequency) and *Klebsiella* (2.13% frequency) as shown in Fig. 1.

Analysis of Questionnaire

The analysis of the questionnaire was done using the histogram, as shown in Figs. 2 – 6. Figure 2 presents the age distribution of the respondents which shows that more than 80% of the respondents were in the age range of 20 – 25years while less than 16% were between the ages of 25 – 30years. Figure 3 gives an illustration of how often the respondents clean their phones; the charts show that most of the respondents clean their phone at least once a week. Figure 4 provides the data on students' phone usage in the toilet, where it was observed that only about 8% of respondents do not use their mobile phones inside the toilet.

The statement on hand-washing after toilet visit was presented in Fig. 5 and it was observed that majority of the respondents wash their hands after using the toilets. Figure 6 shows the type of cleaning agent used by the 114 respondents who wash their hands after using the toilet (Fig. 5). Results showed that 42%, 38%, and 19% of respondents used only water, liquid soap and bar soap respectively in washing their hands after using the toilet.

Table 1: Growth distribution and contamination rate of samples

Category	**Total samples**	**Growth**	**Contamination rate (%)**
Male	60	36	60
Female	60	14	23.33
Total	120	50	41.67

Table 2. Bacterial isolates from male students' mobile phones

Gram reaction	**Cell morphology**	**Organism**
+	Rod	*Actinomyces* spp
-	Rod	*Alcaligenes faecalis*
+	Rod	*Corynebacterium* spp
+	Rod	*Listeria monocytogenes*
+	Cocci	*Staphylococcus aureus*
-	Rod	*Pseudomonas aeruginosa*
-	Rod	*Pseudomonas* spp
-	Rod	*Pseudomonas* spp
-	Rod	*Aeromonas* spp
+	Rod	*Sporosarcina* spp
+	Cocci	*Micrococcus luteus*
+	Rod	*Bacillus subtillis*

4. Discussions

The current study aimed at evaluating the bacterial contamination of mobile phones of students of AAUA, and also assessing their phone usage patterns. There was a high level of bacterial contamination of mobile phones used by male students with a rate of 60% while a contamination rate of 23.33% was recorded in the mobile phones of the female students in AAUA as shown in Table 1. The difference observed in the contamination rate could be as a result of the differences in phone usage patterns of the students. It was found that more than 58% of female students polled cleaned their mobile phones either daily or weekly, compared to less than 42% of male students (Fig. 3).

Table 3. Bacterial isolates from female students' mobile phones

Gram reaction	Cell morphology	Organism
+	Rod	*Actinomyces* sp.
+	Rod	*Bacillus subtilis*
+	Rod	*Listeria* sp.
+	Rod	*Listeria monocytogenes*
-	Rod	*Klebsiella pneumoniae*
-	Rod	*Enterobacter agglomerans*
+	Cocci	*Staphylococcus aureus*
-	Rod	*Proteus mirabilis*
+	Cocci	*Micrococcus luteus*
+	Rod	*Corynebacterium* sp.
+	Rod	*Bacillus* sp.

Similarly, six out of 10 male students reported that they use their mobile phones in the toilet, while only about half of female students use their phone in a similar fashion (Fig. 4). These observations indicated that there is a likely correlation between proper mobile phone usage and reduced bacterial contamination. The use of the mobile phone in this location could convert the devices as a reservoir and source of pathogenic and non-pathogenic microorganisms and favor cross-contamination after handling (Ulger *et al*., 2009).

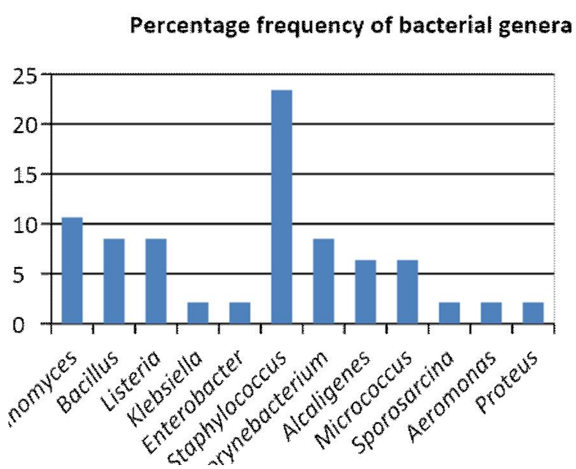

Figure 1. The percentage frequency of bacterial isolates' genera

Mobile phones, due to their nature and closeness to sensitive parts of the users' body, could become conventional reservoirs of the pathogen and this can lead to infections (Chawla *et al*., 2009).

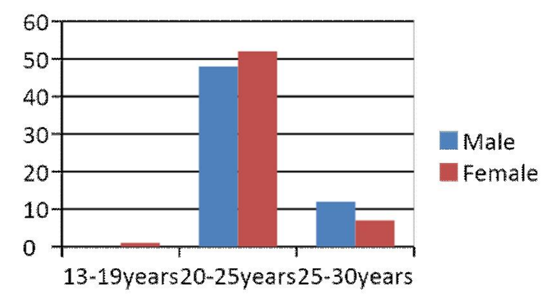

Figure 2. Age distribution of students' respondents

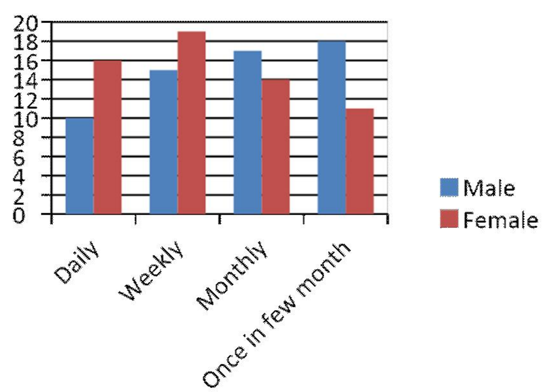

Figure 3. Frequency of phone cleaning by users

One of the bacteria isolated in this study (*Staphylococcus* spp) was also isolated by Yazhini *et* *al*. (2013) as reported in their study of microorganisms from mobile phones of students. The results obtained in this study also coincides with what Tagoe *et al*. (2011) obtained in their study, where they revealed a high level of bacterial contamination on the mobile phones of students of Cape Coast University where they isolated *Staphylococcus* and *Escherichia coli* among other organisms.

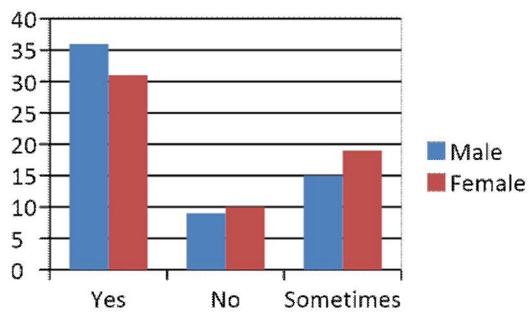

Figure 4. Phone usage inside the toilet

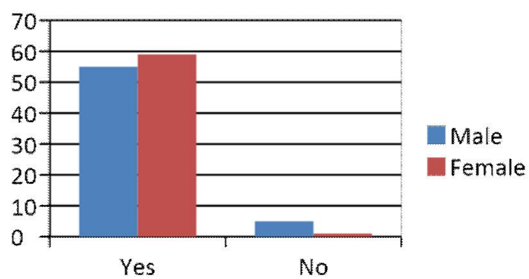

Figure 5. Histogram showing statement of hand washing after each toilet visit

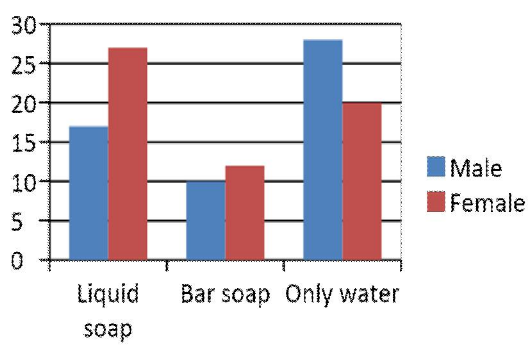

Figure 6. Histogram showing the choice of hand washing agent

Yusha *et al.* (2010) also demonstrated the presence of *Staphylococcus* contamination on mobile phones of students of Bayero University, Kano. This agrees with the result of this study which shows *Staphylococcus* as the predominant isolate, as shown in Fig. 1. This is likely because the bacterial species are normal flora of the human skin and may have come in contact with the mobile phone through the skin or hand to hand distribution (Ekrakene and Igeleke, 2007). Although normally harmless, it could wreak havoc as an opportunistic pathogen.

The isolation of *P. aeruginosa* in this study was also reported by Karabay *et al*. (2007). Their study confirms that mobile phones may get contaminated by bacteria such as *E. coli*, *P. aeruginosa,* and *K. pneumoniae*. The presence of coliform bacteria such as *Klebsiella* and *Enterobacter* on the cell phone surface suggests that the contamination may be of faecal origin. However, the presence of these bacteria does not exactly imply faecal contamination or the presence of pathogens on mobile phones. This is because some members of the *Enterobacteriaceae* and coliform bacteria are common in both human and animal faeces, and some others are also commonly found in soil, water, and raw foods. From those sources, these microorganisms can be transferred to the surface of mobile phones (Reynolds *et al.,* 2005).

Similarly, in line with this study *Staphylococcus aureus* was the main bacteria isolated by Tambe and Pai (2012) while *Pseudomonas* and other Gram-negative bacteria like *E. coli*, *Acinetobacter* and *Enterobacter* were isolated in very few cases. In contrast to this study, research conducted by Brady *et al.* (2006) and Karabay *et al.* (2007) on contamination of mobile phones, showed higher isolation of coagulase negative staphylococci and no isolation of *Staphylococcus aureus*. This discrepancy could be explained by the different lifestyle and environmental conditions of persons and places respectively in which studies were carried out. This confirms the assertion that environment condition and lifestyles could be a factor in the spread of diseases and the onset of infection through mobile phones (Hassan *et al*., 2004).

Furthermore, the isolation of *Bacillus* spp and *P. aeruginosa* in this study concurs with the research by Akinyemi *et al.* (2009) who reported the isolation of *Enterococcus feacalis*, *P. aeruginosa*, *E. coli*, and *Klebsiella* spp from mobile phones of marketer and food vendors, students and lecturers, public servants and healthcare personnel, with the mobile phones of students and lecturers having higher bacterial contamination. More so, the broad spectra of bacteria isolated by Akinyemi *et al.* (2009) also concur with what was observed in this study. Similarly, Rusin *et al.* (2002) documented both Gram-positive and Gram-negative bacteria in the hand-to-mouth transfer during casual activities. With the types of bacteria isolated in this current study, the phones could contribute to the spread of diseases commonly caused by bacterial isolates.

Conclusion

Mobile phones have become indispensable among students, where they serve many purposes ranging from communication to reading and recreation. However, the increased use of mobile phones has been seen as a factor that could contribute to the spread of infections. This research highlights mobile phones as transmitters of potentially pathogenic organisms which can result in community-acquired infections with possible public health implications. Therefore, we suggest introducing basic training sanitary procedures, especially as it relates to the transmission and control of microorganisms, during the annual orientation programmes for new students. We also recommend regular cleaning of mobile phones with disinfectants or detergents, frequent hand-washing (especially after each toilet visit), and non-usage of mobile phones in toilets as possible means of curtailing potential disease transmission by mobile phones.

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