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Bacterial Contamination of Mobile Phones Used by Food Vendors in Rumuolumeni, Port Harcourt, Nigeria

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Abstract
Food vendors are essential in all socio-economic sectors in developing countries, they provide ready-to-eat food to the inhabitants and during this process, they could transmit harmful bacteria through their mobile phones. This study aims to ascertain if the phones used by food vendors could be a potential source of circulation of pathogenic bacteria. Phone swabs were obtained from the phones used by the food vendors from 10 different locations in Ignatius Ajuru University of Education, Rumuolumeni. The phone swabs were analyzed bacteriologically using standard methods. It was incubated for 24 hours, at 37^{o}C and the plate was examined for growth. Viable counts were also obtained using standard procedures. The total plate count of bacteria obtained from the samples ranged from 4.0 X 10^4 (sample 4) to 7.0 X 10^5 (sample 8) in total bacteria load of mobile phones. The total number of coliform bacteria ranged from 7 (sample 6) to 17 (sample 7). The total *Staphylococcus aureus* load has the highest occurrence of 9 while *Salmonella typhi* and *Escherichia coli* has the same number of occurrences of 2. Samples 5, 7, and 9 have the highest load of the bacteria (2 cfu/ml), while samples 1, 2, 3, 4, 6, 8, and 10 have the same load of bacteria (1 cfu/ml). Biochemical characteristics of *Staphylococcus aureus*, *Escherichia coli*, and *Salmonella typhi* were analyzed using catalase, citrate, indole, methyl red, urease, gas, vogas Proskauer, glucose, lactose, sucrose and mannose test. The study revealed that the mobile phones used by food vendors were contaminated by bacteria. It was recommended that food vendors be emboldened to show interest in tight personal hygiene to the mobile phones handled and develop active preventive strategies such as decontamination of mobile phones with alcohol-containing disinfectant to reduce cross-infection.

Keywords: Bacterial contamination, Mobile phones, Food vendors, Food Safety, Hygiene

Introduction

To create and enhance a communication network, the Worldwide System for Mobile Telephony (GSM) was founded in Europe in 1982. Mobile phones are becoming among the most important equipment for both social and professional life. Mobile phones are regularly handled and held near the face, even though they are typically kept in bags or pockets. In the modern world, mobile phones are frequently utilized, however, due to improper handling, they serve as a major source of a variety of harmful bacteria (Zakai et al., 2016; Adhikari et al., 2018). Mobile phones may operate as vehicles to spread different bacteria due to their widespread usage in places that are polluted with microbes, such as restrooms, marketplaces, and kitchens (Bhoonderowa et al., 2014). Tens of thousands of bacteria may live on each square inch of a mobile phone, making them a highly populated reservoir for many intestinal infections that are often disregarded. Numerous microorganisms that are often present on the skin might flourish because of repeated handling and the heat produced by phones. Mobile phone users may be found everywhere, including in homes, marketplaces, restaurants, and schools. Therefore, they could be to blame for the dissemination of various illnesses across the neighbourhood. Mobile phones may get contaminated while being handled by bacteria from the anal area, skin, wounds, nasal secretions, and aerosols produced by sneezing and coughing. Due to their intimate nature and closeness to delicate body parts including users' faces, ears, lips, and hands, mobile phones risk developing into a pathogen reservoir of unrivalled proportions that might spread illnesses.

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Numerous bacteria, including those that cause illnesses and may spread diseases, such as *Escherichia coli*, *Pseudomonas aeruginosa*, and *Klebsiella pneumonia*, can contaminate mobile phones. Increased antibiotic resistance in recent years has led to increasing infection-related morbidity and death. Mobile phones have been the source of the isolation of extended-spectrum beta-lactamase (ESBL), methicillin-resistant *Staphylococcus aureus* (MRSA), and multi-drug resistance (MDR) bacteria strains. According to Adhikari et al. (2018), Gashaw et al. (2014), and Lee et al. (2014), these infections might pose serious health risks to users.

Globally, the usage of mobile phones has grown quickly, opening up a wide range of opportunities for people's everyday lives. According to estimates from 2017 (Gillwald et al., 2018), 71% of Nigerians make use of mobile phones as their primary method of communication and internet access. With African markets growing as quickly as Asian markets in terms of the use of mobile phones, Africa has one of the highest rates of cellular subscriber growth worldwide. However, constant handling and unhygienic practices of using mobile phones by various users make them vulnerable to a variety of microorganisms with the potential to pose several health risks to users. numerous consumers are typically unaware of the level of microorganisms present on numerous common things in their homes and workplaces (Shalinimol, 2016). Mobile phone surfaces may act as vehicles for the spread of these bacteria due to unclean handling that makes them major reservoirs of harmful microorganisms (Bhoonderowa et al., 2014; Zakai et al., 2016; Adhihari et al., 2018).

Food sellers, hawkers, and marketers often use mobile phones in public places, making this one of the settings where infections are most common. Additionally, since they carry phones and it is unclear if such accessories contribute to the spread of bacterial infections, tourists who visit low-income nations with inadequate access to drinking water and sanitary conditions run the risk of being infected. The most common cause of diarrhea is enteric bacteria, which are responsible for around five million deaths annually globally. The first investigation on the bacterial contamination of cell phones took place at a Turkish teaching hospital with 200 beds and one critical care unit. In a New York-based investigation, it was discovered that one-fifth of the mobile phones under examination had harmful bacteria. Many different bacterial species, many of which could be harmful, may be found in large numbers on both public telephones and mobile phones. The usage of mobile devices by food sellers is of special relevance since these gadgets have been linked to the transmission of nosocomial illnesses. The mouthpiece of a public telephone is where microbial contamination is most often discovered, while bacterial species may also be detected in the earpiece and grips. The usage of public payphones has declined, reducing direct contamination from person to person, but cell phones with buttons and keyboards and other personal mobile phones have been discovered to be significantly more bacterially contaminated. Mobile phones are among the most essential equipment for both social life and work. Mobile phones are mostly held and handled near the face, even though they are usually kept in bags or pockets.

Mobile phones are one of the common technologies in use today. When mobile phones became widely used in the 20th century, concerns were raised about the potential harm they may do to people's health. Mobile phones are crucial communication tools for use at home, at school, and in the office. They are often handled, dropped, or pocketed, which creates the potential for them to take up and retain microbes from their handlers and the surrounding area. Numerous studies have shown that the transmission of infectious diseases is significantly aided by mobile phones that have been exposed to dangerous microorganisms. Mobile phones act as a reservoir for harmful germs even though they are essential equipment for both social and professional situations. Consequently, the goal of the research is to ascertain if mobile phones used by food sellers may have an impact on the transmission of bacterial infections.

Aim and Objectives of the Study

The aim of this study was to determine the level of bacterial contamination of mobile phones used by food vendors. The objectives of this study were to:

1) determine the bacterial counts of mobile phones used by food vendors;
2) determine the total coliform bacteria of mobile phones used by food vendors;
3) investigate mobile phones for the presence of the food contaminating pathogenic bacteria: *Salmonella typhi*, *Escherichia coli* and *Staphylococcus aureus*.

Materials and Methods

The study was carried out on mobile phones of food vendors in Ignatius Ajuru University of Education, Rumuolumeni. At the Rumuolumeni campus of the Ignatius Ajuru University of Education, 10 samples were taken from the phones of food sellers. All participants received an explanation of the study's purpose and were asked for their verbal

agreement. The overall bacterial count was calculated using the serial dilution technique. 9ml of the dilution blank tube 1 was combined with 1ml of the stock sample. Once the required concentration was attained, the same process was again used, adding 1 ml from tube 1 to 9 ml of tube 2, 1 ml from tube 2 to 9 ml of tube 1, and so on. Concurrently, samples were purchased from the food sellers. Rotating moist cotton swabs on the phone's earpiece, keypad, and mouthpiece allowed for the aseptic collection of the samples. At the time of sample collection, they were initially placed into brain heart infusion (BHI) as a transport medium and incubated for 24 hours under aerobic conditions at 37°C. Swab sticks were inoculated on Eosin methylene-blue agar plates after being dipped in 0.5ml of saline water. For 24 hours, all inoculation media were incubated aerobically at 37°C, and the isolates' growth and colonial morphology were assessed.

Bacterial growth on the Plate Count Agar showed 30-300 colonies after incubation for 24 hours at 370C. The presence of microorganisms was evaluated on the Eosin methylene-blue agar plates. The bacteria's growth traits and other colonial features, including the production of mucoid colonies and lactose fermentation, were meticulously documented. Five isolated identical colonies on Eosin methylene-blue agar plates were carefully selected and inoculated into buffered peptone water in sterile microtitre wells when there were more than five similar colonies detected on a plate. Utilizing the pure culture on the nutrient agar slant, bacteria were identified. The isolates underwent Gram staining and further biochemical testing.

Ten samples in all were taken from the phones of food sellers at the Ignatius Ajuru University of Education in Rumuolumeni. All participants received an explanation of the study's idea, and their verbal permission was requested. Lactose broth was injected into many tubes. A plate of medium was streaked with a lactose-broth tube that had tested positive, and the plate was then incubated for 24 hours at 370°C. The material was put into test tubes that had growing media in them. In the second method, germs were retained after the sample was run through a fine filter. The filter was incubated after being put on culture media. Rotating moist cotton swabs on the phone's earpiece, keypad, and mouthpiece allowed for the aseptic collection of the samples. At the time of sample collection, they were initially placed into brain heart infusion (BHI) as a medium of transport and aerobically incubated for 24 hours at 37°C. MacConkey agar and Blood agar were employed for the first isolation of coliform bacteria taken from the swab. Plates of MacConkey Agar and Blood Agar were aerobically incubated for 24 hours at 370C. After culture, the colonies were recognized by their typical appearance on the cultivation medium (including usual growth and haemolysis features). The presence of coliform bacteria was checked on the MacConkey and blood agar plates. The coliform bacteria's growth traits and hemolysis were meticulously documented. If there are more than five identical colonies on a plate, they were carefully selected one at a time and inoculated into buffered peptone water in sterile microtitre wells. This was done for both blood agar and MacConkey agar plates. On the nutrient agar slant, pure culture was used to identify coliform bacteria. All of the isolates underwent further biochemical testing after being Gram-stained.

The Food and Drug Administration (FDA) suggested that *Salmonella typhi* be isolated. For pre-enrichment, the swab was infected and incubated at 370C for 18 hours. Additionally, 0.1ml of a pre-enriched inoculum was transferred to a broth for selective enrichment, where it was cultured for 24 hours at 37°C. A loop of inoculums was streaked on xylose lysine desoxycholate (XLD) agar and incubated at 37^0C for 24 hours after enrichment. On xylose lysine desoxycholate (XLD) agar, probable *Salmonella typhi* colonies with a somewhat translucent red halo and a black core encircled by a pink-red zone were examined for their biochemical properties. The presumed colonies of *Salmonella typhi* were then put through a series of biochemical tests, including the triple sugar iron (TSI), catalase, urease broth, indole, methyl red, Voges-Proskauer, and citrate tests (IMViC), following the standard test protocol outlined in the Food and Drug Administration's (FDA) Bacteriological Analytical Manual.

Escherichia coli was isolated following ISO-16654: 2001 recommended procedures. The samples were incubated aerobically at 370C for 18 to 24 hours after being mixed in sterile Tryptone soya broth at a ratio of 1:10 for the first time. For 24-48 hours, a loopful of the incubated broth was scattered over a MacConkey agar substrate and incubated at 370C. Each plate's colonies that exhibit *Escherichia coli* traits were picked up and streaked over buffered peptone water (BPW). 1 ml of the buffered peptone water was added to the Eosin methylene blue and incubated for 24 hours at 37°C. Following purification, the colonies were streaked into nutrient broth and further identified by incubating at 37^0C for 18 to 24 hours. Using the method described in ISO, (2003), several different biochemical tests were performed on the isolated strains to identify Escherichia coli. To confirm the presence of Escherichia coli in all probable isolates, tests for catalase, indole formation, methyl red, Voges-Proskauer, and

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Simon's citrate were run on tryptone broth, MR-VP medium, Simon citrate agar, and sugar fermentation. Peptone water enrichment broth was used for the enrichment process. The material was homogenized in a sterile enrichment broth containing peptone water, and it was then enhanced for 24 hours at 370C. Colonies that were jet black in colour and had a white halo around them were thought to be presumptive Staphylococcus aureus. The pure cultures were streaked on Nutrient agar, cultured for 24 hours at 37^0C, and then subjected to biochemical assays to determine their further characteristics.

Based on colony morphology on mannitol salt agar, gram staining, beta-hemolytic patterns on blood agar, catalase and coagulase tests, the isolates were determined to be *Staphylococcus aureus. Staphylococcus aureus* pure colony was deposited on a neat glass slide making use of a sterile inoculation loop, and a drop of the appropriate reagent was added, and mixed with the loop to conduct agglutination tests. Amplification of the nuc gene unique to Staphylococcus aureus further verified the isolates.

Results

Table 1: Total bacterial counts of mobile phones used by food vendors

Samples	Bacterial Count (cfu/ml)
1	3.0×10^5
2	1.0×10^5
3	6.0×10^4
4	4.0×10^4
5	3.8×10^5
6	2.5×10^5
7	2.3×10^5
8	7.0×10^5
9	8.0×10^4
10	2.3×10^5

Ten samples revealed the total bacterial counts of mobile phones used by food vendors. The result showed that the total bacterial count ranged from 4.0×10^4 (Sample 4) to 7.0×10^5 (Sample 8). Sample 4 had the lowest bacterial count while sample 8 had the highest bacterial count.

Table 2: Total coliform bacteria count of mobile phones used by food vendors

Sample	No. of Coliforms (MPN)	Range
1	11	2-25
2	9	2-21
3	12	3-28
4	14	4-34
5	11	2-25
6	7	1-17
7	17	5-47
8	14	4-35
9	8	1-19
10	9	2-21

The total coliform bacteria count of mobile phones used by food vendors was shown in this study and a coliform bacteria table was used. The result showed that the total number of coliform bacteria ranged from 7-17. Sample 6 had the lowest number of coliforms, while sample 7 had the highest number of coliforms.

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Table 3: The presence of the food-contaminating pathogenic bacteria: *Salmonella typhi, Escherichia coli* and *Staphylococcus aureus*

Samples	*Salmonella typhi*	*Escherichia coli*	*Staphylococcus aureus*	Total
1	+	-	-	1
2	-	-	+	1
3	-	-	+	1
4	-	-	+	1
5	+	-	+	2
6	-	-	+	1
7	-	+	+	2
8	-	-	+	1
9	-	+	+	2
10	-	-	+	1
Total	**2**	**2**	**9**	**13**

From the table above, samples 5, 7, and 9 had the highest load of bacteria investigated (2 cfu/ml each). Samples 1, 2, 3, 4, 6, 8, and 10 had the same load of bacteria (1 cfu/ml each). *Staphylococcus aureus* load had the highest occurrence of 9, while *Salmonella typhi* and *Escherichia coli* had the same number of occurrences of 2.

Discussion

Total bacteria count of mobile phones used by food vendors

In this study, the total plate count ranged from 4.0×10^4 to 7.0×10^5, the least total plate count was calculated to be 4.0×10^4 while the most contaminated was the phone swab from sample 8 with 7.0×10^5. The low total plate count recorded from sample 4 was not surprising as the environment where the food was being prepared was hygienic, having good sanitary practices. Unlike the samples with highly contaminated plates, the environments where the samples were obtained were kept unhygienic. It is also noteworthy that the high total plate count observed in the samples obtained from the food vendors could be attributed to the mode of serving and preparing the meal. This result is in consonant with the work carried out by Felgo and Salkyi (2012). According to the study, fufu, which was one of the food samples collected had the highest total count plate and this they attributed to the mode of preparing the food which involves using a pestle and turning the resulting paste with bare hands. Also, according to a study by Monday et al. (2012), it was observed that moi moi (Beans cake) had the most total plate count of 8.7×10^3 cfu/ml which is usually served with bare hands. This similar process was observed in dishing out food to customers using the fork and the thumb to serve the product to the customers, in addition, the type of food sample analyzed could also be a predisposing factor to the high total plate count obtained as they are usually exposed easily to the atmosphere because of their constant demand and preference by consumers. Although the International Commission for Microbiological Specification for Foods (ICMSF) states that ready-to-eat foods with a plate count between 10^3 are acceptable, between $10^4\leq$ and 10^5 is tolerable and 10^6 and above is unacceptable, nevertheless, it's also important to take into full consideration that the microbial load can only be ascertained by microbial analysis which cannot be done at regularly, thus, strict hygienic practices must be maintained.

Total coliform bacteria count of mobile phones used by food vendors

A total of ten bacterial isolates were recorded on phone samples. The isolates, all belong to the family of Enterobacteriaceae, a very important group of bacteria known to man. They are the largest and most heterogeneous collection of Gram-negative bacilli of medical importance. They are involved in almost all infections acquired in the environment, particularly respiratory infections and urinary tract infections. Sample 7 has the highest number of coliform (17) from the phone swabs with a range of 5-47, while sample 6 was recorded with the lowest number of coliform (7) with a range of 1-17. These isolated organisms indicate a low level of sanitary practices maintained by the food vendors. The sanitary practice in this case is not just at the vending site but also on the mobile device being handled. Contaminated phones of food vendors serve as a major source of foodborne diseases even if strict cleanliness and standard are maintained, phones are taken everywhere even to the toilet and are rarely cleaned.

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The occurrence of *E. coli* recorded from phone samples in this research indicates faecal contamination of the hands of the food vendors. This is by the study carried out by Thidarat et al. (2011). They reported that the highest contamination level was intestinal bacteria *E.coli* which is about 22% also revealing that these bacteria can be transferred from the hands of the food vendor to the customer's food which leads to foodborne diseases. Interestingly, phone samples collected from the food vendors had *E. coli*. This signifies cross-contamination between the phone handled by the food vendor and the vendor's food. This could be a result of the nature of the sample collected at both vending sites. Nevertheless, if care is taken, microbial contamination could occur. Also, the mode of serving this food mostly involves the use of the thumb to support the utensil (e.g. fork or spoon) which could ultimately lead to Phone→Hand→Food contamination. Although, in the course of this research, the vendors were not subjected to any study, it is generally perceived that mobile phones due to mobile phones proximity and personal nature to sensitive parts of our bodies in usage such as hands, face, ears, and lips of users could harbour pathogens that could result in diseases and infections, at such, most of the vendors were seen constantly using their phones for making calls which can ultimately lead to contamination of the phone.

Presence of *Salmonella typhi, Escherichia coli* and *Staphylococcus aureus*

High occurrence of *Staphylococcus aureus* recorded from phone samples in this research indicates contamination of the hands of the food vendors. *Salmonella typhi* and *Escherichia coli* were also among the intestinal bacteria isolated on food vendors' phones, which also indicated contamination of hands from the faecal sources. Also, this research shows that *Staphylococcus aureus* appeared positive in most of the samples which signified poor hygiene practices of the food handlers, which when this bacterium is transmitted to food from a phone may result in bacillary dysentery among the consumers. *Salmonella* has been reported to be an environmentally persistent pathogen capable of surviving and proliferating in diverse environments (Winfield & Groisman, 2005). The contamination of hands with fecal bacteria due to the inadequate hand washing practice of the food handlers, and consumption of this pathogen in the food may lead to typhoid fever infection. These organisms may probably have found their entry to the phone through the skin and hand-to-hand mechanism. This is because they are a subset of the normal microbiota of the skin as advanced by earlier researchers. Frequent handling by many users of different hygiene profiles having regular skin contact with the phones may have resulted in the frequency and the degree of population of the isolates. This has a lot of health implications.

Distribution of the isolate of each vending site shows that samples 5, 7, and 9 have the highest number of bacterial isolates, appearing twice positive each. One of the predisposing factors for the high contamination of food vendors' phones found in these samples may be due to the unhygienic conditions where the vented food is being sold. According to a study conducted by Rasmwaki (2007), it was observed that the majority of premises did not comply with pest control treatment (68.8%), management of refuse (50.0%), proper clothing of food handlers (46.9%), hand washing facilities (40.6%) and proper personal hygiene (28.1%) and these were predisposing factors to the occurrence of foodborne illnesses. One conspicuous occurrence is the presence of *E. coli* on food vendors' phones obtained from the samples and the occurrence of *Salmonella typhi, E. coli* and *Staphylococcus aureus* on food vendors' phones. This is in agreement with the study conducted by Akinyemi et al. (2009), in Lagos, Nigeria, according to the study, the highest rate of contamination was food vendors and marketers and most of the isolated organisms were found to be members of the Enterobacteriaceae. The occurrence of these isolates could be a result of the constant use of mobile phones by the food handlers at the different restaurants as observed during the study.

However, despite the hygienic practices maintained by the food handlers, there was isolation of the same organisms from phones. This shows that the sanitary practices maintained by the food vendors in their surroundings were not transcended to their mobile phones, neglecting the fact that the phones handled are a potential source of pathogenic bacteria which could be transmitted to the vendor food sold to the consumers giving rise to foodborne illnesses. Generally, it was observed that phones handled by food vendors have pathogenic organisms isolated on it was because of the site where they were kept when not in use. Most food vendors were seen bringing out their phones from handbags. This observation is in agreement with the study conducted by Braddy et al. (2006), it was discovered that mobile phones emit Electro Magnetic energy and this shapes a conducive environment for the bacteria, so the bacteria find their way onto the mobile phones and on reaching the mobile phones, the count of these bacteria increases as the bacterial count increases in high temperature. Phones are the perfect breeding sites for these microorganisms as they are kept warm in the handbags and pockets. Thus, this is the reason for the higher load of bacteria on our mobile phones

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Conclusion

Generally, this study has helped to reveal that phones handled by food vendors could pose as a source of dissemination of pathogenic bacteria. Examples of these bacteria are *Salmonella typhi*, *Escherichia coli*, and *Staphylococcus aureus*. Furthermore, it can also be observed in the cause of this study that the presence of these pathogenic bacteria on phone cannot be determined by the level of hygienic practices maintained in the immediate environment, rather a constant cleansing of the surface of the phone is the utmost way to prevent contamination of phone.

Recommendations

1. Food vendors are recommended to show interest in strict personal hygiene to the mobile phones handled and environmental sanitation to prevent disease outbreaks and transmission.
2. Developing active preventive strategies like decontamination of mobile phones with alcohol-containing disinfectant might reduce cross-infection.
3. Another way of reducing microbial contamination on mobile phones is by enlightening the public on the microbial colonization of mobile phones and the use of regular cleansing agents and rearranging of their environment.

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