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STUDIES ON THE MICROBIAL CONTAMINATION OF SMARTPHONES USED BY KOGI STATE POLYTECHNIC STUDENTS, LOKOJA, KOGI STATE

BY

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Abstract

Smartphone usage has become an indispensible part of our everyday lives, particularly the students who are actively involved in learning process for academic purposes. It has yielded many benefits to them, particularly in the area of data collection for learning and research. However, the pervasive and unhygienic use of this device has introduced new challenges in terms of hygiene and public health. One of such challenge lies in the possibility of smartphones acting as formites for the transmission of microbes. This was studied through survey of smartphone usage among the students in Kogi State polytechnic Lokoja, during which fifty (50) smartphones of volunteer participants were swabbed with sterilized cotton swab, and cultured on appropriate agar media to observe the microbial growth and their morphology. Out of the 670 (CFU) formed upon counting, 520 (CFU) were found to be bacteria, while 150 (CFU) were fungi. Twenty (25) of the colony were isolated and subjected to gram staining to assess their reaction, during which 16 of the bacteria were found to be Gram positives, while 9 were Gram negatives; with Staphylococcus spp having the highest frequency of occurrence among the Gram positives, and E. coli having the highest frequency of occurrence among the Gram negatives. Lactophenol test was also carried out on the fungal isolates and several fungi species were identified including Rhizopus spp, Candida spp, Fusarium spp, Aspergillus spp and Penicillium spp; among which the Aspergillus and the Candida species have the highest frequency of occurrence respectively. In general, study confirms the contamination of smartphones by microbes, with the potential to transmit infections if not addressed.

***Keywords**:* isolate, contamination, infection, fomites, colony.

Introduction

The pervasiveness in the proliferation of smartphones usage for over a decade has revolutionized various aspects of human lives including communication, learning, and social interaction among users. Smartphones have become indispensable tools, predominantly among students, facilitating unlimited access to valuable information, educational resources, and social networks. Despite the numerous benefits, the prevalent use of smartphones has introduced new challenges, particularly in terms of hygiene and public health. One significant concern is the possibility of smartphones to act as formites for the transmission of pathogenic microorganisms. Smartphones have become an integral part of the daily lives of students, serving as platforms for their academic activities, entertainment, and social interaction.

Research showed that students use their smartphones extensively, often touching them multiple times per hour. This regular handling creates opportunities for the transfer of microbes from the skin, mouth, and surrounding environment onto the surfaces of their devices. Studies have shown that smartphones can harbour a wide range of microorganisms, including bacteria, viruses, and fungi, some of which may be pathogenic (Fraser *et al.,* 2017). The contamination of smartphones by microbes is influenced by certain factors including the surrounding environment in which the device is use, personal hygiene practices, and the nature of the materials used in the construction of the device. Study by Juyal *et al*. (2015) demonstrated that smartphones often harbours harmful bacteria such as *Staphylococcus aureus, Escherichia coli*, and *Pseudomonas aeruginosa*. These pathogens are responsible for several infections ranging from skin conditions to more severe diseases such as the urinary tract infections and respiratory illnesses. The sources of microbial contamination are diverse including the direct contact with the skin in the hands and face, which are themselves often contaminated with microbes.

Additionally, smartphones can come into contact with various surfaces that harbour bacteria, such as desks, books, and some other personal items. The transmission routes are chiefly through direct contact and the formation of biofilms on the smartphone surfaces. Biofilms are complex communities of microorganisms which stick to surfaces and are protected by an extracellular matrix, making them resistant to cleaning and disinfection (Gandhi *et al.,* 2015). The role of smartphones in public health is further emphasized by the need for policies to address hygiene in educational settings. For instance, the Centers for Disease Control and Prevention (CDC) recommends, regular cleaning of high-touch surfaces and this include personal electronic devices. By implementing these recommendations in schools, educational institutions can play a crucial role in infection control, ultimately

protecting students' health thus, ensuring a conducive learning environment. Despite the obvious risks, awareness and practices related to the hygiene and disinfection of smartphones remain largely limited. Many students do not clean their devices regularly, and perhaps those who do use ineffective methods. Proper cleaning and disinfection protocols are essential to mitigate the risk of microbial infection.

Literature Review

Smartphones have become an indispensable part of modern life, with an estimated 5 billion mobile phone users worldwide (International Telecommunication Union, 2020). The widespread use of smartphones has led to increase in the transmission of infectious diseases, as they can harbour a wide range of microorganisms, including bacteria, viruses, and fungi (Kumar *et al*., 2017). Students, in particular, are at higher risk of microbial contamination due to their frequent use of smartphones in various settings, including classrooms, libraries, and social gatherings. Recent studies have highlighted the extent of microbial contamination of smartphones. A study conducted by Blanke *et al*. (2016) found that smartphones harbour a diverse array of bacteria, including pathogens such as *Staphylococcus aureus* and *Escherichia coli*, which are known to cause various infections. This contamination raises concerns, particularly in schools where close contact and shared resources are common. The findings showed that smartphones may facilitate the transmission of infections, like respiratory and gastrointestinal illnesses, which are prevalent among students. Moreover, the implications of these findings extend to mental health and academic performance. In another study by Ghasemian *et al.* (2020), it was found that increased exposure to pathogens, including those found on personal devices, was linked to higher rates of absenteeism due to illnesses.

This may not only affects the health of students only, but also disrupts the learning environment, leading to broader public health issue within educational institutions. Public health interventions are often informed by these insights, thus emphasizing the importance of good hygiene practices. For example, study by Soni *et al.* (2017) highlighted the effectiveness of educational campaigns aimed at promoting cleaning of smartphones. The study demonstrated that when students were educated about the potential health risks associated with dirty devices and were provided with easy access to disinfecting materials, there was a significant decrease in microbial load on smartphones. The initiative can foster a culture of hygiene among students, encouraging them to adopt regular cleaning practices as part of their routine. In another study by Raudonis *et al*. (2017), it was found that 92% of smartphones used by healthcare workers were contaminated with bacteria, including MRSA and E. coli. Similarly, a study by Akinyemi *et al.* (2018) found that 85% of smartphones used by students in a Nigerian university were highly contaminated with bacteria, including *Staphylococcus aureus and E. coli.*

Microbial contamination of smartphones has emerged as a significant public health concern due to the widespread use of smartphones and their potential to transmit pathogens from one surface to the other. Generally, smartphones serve as reservoirs for various microorganisms including bacteria, viruses, fungi, and protozoa, capable of surviving and proliferating on device surfaces. A study by Brady *et al*. (2016) show that pathogens such as *Staphylococcus aureus*, *Escherichia coli*, influenza virus, and Norovirus can survive on cellphone surfaces resulting in the spread of infections in community and healthcare settings. Understanding the extent, diversity, and sources of microbial contamination on smartphones is essential for assessing the potential health risks associated with cellphone use and developing effective hygiene interventions. Investigating the types of microbes present on smartphones, their sources of contamination, and the factors influencing the contamination levels; researchers can identify strategies to minimize microbial transmission and promote smartphone hygiene practices among users.

Methodology

Sterile cotton swabs, Sterile tubes, Sterile saline solution, Nutrient Agar & Sabouraud Dextrose Agar, Incubator, Autoclave, Microscope, Colony counter, Gram staining kits (Crystal violet, iodine, Ethanol, Safranin), Petri dishes, Inoculating loops/needles, Sterile test tubes, Glass slides and cover slips, Disinfectants (ethanol), and Smartphones. A cross-sectional study was conducted to swab the surfaces of the smartphones from fifty (50) students in Kogi State Polytechnic Lokoja, as well as gathering data on the perception of the students on the potential of smartphones as formites for pathogens. Experimental materials used were sterilized autoclave, after which the media were prepared and labeled appropriately. The cotton swabs were sterilized in saline solution, and used to swab the surfaces of each smartphones, streaked aseptically on Nutrient agar and SDA media plates. Each cultured and incubated at 37^0C for 24-48hrs, and 25-30^0C for 48-72^0C for bacteria and fungi respectively, after which the plates were observed for the morphologies of the microbes, and the colony formed were counted. At the end of the incubation, the cultured plates were observed for growth, morphology, number of colonies of microbes formed. Gram staining and biochemical tests including catalase, coagulase and oxidase were performed on 25 of the colony samples for further identification of the bacteria present. Lactophenol test was also performed for further identification of the fungi.

Results

Table 1
Demographic characteristics of participants.

Demographic	Number of participants (n =50)	Percentage (%)
Gender		
Male	30	60%
Female	20	40%
Age group		
18-20 Year	10	20%
21-26 Year	30	20%
27–31 Year	10	60%
Course of Study		
Science Lab. Tech.	25	50%
Art & Design	10	20%
Business administration	15	30%

Table 2
Average microbial load on smartphones

Types of Microorganism	Mean (CFU)
Bacteria	520
Fungi	150
Total microbial load	670

Table 3
Result of Gram staining test on the samples

Sample Id	Gram Staining Reactions	Colour Observed	Morphology	Preliminary Identification	Frequency Of Species Occurrence
1	Gram positive (+)	Purple colour	Cocci, clusters	*Staphylococcus spp.*	6
2	Gram positive (+)	Blue colour	Cocci, chains	*Streptococcus spp.*	3
3	Gram negative (-)	Pink colour	Rods, single	*Escherichia coli*	5
4	Gram positive (+)	Blue	Rods, single	*Bacillus spp.*	4

5	Gram positive (+)	Purple	Cocci, pairs	*Neisheria spp.*	3
6	Gram negative (-)	Pink colour	Rods, pairs	*Pseudomonas spp.*	4

Table 4

Catalase test table, showing number of catalase positive and negative samples.

Catalase Reaction	Frequency Of Occurrence
Catalase Positive (There's presence of bubble)	15
Catalase Negative (There's no bubble reaction)	10

Table 5

Oxidase test table, showing number of oxidase positive and negative samples

Oxidase Reaction	Frequency Of Occurrence
Oxidase - positive (presence of purple or dark color)	16
Oxidase - Negative (presence of light blue color)	9

Table 6

Coagulase test table showing number of coagulase positive and negative samples

Coagulase Reaction	Number Of Occurrence
Coagulase - Positive (A cloth was formed)	14
Coagulase - Negative (Cloth was not formed)	11

Table 7

Result showing Lactophenol Cotton Blue Stain on Fugal Isolates.

Sample Id	Morphology	Colour Observed	Preliminary Identifications	Number Of Occurrence
1	Filamentous, septate hyphae	Black/dark-brown	*Aspergillus spp.*	7

2	Hair-like/No septate hyphae, sporangia	Grayish	*Rhizopus spp.*	4
3	Round, smooth	Pale blue	*Candida spp.*	6
4	Filamentous, septate hyphae	Pink to violet	*Fusarium spp.*	3
5	Filamentous, septate hyphae	Gray	*Penicillium spp.*	5

Discussion

The demographics of the participants including gender, age and course of study were taken into consideration to ensure a representative sample of the population of the participants. As seen in table 4.1, the participants of the survey were within the age of 18-31, with those within the age of 21-26 having the highest percentage. With regard to course of study, students who are studying Science Laboratory Technology were the highest participants, and this could be attributed to their understanding of the significance of the research in relation to personal hygiene. Result of the laboratory analysis of the phones swab samples revealed the presence of many of microbes including several species of bacteria and fungi. The microbial loads counts showed a total of 670 (CFU) of microbes out of which 520(CFU) of the microbes were bacteria, while 150 (CFU) were fungi. This result agrees with the findings of Flores *et al*. (2018) and Kembel *et al*. (2014) that observed high load of bacterial and fungal growth on surfaces of desks, chairs and dormitories of college. The identification of *Staphylococcus aureus, Escherichia coli* in the samples indicated the tendency of the smartphones to transmit pathogenic bacteria, and this is in line with the research of Akinyemi *et al*. (2018) which revealed that 85% of phones used by students in a Nigeria university were contaminated; and Brady *et al*. (2016) on the prevalence of *Staphylococcus aureus and E.coli* on smartphones.

The fungi, *Candida spp*. was isolated from the growth plates, suggesting the potential of the smartphones to act as formite for pathogenic fungi, which can easily be transmitted to other individuals through food handling and contact with contaminated surfaces. This is in accordance with the findings of Vijaykumar *et al*. (2016), which highlighted the potential of smartphones to transmit fungal infection. Owing to the array of microbes found on the swab culture which include all bacteria and fungi species listed in table 3 and 7, it is evident that the phone swabs contain numerous microbes. This finding concurs with the result of Blanke *et al*. (2016) which confirms the tendency of smartphones to habour wide arrays of microbes. It is obvious from the result of this research that smartphones swabbed were

contaminated with different arrays of microorganisms usually through handling, poor hygienic conditions and lack of regular cleaning.

Conclusion

Smartphones are prone to contamination with different arrays of microorganisms, some of which have the potential to transmit infectious diseases. This pose new challenge to public health as these microbes can easily get into our body through handling or contact with food items. It is therefore imperative to educate the public on the need to maintain proper hygienic conditions in handling phones, through regular cleaning of the phones to decontaminate it using appropriate disinfectants.

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