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Degree of Microbial Contaminants Isolated from Smart Mobile Phones Used by University Students in Bangladesh

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Abstract

Background: Microbial survival capabilities on smartphone surfaces works as a major source of harmful microbial transmission among users. **Objectives:** This study sought to determine the microbial growth on the surface of smartphones, used by students of Jahangirnagar University in Bangladesh. **Methodology:** This cross-sectional study, from May to August 2021, involved 20 students, where 8 (40%) were females and 12 (60%) were males. The socio-demographic data and information about their phone usage were collected utilizing a self-administered questionnaire. A sterile swab was rotated over the surface of both sides of each smartphone, and moistened with sterile saline. All swabs were cultured on MacConkey Agar and Nutrient Agar and examined for growth. Plates were incubated aerobically at 37^0C for 48h and identification was done as per standard laboratory procedures. **Results:** Out of the total 20 swab samples collected, 16 (80%) of them presented with bacterial growth, and 10 (50%) of them presented with fungal growth. Gram-positive bacteria occurred on smartphones at 89.7%, whereas Gram-negative bacteria were contaminated at 10.03%. The total frequency of one or several micro-organisms on smartphones was 100%. The predominant isolates were Staphylococcus epidermidis (37.1%) and Staphylococcus aureus (37.1%). Other isolates were Klebsiella sp. (5.7%) and Escherichia coli (2.9%). No significant association was found between smartphone contamination and gender, age group, educational level, phone sharing, presence of scratches, use of front cover, and regular cleaning of smartphones. **Conclusion:** The study indicated that smartphones used by students are a vehicle for several microorganisms. According to the findings of this study, smartphones have the potential to act as a mode of transportation for various micro-organisms. [*Bangladesh Journal of Infectious Diseases, December 2024;11(2):108-114*]

Keywords: Smartphones; microorganisms; bacteria; students; contamination

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Introduction

Smartphones are an essential addition to life in today's world. University students use their smartphones daily and most of the time while eating food, talking with friends, before sleep and even in washrooms for watching reels. By constant hand contact, smartphones can spread infectious diseases[1] and act as micro-organism reservoirs[2]. *Escherichia coli*, commonly known as the fecal coliform bacteria typically found in the intestine of humans, is by far the most prominent bacterium on the surface of the smartphone[3].

The smartphones we often hold with clean or unclean hands may result in possible danger such as microbial transmission[3]. Previous studies indicated that micro-organisms flourish with humidity, moisture, and temperature[4]. Bacteria cells can easily stick to mobile phone surfaces, and structured colonies can form[5]. Many microbes may be transmitted to smartphone glass touchscreens by users' hands[6-7] and bidirectionally, making the touchscreens possible carriers of microbiota[8]. Transferred microbes can induce diseases, especially in persons with weakened immune systems, such as children and older adults[7]. Fungus can transfer to the people with suppressed immune system, cause opportunistic infections and mild to chronic disease. Similarly bacteria migrate to the ears and faces of the smartphone from the surface of the hands to infect any cuts or open wounds or even other individuals who interact with each other after washing[5]. This can harm vulnerable populations such as children or older adults of the family.

However, determining the bacterial presence and type that contaminates smartphones of students from Jahangirnagar University, Bangladesh, maybe a foundation for any initiatives on public awareness of the health hazards of contaminated smartphones and will be a significant step in the right direction. Also, findings can be used as an indication for formal hygiene practices that would eventually help prevent harmful pathogens from spreading within academic settings. Moreover, the results might also inspire future investigations on microbial contamination of other multiple-user devices, such as computer keyboards, tablets, and public touchscreens, to ensure a broader understanding of their impact on public health with guiding protocols to promote safe smartphone usage among students and the general population, encouraging health-conscious behavior in digital environments. This study aimed to experiment on various smart devices of students by isolating and diagnosing the microbial contaminants and identifying the most predominant microbial species associated with these devices to take the appropriate remedial actions.

Methodology

Study Location and Population: This cross-sectional study was conducted among the residential students of Jahangirnagar University in Bangladesh from May 2021 to August 2021. A total of 20 smartphones were conveniently sampled from students: 8 female students and 12 male students. The laboratory analyses were undertaken in the Department of Public Health and Informatics laboratory, Jahangirnagar University, Savar, Bangladesh.

Data Collection: A questionnaire was developed inquiring about socio-demographic variables like age, gender, education and smartphone use behavior like frequency and purpose for use, brand of smartphone, habit of smartphones cleaning, presence of scratches, use of front cover, and the duration of smartphone use.

Sample Collection: Swabs from the investigated surfaces of 20 smartphones were collected by thoroughly rotating sterile cotton swabs moistened with normal saline on the smartphone's surface and back, including the touch screen and both sides of the phone. The swab was obtained from the outside surfaces of the cover, in the case of smartphones with covers. To avoid cross-contamination, the researcher's hands were disinfected with an alcohol-based quick hand sanitizer before taking a swab, and powder-free disposable gloves were worn per sample throughout the procedure. The swab was immediately placed into 1 mL sterile normal saline in a sterile container to keep the bacteria viable. The samples were temporarily placed in a cool box maintained at 4^0C and transported immediately to the Laboratory of the Department of Public Health and Informatics, Jahangirnagar University.

Sample Processing: Nutrient agar and MacConkey agar were used to evaluate the microbial load in samples using the spread-plate technique. The swabs were placed onto the prepared culture media when they arrived at the lab, where Nutrient Agar and MacConkey Agar were streaked with a loop of the suspension. After that, the streak plates were incubated at 37°C for 48 hours before being examined for bacterial growth.

Identification of Bacteria: Colonies from primary cultures were extracted and used for carrying out biochemical tests for the identification using morphological descriptions of colonies, gram staining, motility tests, and biochemical assays (catalase and coagulase test) in accordance with standard methods. In addition to the culture tests, microscopic examinations were performed to determine pure bacterial cultures. Compressed drop technique was used to monitor the motility of bacteria.

Statistical Analysis: The Microsoft Office Excel 2013 was used for data entry and analysis. Using Statistical Package for Social Sciences (SPSS) version 22, the relationship between microbiological

contamination of device surfaces and user habits reported in the surveys was statistically analyzed using Fisher's exact test. The difference was considered statistically significant if the attained level of significance (p-value) was less than 0.05. Descriptive statistics were calculated for various variables, such as mean, frequency, and percentage. A fraction of smartphone samples that had bacterial isolates were tested using a culture test to calculate the extent of mobile bacterial contamination.

Ethical Clearance: The individuals who participated in the study gave their informed written consent. Ethical approval was taken from the Biosafety, Biosecurity & Ethical Committee of Jahangirnagar University.

Results

A total of 20 students participated in this study, where 8 (40%) were females and 12 (60%) were males, ranging from 20 to 27 years old. In this study, only 4 (20%) participants were less than 24 years old and 16 (80%) participants were above or equal to 24 years old (Table 1).

Table 1: Socio-demographic characteristics of students

Characteristics	Values
Age Mean (± SD)	24.7 (± 2.003)
Sex Ratio (12 Males: 8 Females)	1.5
Level Of Education	
• Honors	12 (60.0%)
• Masters	8 (40.0%)
Faculty	
• Mathematical & Physical Sciences	4 (20.0%)
• Arts & Humanities	3 (15.0%)
• Biological Sciences	9 (45.0%)
• Social Sciences	4 (20.0%)

Among 60% of study participants who shared their smartphones, only 5% shared those for work purposes with others. About 20% shared their phones with their families to view pictures or interesting news, and 40% with friends for study purposes (Figure I).

The most common use of smartphones was surfing the internet(100%) and making or receiving calls(100%). Most of the participants indicated that they use their smartphones to capture, send, and receive photographs and record, send, and receive videos. In addition, individuals indicated using social networking websites(95%), taking notes(60%) for studying or lectures, playing games(55%) and reading newspapers(35%). A few participants(15%) indicated that they use their phones to maintain time when they don't have a watch (Figure II).

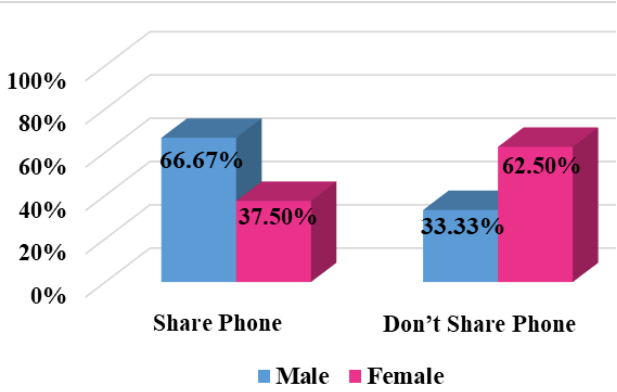

Figure I: Relation between Gender and Sharing Phone

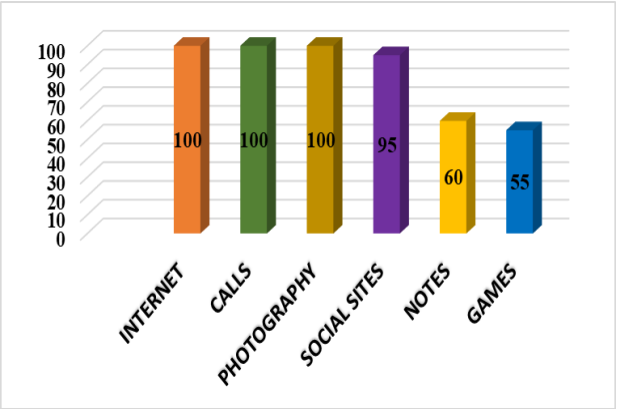

Figure II: Distribution (%) of the Purpose of Using Smartphone

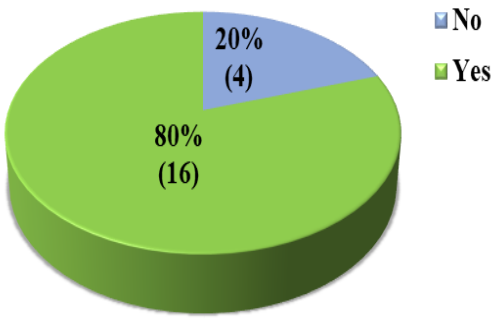

Figure III: Distribution (%) of Gender-based Cleaning Status

In this study, 75% of female students clean their smartphones regularly, which is higher than the male students cleaning habit (58.33%). Only 65% (13) of

students said they wash or sanitize their cell phones on a daily basis. The cleaning method was described as wiping the surface with moist cloths, personal clothes, tissue, and hand sanitizer, among other things. All of the students claimed they clean their phones by breathing on the device's surface and rubbing it on their clothes. No statistically significant differences were observed (p-value> 0.05) between the gender of students and their cleaning status (Figure III).

Out of the total 20 swab samples collected, 16(80%) of them presented with bacterial growth, whereas the remaining 4 (20%) of the swabs had no bacterial growth after 48 hours of incubation (Figure IV).

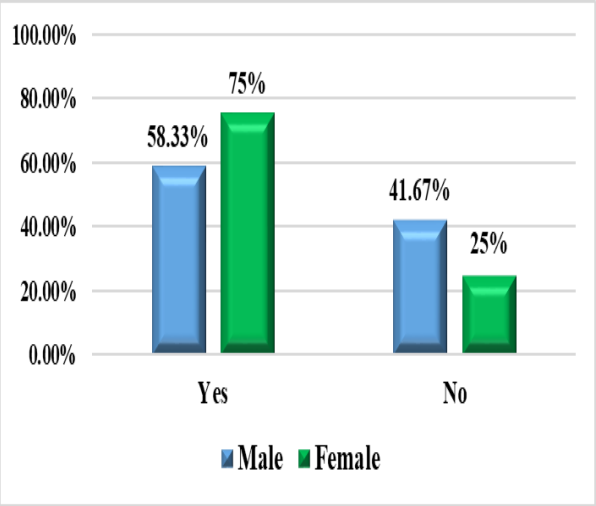

Figure IV: Distribution (%) of bacterial growth from the sampled smartphones

Of 16 samples that showed bacterial growth, only 3 (10.3%) were Gram-negative, while 13 (89.7%) were Gram-positive. The presence of Gram-negative bacteria on the smartphones of male and female students differed slightly but was not statistically significant (p > 0.05).

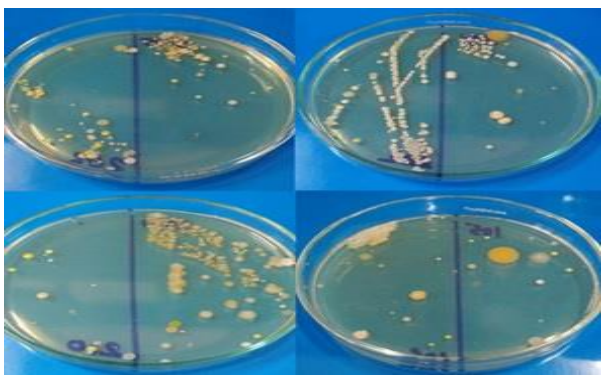

Figure V: Bacterial colonies on Nutrient agar following direct smartphone inoculation

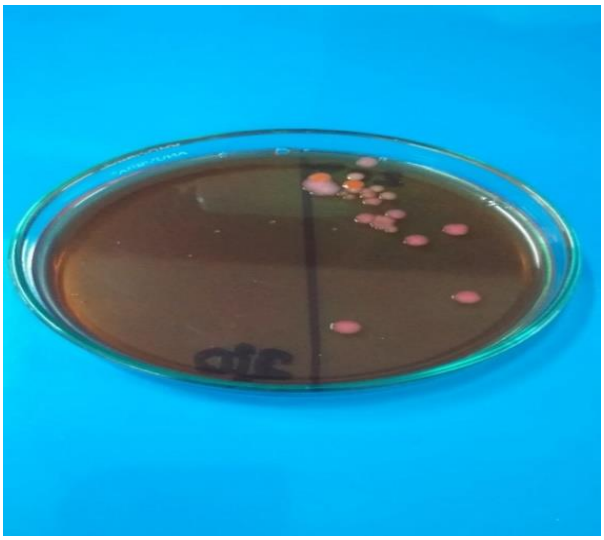

Figure VI: Different types of bacterial colonies on MacConkey agar

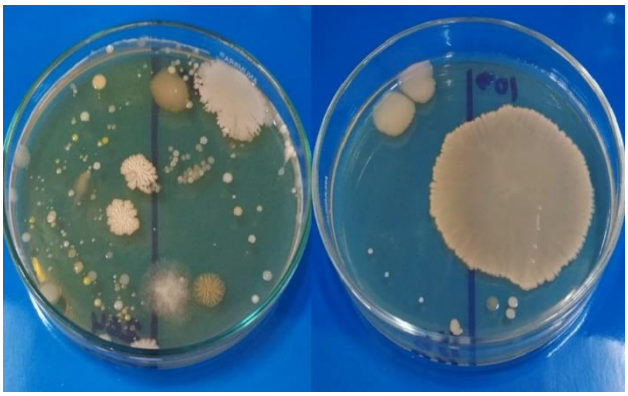

Figure VII: Different Types of Fungal Growth

This research identified at least one or more bacteria species in 16 out of 20 smartphones sampled. Bacteria are categorized based on their morphology. Cocci (spherical-shaped bacteria) and bacilli (rod-shaped) are the two major types of bacteria.

Out of the total 20 swab samples collected, 10 (50%) presented with fungal growth whereas the remaining 10(50%) had no fungal growth after 48 hours of incubation.

Table 2: Percentage of bacteria isolated from university students' smartphones

Bacterial isolates	Percent
Escherichia coli	2.9
Klebsiella	5.7
Staphylococcus epidermidis	37.1
Staphylococcus aureus	37.1

According to the research findings, the most common bacterial isolates linked with smartphones

are Staphylococcus aureus, Staphylococcus epidermidis, E. coli, and Klebsiella, as shown in Table 2. Colonies were isolated by their color. The Catalase, Coagulase, Gram Staining, and Motility tests were used to identify isolated colonies. Pink color colonies were detected when the isolates were grown on Mac-Conkey agar, which was identified as E. coli and Klebsiella in biochemical tests. The majority of our isolates tested positive for catalase.

Table 3: Association between Study Variables and Smartphone Contamination

Variables	Mobile Phone Contaminated		
	Yes	No	Total
Gender			
• Male	9(75%)	3(25%)	12(60%)
• Female	7(87.5%)	1(12.5%)	8(40%)
Share Smartphone			
• Yes	10(83.3%)	2(16.7%)	12(60%)
• No	6(75%)	2(25%)	8(40%)
Regularly clean smartphone			
• Yes	10(76.9%)	3(23.1%)	13(65%)
• No	6 (85.7%)	1(14.3%)	7(35%)
Use Front Cover			
• Yes	13(81.3%)	3(18.8%)	16(80%)
• No	3 (75%)	1 (25%)	4 (20%)
Presence of Scratches			
• Yes	11(91.7%)	1 (8.3%)	12(60%)
• No	5(62.5%)	3(37.5%)	8(40%)

When male and female students' mobile phones were compared, contamination was slightly higher in the smartphones of male students than in female students. However, the difference was not statistically significant (Fisher's Exact Test: $p > 0.05$).

A high rate of contamination (83.3 %) was found in phones that were reported to be shared among friends, family, or others (Fisher's Exact Test: $p > 0.05$). According to the data collected from the students, 65% (13/20) of the students regularly clean their phones with tissues, clothing, hand sanitizer, and so on.

The occurrence of contamination was not significant (Fisher's Exact Test: $p > 0.05$) in the smartphones that were stated to be cleaned regularly. Although there were small variations, statistically significant differences were not found (Fisher's Exact Test: $p > 0.05$) between the occurrence of various species of bacteria and the presence of front cover or scratches on the phone or the phone age (Table 3).

Discussion

Smartphones can potentially act as a mode of transportation for various micro-organisms. Our study found that all of the smartphones under examination were contaminated with a variety of micro-organisms, the majority of which belonged to the human body's natural flora and fungus. The present study revealed the common bacteria isolated from the smartphones were *E. coli* (2.9%), *Klebsiella* (5.7%), *Staphylococcus epidermidis* (37.1%), and *Staphylococcus aureus* (37.1%). Similarly, The most common bacteria isolated from smartphones in a study by Oguz Karabay was *Staphylococcus epidermidis*[9].

This study found that these smartphones enhance the chance of microbiological contamination by pathogenic micro-organisms. These devices might become major routes of transmission for diseases that can lead to illness[9-10]. Students' smartphones contained the most diversity of micro-organisms and the greatest contamination rates (65.35%)[11].

This investigation identified Gram-positive bacteria more frequently (89.7%) than Gram-negative bacteria (10.3%). Previously, similar findings have been revealed by Arora et al[12] and Zakai et al[13]. Gram-positive bacteria make up the majority of the normal microbial skin flora; this explains their prevalence on smartphones[14].

The Gram-positive bacteria isolated from the smartphone's surface was Staphylococcus aureus, with 37.1% constituting the highest prevalence among all the isolates obtained. These findings are consistent with previous research, including one conducted in Nigeria that found Staphylococcus aureus to have the highest frequency of 30.2%[15], 26.2% in Ethiopia[16], and 28.4% in Cameroon[17]. Amongst the Gram-negative in our study, *Klebsiella* (5.7%) was the most prevalent isolate. Gram-negative rod, *E. coli* (2.9%) on smartphones suggests the potential for fecal contamination. E.coli and *Klebsiella* spp. are the most frequent bacteria that cause gram-negative sepsis[18]. In another study, the proportion of *E. coli* isolated from smartphones was found to be 28.2%, slightly higher than ours[19].

The overall implication of these results is that smartphones facilitate and make communications easier and also constitute ideal carriers of disease transmission pathogens. If no attention is given, they can be biological weapons transmitters[20]. Simple cleaning of smartphones with 70.0% isopropyl alcohol may help to reduce bacterial burden[20]. To

propose conventional cleaning procedures, more research utilizing various solutions for decontamination of smartphones is needed.

As we accept the new normal and live with COVID-19, hand hygiene has become essential to our daily routine. Although people frequently wash their hands, our study shows substantial microbiological contamination. So, we can say that washing hands many times a day is not enough. One should also clean the phone, which is an extension of one's hand and a breeding ground for microorganisms.

A limitation of this study concerns the recruitment method for students to participate in the interviews and their phones to collect samples during the COVID-19 pandemic. The study does not investigate the impact of period variations. The limited sample size makes it difficult to comprehend students' actual practice and do further multivariable analyzes to determine the influence of certain parameters on contamination by smartphones.

Conclusion

The findings in this study indicated the potential of smartphones to be a carrier for many micro-organism strains. This study also showed that Staphylococcus aureus was the most predominant bacteria found contaminating smartphones. Other bacterial contaminants included Klebsiella, E. coli, and Staphylococcus epidermidis. Engineering changes, such as using easy-to-clean surfaces and surfaces that prevent micro-organisms from being transferred through direct touch with the phone's surface, should be incorporated as a control measure. Companies that manufacture smartphones should provide a guidelines to disinfect smartphones. All preventative measures should be taken to limit these sorts of contaminations while keeping in mind the inevitable usage of smartphones.

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Conflict of Interest
None

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Contribution to authors:
All of the listed authors have reviewed and approved the manuscript. The individual contribution of the authors is given herewith: Ishrat Anzum Nabila: Conceptualization; Methodology; execution; Investigation; Data collection; laboratory processing; Formal analysis and Interpretation; Writing- original draft; Writing- review and editing; Tasnima Akhter Tasin: Data collection; Writing- original draft; Writing- review and editing; Jobaida Saba: Formal analysis and Interpretation; Writing- original draft; Writing- review and editing; Most. Zannatul Ferdous: Conceptualization; Methodology; Supervision; Reviewing and revising and editing.

Data Availability
Any questions regarding the availability of the study's supporti ng data should be addressed to the corresponding author, who can provide it upon justifiable request.

Ethics Approval and Consent to Participate
The Institutional Review Board granted the study ethical approval. Since this was a prospective study, every study participant provided formal informed consent. Each method followed the appropriate rules and regulations.

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