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MICROBIAL CONTAMINATION AND ANTIMICROBIAL RESISTANT PATTERNS OF MOBILE PHONES USED BY HEALTH WORKERS AND STUDENTS IN OKADA, EDO STATE NIGERIA

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ABSTRACT

Mobile phones are widely used in healthcare and academic environments and may serve as reservoirs for pathogenic microorganisms associated with hospital-acquired infections (HAIs). This study investigated the microbial contamination and antimicrobial resistance patterns of microorganisms isolated from mobile phones used by health workers and students in Igbinedion University and the Igbinedion University Teaching Hospital.

A total of 200 mobile phones were sampled, comprising 100 from students and 100 from health workers. Sterile swab sticks were used to collect samples from the speaker and back surfaces of phones, after which microbiological analysis, colony count determination, and biochemical identification were performed using standard microbiological methods. Antimicrobial susceptibility testing was also carried out on recovered isolates.

The predominant isolates recovered were *Staphylococcus aureus*, *Staphylococcus epidermidis*, *Escherichia coli*, *Klebsiella* spp., *Bacillus* spp., mold, and *Pseudomonas aeruginosa*. Female health workers showed significantly higher prevalence of *E. coli* contamination compared to males (60% vs 20%; p = 0.008), while male students demonstrated significantly higher prevalence of *S. aureus* contamination (80% vs 44%; p = 0.004). Male participants generally exhibited higher microbial colony counts across most isolates. Antimicrobial susceptibility testing revealed high resistance among *S. aureus* isolates, particularly against cefixime, amoxicillin-sulbactam, and ciprofloxacin, indicating multidrug resistance tendencies. In contrast, ofloxacin and levofloxacin demonstrated near-complete effectiveness against most isolates.

The study demonstrates that mobile phones used by students and health workers harbor potentially pathogenic and multidrug-resistant microorganisms capable of contributing to healthcare-associated and community-acquired infections. Regular hand hygiene, routine disinfection of mobile phones, and strict infection prevention practices are therefore recommended to minimize microbial transmission.

Keywords: antimicrobial resistance, health workers, mobile phones, multidrug resistance, microbial contamination

Introduction

Electronic devices have become one of the most essential accessories being used in hospitals, homes and have become part of man's daily companion. Mobile cell phones has expanded rapidly on a global scale and has brought numerous changes in the daily lifestyles of individuals (Glenton et al., 2024). The use of electronic devices increases the communication as well as making health-care delivery more efficient and effective (Trinh *et al*., 2025). Inspite of this being a communication tool among health care workers and the community at large, these devices represent a potential reservoir and source for transmission of infectious agents in clinical settings (Habyarimana *et al*.,2020) as a result of constant handling of mobile phones by users in hospitals (by patients, visitors and Health- care workers (HCWs). This is especially so with those associated with the skin colorizationt due to the moisture and optimum temperature of human body especially our palms (Mushabati *et al.,* 2021). These factors and the heat generated by mobile phones contribute to harboring bacteria on the device at alarming levels. Unlike the hands, which are easily disinfected using alcohol-based hand rubs (ABHRs) that are made available readily across all hospitals and medical facilities, our mobile phones are cumbersome to clean. We even rarely make an effort to disinfect them (Tusabe et al., 2023). Healthcare professionals working in critical areas as intensive care units (ICUs) and operating units are highly exposed to micro-organisms, while those working in culture laboratories may even accidental enhance spread by having contacts with potential pathogens (Bhandari et al., 2025), these vehicular means of transmission may serve as vectors and spread microorganisms wherever they are taken along (Hikmah, N.and Anuar,(2020)) and be transmitted to patients even if patients do not have direct contact with mobile phones (Alnasser *et al*., 2025). The rapid spread of multidrug-resistant (MDR) pathogens in critical care settings creates a life-threatening crisis. Because these organisms survive routine treatments, critically ill patients face drastically elevated risks of prolonged illness, sepsis, and mortality, while clinicians are left with few to no effective drug (Salam *et al*., 2023).
This study is aimed at determining microbial and distribution associated with Hospital acquired infections (HAIs) via smart phones.

Study area

The study was conducted in Okada, Ovia N.E. local government area of Edo state from June 20 to August 2, 2023. The area has a land mass of about 2,354.24 sq. Km, and a population of about 122,107 NPC, 2012. Geographically, it lies on latitude 7^0N and longitude 5^0N. The climatic condition of the district is hot and the annual temperature is estimated to be between 35°C and 41°C. The Annual range of rainfall in the district is 900–1200mm.

Study design

The study was carried out in the Medical Laboratory Science Department, Igbinedion University Okada Edo State, Nigeria from July to August 2023. Approval for the study was given by the Health Research and Ethics Committees (HREC) of Igbinedion University Teaching Hospital, Okada in accordance with the code of ethics for biomedical research involving human subjects. Consent to and rights to participate or refuse to participate in the study was acknowledged as explanation was made in simple understanding terms. Socio-demographic data such as age, gender and status of each participants were extracted by a semi-structured questionnaire. Information regarding the type of mobile phones used, a span of use by the users, the practice of handling the mobile phones such as disinfection, place of storing (if not in use) and their use in convenience such as toilets, bathrooms, kitchen or laboratory were also noted.

Sample size determination

The sample size was determined using the Slovin's formula (Jaykaran & Tamoghna, 2013) using a 5% margin of error

$$n = \frac{N}{1+N\,d^2}$$

Where:
n = number of samples
N = Total population (Students currently engaged with Clinical/ lab posting) is 500
d = margin of error (Standard value = 0.05)
$n = 300 / 1 + (300)0.05^2$
= 300/1 + (300) 0.0025
= 171
However, 200 mobile phones from health workers was utilised for the study.

Ethical consent

Ethical approval for this study was obtained from the Ethics and Research Committee of the Igbinedion University Teaching Hospita Okadal with ethical approval number: **IUTH/ETHIC/07/2024.**
Participation in the study was voluntary, and informed consent was obtained from all participants prior to sample collection. Confidentiality and anonymity of participants' information were strictly maintained throughout the study in accordance with established ethical guidelines for biomedical research

Sample Collection and Processing

A total of 200 mobile cell phones were swabbed out of which 100 belonged to students and 100 for health workers. The hearing (speaker) and the back regions of the mobile cell phones were swabbed using sterile swab sticks. The swab samples were immediately placed in sterile airtight containers and transported to the laboratory. Microbiological examination of all samples collected was conducted. Briefly, swab sticks were dipped in 1.0 mL sterile saline water and inoculated on the following culture media: Nutrient agar, MacConkey agar, Mannitol Salt Agar, and Sabouraud dextrose agar using serial dilutions of 1:10, 1:100, 1:1000, 1:10000 and 1:100000. The culture plates were then incubated at 37°C for 48 hrs (Forbes et al., 2007).

Preparation of dilutions

Onto sets of sterile test tube , labeled 1-6,9 ml of sterile distilled water was added to
all tube
1ml of the well mixed suspension of phone swab saline solution was added to tube
1 to obtain a 1:10 dilution
1 ml from tube 1 was transferred to tube 2 to obtain 1:100.
1ml from tube 2 was transferred to tube 3 to obtain 1:1000
This procedure was done to all tubes obtain final dilutions of 1:10000, 1:100000 respectively

Bacterial Count and Identification of Isolates

Immediately, after incubation, the plates were checked for bacterial growth and counted using a colony counter and expressed as colony-forming units per millilitre (CFU/mL). Isolates were identified by colony morphology, arrangement, size and color as described by Barry (2012). The isolates were further subjected to Gram staining reaction and appropriate biochemical test as described by Cheesebrough, (2006)

Statistical Analysis

Descriptive statistics were used to present the socio-demographic information and bacterial count analysis. The results were presented in tabular form and analysed using percentile and SPSS version 20.0.

A total of 100 health workers and 100 students comprising of equal ratio for gender in both categories of participants. The prevalence of Escherichia coli was significantly higher in females than male (Male vs Female: 20% vs 60%: p =0.008). (Table 1) The risk for acquisition of Klebsiella species in male and female was equal (0R=1.000). Males were observed to have over twenty times higher risk (OR=24.771) of being colonized with Bacillus spp, with this risk reaching statistically significant proportion (P=0.004)

The prevalence of *Staphylococcus aureus* was higher in males than females. The risk for *Staphylococcus aureus* colonization in males although not statistically significant (P= 0.114) was over three times higher (OR= 3.500) in males than females. More female (72%) was found to harbor *Staphylococcus epidermidis* than male (56%), As was the case with *Staphylococcus aureus*, the difference was not statistically significant (P= 0.377).

Males had over four times higher risk (OR=4.571) of being colonized with Bacillus spp, than female counterparts, albeit the difference was not statistically significant (P=1.000)

Table 2 shows the distribution of student's phone with respect to gender. N- Number of subjects, n- number of positive cases, OR-odd ratio, and CI- confidence interval.

An insignificant (P = 0.356) higher number of female participants were observed to harbor Escherichia coli (Male vs. Female: 20% vs 30%), as was also the case with Bacillus Specie (Male vs Female: 40% vs 48%; P=0.545). However, the converse was the case with Klebsiella specie, where more males were found to harbor the bacterium than female (Male vs Female: 20% vs 16%), albeit the difference was statistically insignificant.
Male participants were observed to have over a five times significant higher risk of being colonized with Staphylococcus aureus than their female counterparts (Male vs female 80% vs 44%, OR= 5.091. P=0.004). Similarly, a significantly higher number of females were observed to be colonized with Staphylococcus epididymis than males (Male vs Female: 16% vs 60%; P <0.0001)
The prevalence of mold in male subjects was significantly higher than figure recorded in female subjects, the risk being over one hundred time higher in males than females (OR=101.00; P <0.0001)

Results

Table 1 shows the distribution of microbial isolates recovered from health workers according to gender. A statistically significant association was observed between gender and the isolation of *Escherichia coli* (OR = 0.167; 95% CI: 0.047–0.590; p = 0.008). Female health workers had significantly higher isolation rates of *E. coli* (60.0%) compared to males (20.0%). The odds ratio below 1 indicates that males were less likely to harbor *E. coli* isolates than females.

Similarly, isolation of *Bacillus* spp. was significantly associated with gender (OR = 24.771; 95% CI: 1.340–457.940; p = 0.004), with isolates recovered only among male participants (32.0%) and none among females. The large odds ratio and wide confidence interval suggest a strong but unstable association, likely influenced by the zero count among females.

Although *Staphylococcus aureus* was more prevalent among males (40.0%) than females (16.0%), the association was not statistically significant (p = 0.114). Likewise, no statistically significant gender differences were observed for *Klebsiella* spp. (p = 1.000), *Staphylococcus epidermidis* (p = 0.377), mold isolates (p = 0.074), or *Pseudomonas aeruginosa* (p = 1.000), indicating that the distribution of these organisms did not differ significantly between male and female health workers.

Table 2 presents the distribution of microbial isolates recovered from students' phones according to gender. A statistically significant association was observed between gender and the isolation of *Staphylococcus aureus* (OR = 5.091; 95% CI: 2.090–12.399; p = 0.004). Male students showed a significantly higher prevalence of *S. aureus* contamination (80.0%) compared to females (44.0%), suggesting that males were approximately five times more likely to harbor the organism.

A highly significant association was also observed for *Staphylococcus epidermidis* (OR = 0.127; 95% CI: 0.049–0.327; p < 0.001), with females demonstrating a markedly higher prevalence (60.0%) than males (16.0%). The odds ratio below 1 indicates lower odds of isolation among male students.

Mold contamination was significantly associated with gender (OR = 101.000; 95% CI: 5.902–1728.300; p < 0.001), as mold isolates were recovered exclusively from male students' phones (50.0%) and absent among females. The extremely high odds ratio and broad confidence interval suggest a strong association, though the estimate may be unstable due to the zero count among females.

No statistically significant associations were found between gender and the isolation of *Escherichia coli* (p = 0.356), *Klebsiella* spp. (p = 0.795), or *Bacillus* spp. (p = 0.545), indicating comparable distribution of these organisms between male and female students.

Table 3 compares the mean microbial colony counts and distribution of isolates recovered from health workers according to gender. Overall, male participants demonstrated higher microbial loads and higher frequencies of isolation compared to females across most organisms.

A statistically significant difference was observed in the mean colony counts of *Staphylococcus aureus* between male and female health workers (p = 0.004), with males exhibiting substantially higher bacterial loads (28.461 ± 4.946 $\times 10^3$ CFU/ml) compared to females (17.136 ± 3.563 $\times 10^3$ CFU/ml). This indicates a higher level of contamination among male health workers for this organism.

Similarly, *Staphylococcus epidermidis* showed a highly significant difference between genders (p < 0.001), with males having higher mean colony counts (26.125 ± 5.515 $\times 10^3$ CFU/ml) compared to females (16.589 ± 5.281 $\times 10^3$ CFU/ml). This suggests a gender-related variation in colonization or contamination levels.

Mold isolates also demonstrated a statistically significant association (p < 0.001), with isolates detected in males (n = 25) and only one occurrence in females (n = 1), indicating a markedly higher fungal contamination burden among male participants.
Although higher mean colony counts were observed in males for *Escherichia coli*, *Klebsiella* spp., and *Bacillus subtilis*, the differences were not statistically significant (p > 0.05). This suggests that gender did not significantly influence the colony counts of these organisms in these cases.

Table 4 presents the distribution and mean colony counts of microbial isolates from students' cell phones according to gender. Males generally exhibited higher microbial loads than females across most isolates.

A statistically significant difference was observed in *Escherichia coli* contamination (p = 0.0001), with males showing significantly higher colony counts (27.8 ± 2.00 $\times 10^{-3}$ CFU/ml) compared to females (7.2 ± 0.80 $\times 10^{-3}$ CFU/ml). This suggests greater bacterial burden on male students' phones.

Similarly, *Staphylococcus aureus* showed a statistically significant difference (p = 0.0043), with males having markedly higher colony counts (43.8 ± 4.26 $\times 10^{-3}$ CFU/ml) than females (7.67 ± 2.52 $\times 10^{-3}$ CFU/ml).

A highly significant difference was also observed in *Staphylococcus epidermidis* contamination (p < 0.0001), where male students had substantially higher colony counts (50.42 ± 8.42 $\times 10^{-3}$ CFU/ml) compared to females (11.76 ± 1.72 $\times 10^{-3}$ CFU/ml).

Although males had higher mean counts for *Klebsiella* spp., the difference was not statistically significant (p = 0.299), indicating comparable contamination levels between genders for this organism.

Bacillus spp., Mold, and *Pseudomonas aeruginosa* were not statistically analyzed (ND) due to absence or very

low occurrence in one group, limiting comparative statistical testing.

Figure 1 is the heat map illustrating the percentage resistance patterns of bacterial and fungal isolates against a panel of antimicrobial agents**.** Overall, *Staphylococcus aureus* demonstrates the highest and broadest resistance profile, particularly against CF (35%), AS (34%), CP (30%), and PT (22%), suggesting a notable multidrug-resistant tendency among this isolate.

Escherichia coli and *Klebsiella* spp. show moderate resistance levels (approximately 10–22%)**,** with comparatively lower resistance to most agents. *Staphylococcus epidermidis* also exhibits moderate resistance, with peaks observed against CF (28%) and TE (28%), indicating selective resistance to certain antibiotics.

In contrast, *Pseudomonas* spp. shows no detectable resistance across all antibiotics tested, although this finding should be interpreted cautiously due to the very small sample size (n = 1). *Bacillus* spp. demonstrates generally low resistance levels (0–8%), with complete susceptibility to some agents such as CR. Notably, antibiotics such as OF and LE show near-complete effectiveness across all organisms, with 0% resistance recorded, indicating strong therapeutic potential.

Table 1: Distribution of microbes in phones of health care workers

Isolate	Male (n = 50) N (%)	Female (n = 50) N (%)	OR	95% CI	P-value
Escherichia coli	10 (20.0)	30 (60.0)	0.167	0.047–0.590	0.008*
Staphylococcus aureus	20 (40.0)	8 (16.0)	3.500	0.920–13.311	0.114
Klebsiella spp.	4 (8.0)	4 (8.0)	1.000	0.129–7.721	1.000
Staphylococcus epidermidis	28 (56.0)	36 (72.0)	0.494	0.152–1.607	0.377
Bacillus spp.	16 (32.0)	0 (0.0)	24.771	1.340–457.940	0.004*
Mold	8 (16.0)	2 (4.0)	4.571	0.472–44.195	0.074
Pseudomonas aeruginosa	2 (4.0)	0 (0.0)	3.122	0.121–80.455	1.000

Table 2: Distribution of Isolates Recovered from Students' Phones According to Gender

Isolate	Male (n = 50) n (%)	Female (n = 50) n (%)	OR	95% CI	P-value
Escherichia coli	10 (20.0)	15 (30.0)	0.583	0.233–1.464	0.356
Staphylococcus aureus	40 (80.0)	22 (44.0)	5.091	2.090–12.399	0.004*
Klebsiella spp.	10 (20.0)	8 (16.0)	1.313	0.471–3.661	0.795
Staphylococcus epidermidis	8 (16.0)	30 (60.0)	0.127	0.049–0.327	<0.001*
Bacillus spp.	20 (40.0)	24 (48.0)	0.722	0.327–1.596	0.545
Mold	25 (50.0)	0 (0.0)	101.000	5.902–1728.300	<0.001*

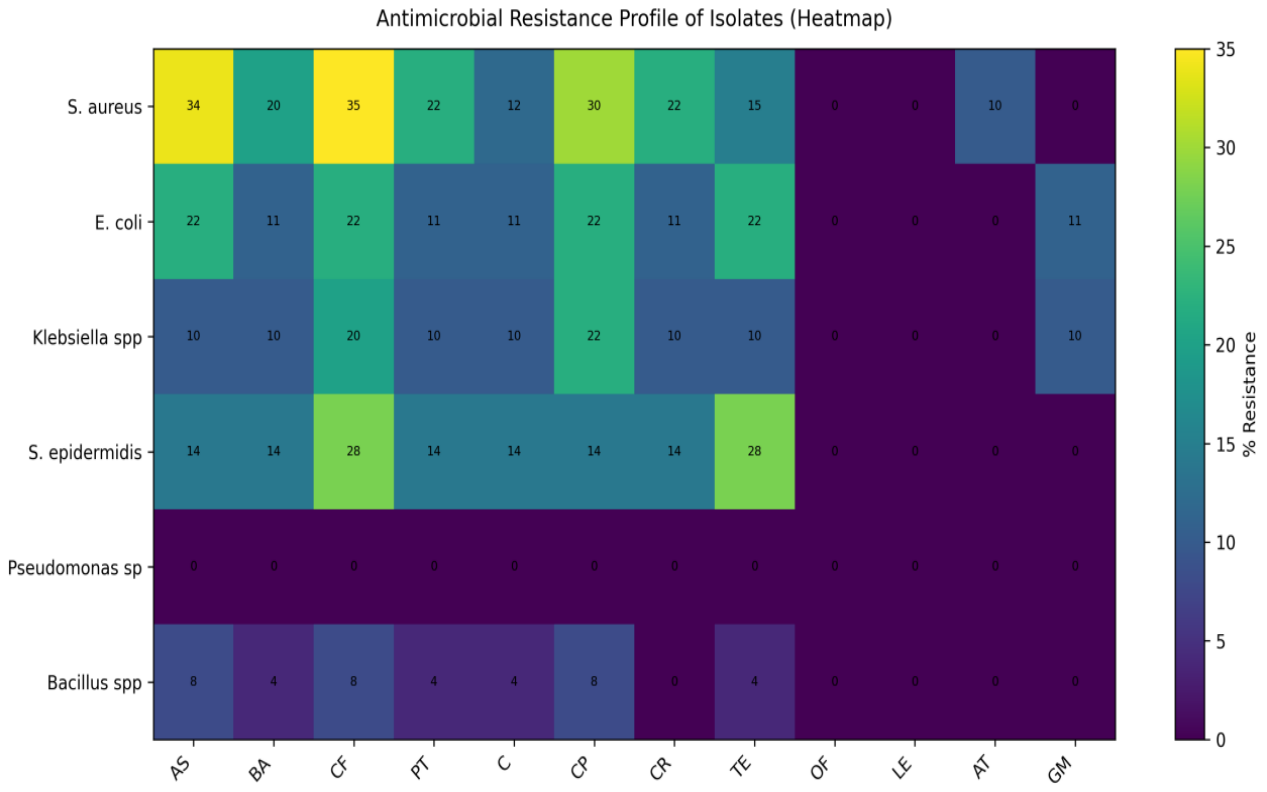
Table 3: Distribution of Isolates from Health Workers Showing Mean Colony Count

Isolate	Male Mean Count ($\times 10^3$ CFU/ml)	Male n	Female Mean Count ($\times 10^3$ CFU/ml)	Female n	P-value
Escherichia coli	13.45 ± 1.293	11	6.571 ± 2.243	15	0.356
Staphylococcus aureus	28.461 ± 4.946	39	17.136 ± 3.563	4	0.004*
Klebsiella spp.	4.54 ± 1.214	11	1.625 ± 0.517	2	0.795
Staphylococcus epidermidis	26.125 ± 5.515	8	16.589 ± 5.281	18	<0.001*
Bacillus subtilis	10.263 ± 3.331	19	5.958 ± 3.000	0	0.545
Mold	1.32 ± 0.477	25	0	1	<0.001*

Table 4: Distribution of Isolates from Students' Cell Phones Showing Mean Colony Count

Isolate	Male n	Male Mean ± SD ($\times 10^{-3}$ CFU/ml)	Female n	Female Mean ± SD ($\times 10^{-3}$ CFU/ml)	P-value
Escherichia coli	10	27.8 ± 2.00	15	7.2 ± 0.80	0.0001*
Staphylococcus aureus	20	43.8 ± 4.26	3	7.67 ± 2.52	0.0043*
Klebsiella spp.	4	10.5 ± 0.71	2	2.0 ± 1.41	0.299
Staphylococcus epidermidis	28	50.42 ± 8.42	18	11.76 ± 1.72	<0.0001*
Bacillus spp.	16	14.0 ± 7.23	0	ND	ND
Mold	8	6.25 ± 2.06	1	4.0	ND
Pseudomonas aeruginosa	2	4.0	0	ND	ND

Figure 1 showing heatmap of antimicrobial resistance pattern



AS – Amoxicillin–Sulbactam
BA – Augmentin (Amoxicillin-Clavulanic acid)
CF – Cefixime
PT – Piperacillin–Tazobactam
C – Chloramphenicol
CP – Ciprofloxacin
CR – Ceftriaxone
TE – Tetracycline
OF – Ofloxacin
LE – Levofloxacin
AT – Azithromycin
GM – Gentamicin

Discussion

Hand contamination of various surfaces with pathogenic and non-pathogenic microbes has been documented (Melaku et al., 2025). The isolation of microorganisms comprising of *Staphylococcus sp., Escherichia coli., Klebsiella sp., Pseudomonas aeruginosa,, Bacillus subtilis* and mold from surfaces of the hand-held mobile phones as demonstrated in this study is an indication of unhygienic practices, poor handling and sharing among multiple users (Ibrahim et al., 2013;Noor, 2019; Suhail, 2019; Ugwu et al., 2021) and as seen in this study.

Microbial distribution and prevalence

The high prevalence of *Staphylococcus aureus* observed among both health workers and students aligns with its well-documented role as a dominant skin and nasal commensal that frequently colonizes hospital personnel and fomites. Similar studies in Nigeria and other regions have reported *S. aureus* as one of the most frequently isolated organisms from mobile phones of health-care workers and students, often with prevalence exceeding 30–80% depending on population and hygiene practices (Danelli et al., 2020; Ogunleye et al., 2025; Morufat et al., 2025**).** The organism's ability to survive on inanimate surfaces and its ease of transmission through hand contact contribute significantly to its persistence in community and health-care environments.This high prevalence are attributed to ethical reasons on the use of phones within work places in most settings

The presence of coagulase-negative staphylococci such as *Staphylococcus epidermidis* further reflects contamination from normal skin flora (Cheung and Otto, 2025. However, its high recovery rate in this study is clinically relevant because it is increasingly recognized as an opportunistic pathogen, particularly in immunocompromised individuals and in device-associated infections.

Gram-negative organisms, including *Escherichia coli* and *Klebsiella* spp., were also isolated across samples,

indicating possible fecal or environmental contamination. This supports findings from earlier mobile phone contamination studies in Nigeria, where enteric bacteria were frequently recovered and attributed to poor hand hygiene and cross-contamination from environmental surfaces (Erinle and Ajayi, 2022; Aliyo et al., 2025; Luyi et al., 2025). Their presence is of public health concern due to their known association with health-care-associated infections and multidrug resistance.

Fungal isolates, including mold, were detected primarily among students' phones and health worker samples . Although fungal contamination is often less emphasized, studies have shown that mobile phones can harbor both bacterial and fungal pathogens (Dubljanin et al., 2022) due to constant exposure to humid environments and irregular cleaning practices.

Colony count and microbial load

The colony count analysis revealed that male participants generally exhibited higher microbial loads than females across most isolates. This suggests possible differences in hygiene practices, frequency of device use, or environmental exposure. The significantly higher counts observed in organisms such as *S. aureus* and *S. epidermidis* indicate a heavier colonization burden, which may translate to increased risk of transmission.

Higher microbial loads on mobile phones and hands of health-care workers have been widely reported in literature, where CFU counts vary depending on clinical exposure, hand hygiene compliance, and frequency of phone use during clinical activities (Maurici et al., 2023; Aprile et al., 2025). The elevated colony counts observed in this study reinforce the role of mobile

phones as potential reservoirs for microbial amplification and dissemination.

Antimicrobial resistance pattern

The antimicrobial susceptibility profile revealed a concerning pattern of resistance, particularly among *Staphylococcus aureus*, which demonstrated high resistance to several commonly used antibiotics. This is consistent with global concerns regarding increasing multidrug resistance in staphylococcal species isolated from health-care environments (Lateefah and Mubarak,2025)

High resistance levels in Gram-positive organisms have been widely documented, especially against beta-lactam antibiotics, due to widespread production of beta-lactamase enzymes and other resistance mechanisms (Saba et al.,2022). The observed resistance pattern suggests selective pressure likely driven by indiscriminate antibiotic use in both community and health-care settings.

In contrast, fluoroquinolones such as ofloxacin and levofloxacin showed the lowest resistance rates across isolates, indicating that they may still retain good efficacy in the study area. This agrees with previous reports where fluoroquinolones remained among the most effective agents against both Gram-positive and Gram-negative isolates from mobile phones and hospital environments.

The detection of multidrug-resistant organisms, particularly *S. aureus* and *E. coli*, is consistent with findings from similar studies in Nigerian hospitals and universities, where mobile phones of health-care workers were identified as reservoirs of resistant pathogens (Lateefah and Mubarak,2025). These findings highlight the potential role of fomites in the dissemination of antimicrobial resistance within both hospital and community settings.

CONCLUSION

Surfaces of hand-held mobile phones of selected male and female students of Igbinedion University Okada as well as Health workers of the Teaching Hospital were observed to be contaminated with different species of bacteria some of which constitute potential health hazards. Mobile cell phone surface of female students was found to be more predisposed to contamination in relation to personal hygienic practices. Hand hygiene, use of gloved hands in receiving phone calls are some practices that should be encouraged especially among the youth. Likewise , Health workers should consistently practice hand hygiene to avoid spread of nosocomial agents to the community.

Author's Contribution

Conceptualization of this work by M.O; Data curation and editing by ZCS

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Conflict of Interest

The authors declared no conflict of interests.

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