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Investigation of Bacterial Flora on Mobile Phones: A Comparative Study between Healthcare Workers and Non-Healthcare Workers

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Abstract:

Background and Objectives: Hospital acquired infections continue to be a major issue for international health systems, despite advancements in contemporary detection and treatment. Potential infections can be found on healthcare personnel' cell phones. Mobile phones are seldom clean and are frequently handled before or after patient examinations and specimen processing without sufficient hand washing, despite the substantial risk of contamination. The primary goal of this study was to separate, characterise, and determine the antibiotic susceptibility of various microorganisms found on the mobile phones of both healthcare and non-healthcare personnel.

Materials and Methods: Aseptic samples were obtained by rolling mobile phones over agar plates. These plates were then incubated in aerobic conditions. Following incubation, the plates were assessed for bacterial growth. The bacteria were identified and subjected to antibiotic sensitivity testing using standard microbiological methods.

Results: A total of 178 samples were analysed in this study, 118 of which came from healthcare workers (HCWs) and 60 from non-HCWs (non-HCWs). Methicillin-susceptible Staphylococcus aureus (15.9%) and Acinetobacter baumannii (26.5%) were the most frequently isolated organisms from HCWs' mobile phones. Thirty samples (50.00%) of the sixty samples obtained from the mobile phones of non-HCWs demonstrated the growth of seven different kinds of bacteria.

Conclusion: The findings of our study indicate that bacteria are present on the mobile phones of healthcare workers (HCWs), suggesting a potential for the transmission of disease-causing microorganisms. These devices, which are not only used for communication but also serve as potential reservoirs for pathogens, can contribute to the spread of nosocomial infections. To minimize the risk of such infections, it is crucial to enforce rigorous hand hygiene practices and establish regulations regarding the use of mobile phones in hospital environments. By implementing these measures, we can help reduce the incidence of healthcare-associated infections.

Keywords: Healthcare-associated infections, Mobile phones, Staphylococcus aureus, contamination

INTRODUCTION

The advancements in modern technology have made a significant impact on the field of medicine. It has led to the development of innovative diagnostic techniques, improved patient care, and more effective treatments, ultimately enhancing the survival rates of individuals with various diseases. Furthermore, the rapid growth of technology has also resulted in the creation of devices and technologies for personal use. These include personal computers, pagers, wireless tablets, and mobile phones, providing individuals with convenient and accessible means of communication and information [(1)]. The establishment of the Global System for Mobile Telecommunication (GSM) in Europe in 1983 marked a significant milestone in enhancing communication systems worldwide [(2)]. The prevalence of mobile phones has surpassed that of landline telephones in numerous countries. It is now common for both adults and a significant number of children to own mobile phones [(3)].

The use of mobile phones in healthcare settings has improved patient communication and delivery efficiency. Mobile phones make it possible for lab and imaging findings, patient information, and photos to be sent quickly. This allows doctors to use their phones to interact with clinicians, residents, and students while doing bedside rounds. Mobile phones are another tool that healthcare workers (HCWs) use to access literature and pharmacological knowledge, which helps with learning and enhances clinical performance. The extensive adoption of mobile phones in healthcare environments has transformed the exchange and application of information, thereby helping patients and healthcare providers alike [(4)]. Even while computers and mobile phones have many advantages, people often ignore the risks they may bring to their health [(5)]. The usage of mobile phones has some hazards, such as the transmission of germs that may cause nosocomial infections, noise, diversions, lack of focus, compromised data security, and invasion of patient privacy [(6)]. The World Health Organisation (WHO) recognised the possible harm that electromagnetic radiation from phones and base stations may cause in 2000. They declared it to be dangerous for human health, stressing that it harmed sperm and DNA in particular [(7)]. Because of the continual microbe interaction with our skin, certain microbial species become colonised. The skin surface area of an adult human averages 2 m^2, and each individual can support around 1012 bacterial cells [(8)]. Mobile phones are in close proximity to the hands, mouth, nose, and ears of people when they are on the phone[(9)], The possibility of possible germs on the skin colonising the mobile phones grows with this touch. Aronson et al. were the first to raise the possibility that phones may aid in the transmission of illnesses back in 1997[(10)].

Healthcare-associated infections (HAIs) remain a major threat to international health systems despite advances in diagnosis and treatment. It is estimated that 25% of patients in impoverished nations get HAIs [(11)]. Healthcare workers' (HCWs') hands are a major factor in the spread of many illnesses. Pathogenic bacteria may infect a variety of items, including gloves, stethoscopes, neckties, bed rails, linens, phones, horizontal surfaces, doorknobs, thermometers, nurses' uniforms, and personal bags. When healthcare workers handle these inanimate things on a regular

basis, their hands are infected with harmful germs, which they then pass on to patients. These possible pathogens are stored on HCWs' cell phones. Mobile phones are frequently used without sufficient hand hygiene procedures during or after patient examinations and specimen processing, despite the substantial risk of contamination. As a result, these cell phones become potential sources of infection, endangering not just patients but also healthcare personnel and their families [(12)].Moreover, the sharing of cell phones among HCWs and non-HCWs can directly contribute to the spread of potential pathogenic bacteria within the community [(13)]. Individual differences exist in the makeup of microorganisms found on mobile phones, especially when it comes to healthcare professionals (HCWs) and the general population. When compared to non-medical persons, the amount and antibiotic susceptibility of bacterial isolates discovered on healthcare workers' cell phones can differ. Cell phones belonging to HCWs reflect the hospital community, whilst those belonging to non-HCWs represent the larger population. Thus, the goal of this study was to look at the different kinds of germs that are on the phones of these two types of people.

MATERIALS AND METHODS

Sample collection: Sterile swabs wet with sterile normal saline were used in aseptic procedures. The cell phones' visible surfaces were covered with the swabs. Particular care was taken to make sure that every surface, including the sides, back, mouthpiece, earpiece, screen, and keypad keys of the cell phones, was completely swabbed. Since these locations are frequently in touch with the fingers and are hence more likely to contain bacteria, they were specifically targeted. Strict precautions were taken to guarantee the precision and thoroughness of the sample collecting procedure.

Sample inoculation: Once collected, the samples were promptly brought to the lab for further analysis. They were injected into 5% sheep blood agar and MacConkey's agar plates. Following that, these plates were incubated in an aerobic condition at 37°C for an entire day. After the incubation period, the plates were carefully examined to track the development and colony form of the isolated bacteria.

Using accepted microbiological methods; the bacteria were identified and divided into Gram-positive and Gram-negative categories. It was necessary to conduct tests and analyses in compliance with established protocols in order to determine the characteristics and features of the bacterial isolates.

Antibiotic susceptibility: Antibiotic sensitivity The Kirby-Bauer disc diffusion technique was used to ascertain the bacterial isolates' susceptibility. In order to test for antibiotic disc susceptibility, Mueller-Hinton agar plates were utilised in accordance with the Clinical and Laboratory Standards Institute's (CLSI) recommendations [(14)].

The antimicrobial drugs linezolid (30µg), erythromycin (15µg), clindamycin (2µg), ciprofloxacin (5µg), cotrimoxazole (1.25/23.75µg), cefoxitin (30µg), and tetracycline (30µg) were evaluated with their corresponding disc concentrations for Gram-positive cocci.

The antimicrobial drugs pipericillin-tazobactam (100/10 µg), ceftriaxone (30 µg), cefepime (30 µg), imipenem (10 µg), cotrimoxazole (1.25/23.75µg), amikacin (30 µg), ciprofloxacin (5µg), and ampicillin (10µg) were evaluated with their corresponding disc concentrations for Gram-negative bacilli.

RESULTS

A total of 178 samples were investigated in this study, of which 60 samples came from non-HCWs and 118 samples were from HCWs. It was possible to isolate 151 bacteria from 118 HCW mobile phones. Of them, 40 (26.5%) Pseudomonas aeruginosa and 57 (37.7%) Staphylococci were the most common pathogens. Samples from healthcare workers (HCWs) included physicians, nurses, medical students, and technicians employed in a range of departments, including wards,ICUs, labs, and operation rooms.

Sixty mobile samples were gathered from non-HCWs who had not visited a hospital or interacted with patients in the previous month. Of the 118 samples provided by HCWs, 25 (21.18%) and 17 (14.40%) came from the Department of Laboratory and Outpatient, respectively, and accounted for the majority of the processed samples.

The largest number of samples processed from staff nurses and students, respectively, was 50 (42.37%) and 44 (37.28%), among healthcare workers.Table 1 shows the distribution of samples by profession and area.

Table 1. Samples of mobile phones for HCWs are distributed based on their area and profession.

Area	Doctors	Nurses	Technicians	Students	Area wise distribution of samples
Laboratory Depatment	00	00	15	20	25
Medical Department	03	07	00	02	12
Dialysis unit	00	08	02	05	15
Intensive care unit	00	03	00	02	05
Emergency medical department	00	05	00	02	07
Operations theater unit	03	7	00	00	10
Outpatient department	05	06	02	04	17
Surgical Department	02	05	00	03	10
E.N.T Department	02	06	00	04	12
Orthopedics Department	00	03	00	02	05
Total NO.	15	50	19	44	118

It was possible to isolate 151 bacteria from 118 HCW mobile phones. Of these, the most common pathogen was *Staphylococcus species*, accounting for 57 (37.7%) [MSCoNS 19 (12.6%), MRSA 04 (2.7%), MRCoNS 07 (4.6%), and S. citreus 03 (2.0%)]. *A. baumannii* accounted for 40 (26.5%) of the total. Table 2 shows several species of bacteria cultured from the mobile phone of the healthcare worker.

Table 2. The quantity and kind of bacteria found on HCWs' cell phones

Isolated organism (n=10)	**Number of isolated organism (n=151)**	**Percentage (%)**
Methicillin susceptible Staphylococcus aureus	24	15.9
Methicillin susceptible coagulase negative Staphylococci	04	2.7
Methicillin resistant Staphylococcus aureus	19	12.6
Methicillin resistant coagulase negative Staphylococci	07	4.6
Staphylococcus citreus	03	2.0
Acinetobacter baumannii	40	26.5
Pseudomonas aeruginosa	23	15.2
Klebsiella pneumoniae	20	13.2
Citrobacter spp.	06	4.0
Escherichia coli	05	3.3
Total	**151**	**100**

Acinetobacter baumannii (31.78%) was the most frequently isolated bacterium from HCWs' mobile phones, followed by K. pneumoniae (19.20%). Table 3 displays the distribution of microorganisms recovered from HCWs working in various places.

Table 3. Distribution of bacteria isolated from mobile phones of healthcare workers according to their location.

Area	**MSSA**	***MSCoNS***	***MRSA***	***MRCoNS***	***S.citreus***	***A. baumannii***	***K.pneumoniae***	***P. aeruginosa***	***Citrobacter spp.***	***E. coli***	**Number of total isolated organism (n=151)**
Laboratory depatment	01	01	01	01	03	07	07	03	02	02	**28**
Medical department	00	00	00	01	01	04	04	01	03	00	**14**
Dialysis unit	01	01	01	01	01	10	01	03	01	01	**21**
Intensive care unit	00	00	00	01	00	03	01	01	00	00	**06**
Emergency medical department	00	00	00	03	00	03	02	02	01	00	**11**
Operations theater unit	00	00	00	01	01	03	01	01	00	00	**07**
Outpatient department	01	01	01	02	01	08	06	05	03	02	**30**
Surgical department	00	00	00	01	00	03	02	02	02	00	**10**
E.N.T department	00	00	00	01	00	03	02	02	02	00	**10**
Orthopedics department	00	01	1	02	00	04	03	02	01	00	**14**

MSSA: Methicillin susceptible *Staphylococcus aureus*; MSCoNS: Methicillin susceptible coagulase negative *Staphylococci*;
MRSA: Methicillin resistant *Staphylococcus aureus*; MRCoNS: Methicillin resistant coagulase negative staphylococci;

Acinetobacter baumannii (25.00%) and *Klebsiella pneumoniae* (50.00%) were the most frequently isolated organisms from the technicians' mobile samples. Table 4 shows the distribution of bacteria from several HCW types.

Table 4. Distribution of bacteria isolated from HCW's mobile phones according to the profession

Isolated micro-organisms (n=151)	Doctor (n=15)	Nurses (n=50)	Technicians (n=19)	Student (n=44)
Methicillin susceptible Staphylococcus aureus	0	01	01	0
Methicillin susceptible coagulase negative Staphylococci	0	01	02	01
Methicillin resistant Staphylococcus aureus	01	01	01	01
Methicillin resistant	02	05	06	03
Staphylococcus citreus	01	01	04	01
Acinetobacter baumannii	09	12	12	15
Pseudomonas aeruginosa	04	06	07	06
Klebsiella pneumoniae	03	08	11	00
Citrobacter spp.	02	04	08	01
Escherichia coli	00	01	03	01
Total	22	**40**	**55**	**29**

MSSA: Methicillin susceptible *Staphylococcus aureus*; MSCoNS: Methicillin susceptible coagulase negative *Staphylococci*; MRSA: Methicillin resistant *Staphylococcus aureus*; MRCoNS: Methicillin resistant coagulase negative *staphylococci*.

In the present study, samples from 60 non-HCW mobile phones were cultivated; 23 (46.00%) of these samples produced the growth of seven distinct bacterial species. The most common organism among them was *Acinetobacter baumanni* (26.66%), followed by *Klebsiella pneumoniae* (20.00%). Table 5 shows the distribution of bacteria from non-HCWs.

Table 5. The number and type of bacterial agent that was extracted from non-HCWs' mobile phones

Source type	Number of samples collected	Number of culture positive samples	Isolated organisms	Number of isolated organisms
			MSSA	02
			MSCoNS	01
			MSSA	02
Non Health care			MSCoNS	01
workers	60	33	*Klebsiella pneumoniae*	03
			Acinetobacter baumanni	04
			Citrobacter spp.	02
			Total	**15**

Table 6 shows the antibiotic susceptibility pattern of *staphylococci* isolated from mobile phones used by healthcare workers. The bacteria *S. aureus* and CoNS were completely sensitive to linezolid.

Table 6. Pattern of antibiotic susceptibility in Gram-positive bacteria isolated from healthcare workers

Antibiotics	***S. aureus*** **(n=7)**		***CoNS*** **(n=18)**	
	S	R	**S**	R
LZ	7	00	18	00
E	5	2	17	01
CD	3	4	15	03
CIP	6	1	13	5
COT	2	5	16	2
CX	2	5	15	3
TE	6	1	11	8

LZ: linezolid; E: erythromycin; CD: clindamycin; CIP: ciprofloxacin;COT: cotrimoxazole; CX: cefoxitin; TE: tetracycline;CoNS: Coagulase negative *staphylococcus*

Of the bacteria classified as Gram-negative, *P. aeruginosa* was sensitive to ciprofloxacin in 100% of cases, and amikacin in91.3%. Table 7 illustrates the antibiotic susceptibility trend of Gram-negative pathogens recovered from healthcare workers.

Table 7. Pattern of antibiotic susceptibility for Gram-negative bacteria isolated from healthcare workers

Antibiotics	***P. aeruginosa*** **(n=23)**		***A. baumannii*** **(n=44)**		***K. pneumoniae*** **(n=23)**		**E. coli (n=05)**		***Citrobacter*** **(n=7)**	
	S	**R**	**S**	**R**	**S**	**R**	**S**	**R**	**S**	**R**
PIT	16	07	40	4	20	03	03	02	05	02
CTR	13	10	30	14	21	02	03	02	7	00
CPM	16	07	20	24	18	05	03	02	7	00
IPM	20	03	30	14	23	00	05	00	05	02
COT	15	08	31	13	20	03	03	02	05	02
AK	21	02	40	04	23	00	05	00	7	00
CIP	23	00	40	04	22	01	04	01	6	01
A	08	15	-	_-	05	18	01	04	00	7

PIT: pipericillin-tazobactam; CTR: ceftriaxone; CPM: cefepime; IPM: imipenem; COT: cotrimoxazole; AK: amikacin; CIP:ciprofloxacin; A: ampicillin

DISCUSSION

The transmission of microorganisms that lead to healthcare-associated infections (HAIs) is significantly influenced by the hospital environment. These microorganisms have the ability to transfer from one individual to another or from inanimate objects to hands, including pens, computer keyboards, stethoscopes, bronchoscopes, cell phones, and landlines. In the current investigation, we specifically examined the microbial colonisation of a particular inanimate object, the cell phone. Modern mobile phones are multipurpose, non-medical devices that can be used in both the home and in healthcare settings.The importance of mobile phones as a communication tool in the community and in medical settings has increased. They are also helpful for collecting epidemiological data and monitoring

chronic conditions.Cell phones are surprisingly common in healthcare facilities, even in highly sensitive areas like operating rooms and intensive care units, despite their unknown microbiological load [(15)].A study found that cell phone bottoms are frequently dirtier than toilet seats and shoe bottoms [(16)]. Due to their frequent use, mobile phones expose multiple users to a wide range of microorganisms, making them effective carriers of pathogens. This is particularly true for skin, where the combination of the heat from cell phones and the skin's natural temperature and wetness—particularly on our palms—creates an environment that is favourable to bacterial colonisation and growth.

As a result, these gadgets may contain a variety of possible pathogens and act as a conduit for nosocomial infections in hospitalised patients [(17)]. In the current investigation, microbiological growth was detected on the mobile phones of 79.72% of healthcare workers (HCWs) and20.27 % of non-HCWs. The results of our investigation regarding the rate of mobile phone contamination among health care workers align with previous studies conducted by Ulger *et al*. [(18)], Marwa *et al*. [(19),] Jaya Lakshmi *et al.* [(20)], and Neha Sharma *et al.* [(21)]. Our results are also consistent with the study conducted by Misgana *et al.* [(22)] about the rate of mobile phone contamination among non-HCWs. Our results are at odds with those of Neha Sharma *et al.* [(23)] who reported an 80% contamination rate among non-HCWs' cell phones.

The findings unequivocally demonstrate that healthcare workers' (HCWs') mobile phones were significantly more contaminated than non-HCWs' mobile phones. This disparity could have multiple explanations, such as direct patient contact by HCWs and potential hospital noncompliance with infection prevention protocols. Different types of bacteria that cause healthcare-associated infections (HAIs) can be found in a variety of clinical settings. These bacteria include *A. baumannii*, *Pseudomonas species*, and *MRSA*, to name a few notable ones [(24, 25)]. Healthcare professionals' cell phones were the source of the bulk of the 178 bacteria that were found for this study, accounting for 57 (37.7%) of the total. These bacteria are Staphylococcal species. Lawani *et al.* have seen and recorded comparable patterns [(26)].

Given their usual presence in the skin flora, it is feasible to explain the significant growth rate of *Staphylococcal* species—more especially, *S. epidermidis*—on mobile phones in the current study. On the other hand, S. aureus can cause a variety of illnesses, ranging from minor skin infections to more severe conditions like bacteremia, pneumonia, and septicemia. Due to its resistance to *β-lactam medicines, Methicillin-resistant Staphylococcus aureus* (MRSA) poses a serious threat to human health [(27)]. *Staphylococcus species* account for 57 (37.7%) of the organisms isolated from healthcare workers (HCWs) [MSCoNS 19 (12.6%), MRSA 04 (2.7%), MRCoNS 07 (4.6%), and *S. citreus* 03 (2.0%)]. Another common bacteria found on healthcare workers' cell phones was *Acinetobacter baumannii*. *A. baumannii* is a gram-negative coccobacillus with a truncated rod-like form. It is ubiquitous and can be found in water, soil, and the normal skin flora. Because of the long-term survival of *A. baumannii* (MDR) in hospital

environments and the establishment of numerous drug-resistant strains, MDR is a nosocomial pathogen that carries potential harm [27]. In this investigation, the majority of mobile phones belonging to healthcare workers (HCWs) had *Acinetobacter baumannii* isolates (26.5%).It is alarming that healthcare workers (HCWs) in crucial situations like intensive care units (ICUs), operating rooms, dialysis centres, and doctor's offices have multi-drug resistance pathogens like *A. baumannii* and MRSA. It was shown that the *staphylococci* isolated from cell phones in this study were 100% susceptible to linezolid and 85.8% sensitive to ciprofloxacin. These outcomes agree with Dardi's [28] findings. 99% of the *A. baumannii* isolates under study were sensitive to both amikacin and ciprofloxacin. *Pseudomonas aeruginosa* showed susceptibility to amikacin (82.60%) and imipenem (86.95%). *K. pneumoniae* exhibited 100% imipenem susceptibility, 100% amikacin susceptibility, and 95.65% ciprofloxacin susceptibility. In a separate study, Dardi [28] discovered that a number of antibiotics, such as ceftazidime, ticarcillin, piperacillin, amikacin, netilmicin, meropenem, and cefepime, were totally sensitive to Gram-negative bacilli isolated from cell phones. Thirty (50%) out of the sixty mobile phone samples collected from non-healthcare workers (non-HCWs) in this study showed germs growing on them.Remarkably, the findings of this study diverge from those reported by Misgana *et al.*, who reported a higher growth rate of 56.06% (37 out of 66) from mobile phone samples that belonged to non-HCW adults. Most of the organisms in their examination were Staphylococci that were negative for coagulase.

CONCLUSION

Our findings clearly demonstrate the presence of bacterial colonisation on mobile phones, which are frequently in close contact with the hands of healthcare professionals. In addition to their ability to send signals, cell phones also have the potential to spread disease. They might act as a suitable medium for nosocomial illness germs to multiply, spread, and wreak havoc .Furthermore, compared to healthcare workers, non-HCWs have less bacterial colonisation on their mobile phones, according to our research.

These contaminated phones could expose the public to the spread of bacteria that are resistant to drugs. laws prohibiting the use of cell phones in hospitals due to the possibility of nosocomial infections .Depending on how HCWs use their phones while working at the hospital, they could be an ally or an enemy.

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