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Abstract

Background and objectives: The widespread use of cellular devices, particularly by hospital staff, contributes to the spread of pathogenic organisms. The study was conducted to determine the microbial contamination of cellular mobile devices in health care workers (HCW) and to compare it with mobile phones of non-HCW's. Materials and Methods: Mobile phones of 90 HCW's were screened for microbial contamination and it is compared with mobile phones of 90 non-HCW's. A sterile moistened swab sample was taken and rotated over the surfaces [both sides] of the cell phones and inoculated in nutrient broth at 37°C for 24 hours, followed by sub-culturing on agar such as: MacConkey agar, Mannitol salt agar, blood base agar and Sabouraud dextrose agar. The isolated microorganism was identified by using standard microbiological techniques. Results: The study revealed microbial contamination in case of 90 mobile phones of HCW's and 90 mobile phones from non-HCW's. Commonest organism isolated was Coagulase negative Staphylococci in HCW's groups. 81 microbe isolates (61.83%) from HCW's were significant nosocomial pathogens whereas 68 isolates (59.13%) from non-HCW were pathogenic; Staphylococcus aureus being the most frequent isolate from non-HCW groups. examined samples showed that (100%) were contaminated with one or more organisms. Five different bacterial species were found to be present. (46.67%) Coagulase Negative Staphylococci, (43.33 %) for each Staphylococcus aureus and Streptococcus spp., (4.44 %) E. coli, (3.33%) Pseudomonas spp. and fungal isolates include (3.33%) Aspergillus spp. and Candida spp. (1.11%). Medical lab samples showed high rates (53.33%) of mixed growth compared with (23.33%) and (20%) from doctor and nurses respectively. In addition, samples taken from females showed a higher contamination rate of single growth (75.56%) than samples taken from males (60%). Conclusions: According to the study, the use of mobile devices by HCWs serves as a reservoir for microorganisms. In order to stop the spread of infectious germs, these should be frequently disinfected as well as using good hand hygiene techniques. Additionally screening of mobile device for the nosocomial pathogens and restricting their use in sensitive areas of hospital is also advisable.

Keywords

Mobile phone, Microbial contamination, Healthcare personnel, hospital acquired infection

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RESEARCH ARTICLE

The Role of Mobile Phones in the Transmission of Bacteria and Fungi Associated with Hospital-acquired infections in Erbil City

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ABSTRACT

Background and objectives: The widespread use of cellular devices, particularly by hospital staff, contributes to the spread of pathogenic organisms. The study was conducted to determine the microbial contamination of cellular mobile devices in health care workers (HCW) and to compare it with mobile phones of non-HCW's.

Materials and Methods: Mobile phones of 90 HCW's were screened for microbial contamination and it is compared with mobile phones of 90 non-HCW's. A sterile moistened swab sample was taken and rotated over the surfaces [both sides] of the cell phones and inoculated in nutrient broth at 37°C for 24 hours, followed by sub-culturing on agar such as: MacConkey agar, Mannitol salt agar, blood base agar and Sabouraud dextrose agar. The isolated microorganism was identified by using standard microbiological techniques.

Results: The study revealed microbial contamination in case of 90 mobile phones of HCW's and 90 mobile phones from non-HCW's. Commonest organism isolated was Coagulase negative *Staphylococci* in HCW's groups. 81 microbe isolates (61.83%) from HCW's were significant nosocomial pathogens whereas 68 isolates (59.13%) from non-HCW were pathogenic; *Staphylococcus aureus* being the most frequent isolate from non-HCW groups. examined samples showed that (100%) were contaminated with one or more organisms. Five different bacterial species were found to be present. (46.67%) Coagulase Negative *Staphylococci*, (43.33 %) for each *Staphylococcus aureus* and *Streptococcus spp.*, (4.44 %) *E. coli*, (3.33%) *Pseudomonas spp.* and fungal isolates include (3.33%) *Aspergillus spp.* and *Candida spp*. (1.11%). Medical lab samples showed high rates (53.33%) of mixed growth compared with (23.33%) and (20%) from doctor and nurses respectively. In addition, samples taken from females showed a higher contamination rate of single growth (75.56%) than samples taken from males (60%).

Conclusions: According to the study, the use of mobile devices by HCWs serves as a reservoir for microorganisms. In order to stop the spread of infectious germs, these should be frequently disinfected as well as using good hand hygiene techniques. Additionally screening of mobile device for the nosocomial pathogens and restricting their use in sensitive areas of hospital is also advisable.

Keywords: Mobile phone, Microbial contamination, Healthcare personnel, hospital acquired infection

INTRODUCTION

Like other inanimate objects, mobile phones can harbor microorganisms that can infect humans. The hands of most people contain microorganisms as part of their normal microflora, as well as transient microorganisms obtained from the environment (Lindberg *et. al.* 2014). Pathogenic bacteria could be transferred between human hands and mobile phones (Kusumaningrum *et. al.*, 2013). Following contamination of inanimate objects such as stainless steels, plastics, and keyboards, researchers have studied the survival of bacteria on those surfaces; In most of these studies, these surfaces concluded by emphasizing the potential role inanimate objects may play in harbouring and transmitting pathogenic microorganisms (Rusin *et. al.*, 2012). The mobile phone has become one of the most essential accessories of both professional and social life today. The use of cell phones often occurs in hospital halls, intensive care units and/or laboratories when dealing with severe illnesses. The mobile phone serves as a good habitat for thrive of microorganisms; It may even serve as a vehicle of transmissibility of nosocomial infections for medical personnel. Microbe transmission may also be affected by the number of people using the same mobile phones and

their personal hygiene (Brady *et.al*. 2016). Findings revealed that around one-fifth of the cell phones under investigation harbored harmful microorganisms, indicating that these devices could be used as transmission methods (Goldblatt *et. al*., 2017). Considering this, the current study was conducted to determine the microbial contamination of mobile phone in health care workers (HCW) as compared to the mobile phone of non-health care workers and analyze the microorganism's percentage of mobile phones by using standard laboratory techniques.

MATERIALS AND METHODS

Sample collection

The study was conducted at the research center of the University of Polytechnic, Erbil, Kurdistan. We collected (180) samples from mobile devices which include:

Control group: Non-HCWs - Personnel who are not involved in patient care, such as teaching personnel, office personnel, and administrative personnel (n=90).

Study group: Healthcare workers (HCW's) – Medical and paramedical staff working in hospitals and who are directly involved in patient care (n=90) belonging to the staff at Rizgary Teaching Hospital in Erbil. They are organized into three groups (30 doctors, 30 Medical Lab. Technicians and 30 Nurses) during a period from January 1st and March 30, 2019. Medical and health staff mobile phones were randomly sampled after written and oral consent was obtained from all participants. The research and samples collection were approved by Rizgari Teaching Hospital and the Board of Medical Ethics in Erbil Health and Medical Technical College and then the question rate form was filled out.

Sampling was performed aseptically using cotton tipped applicators that were immersed in a 0.85% sterilized normal saline solution (NSS). From each mobile phone, two samples were taken, in one, bacteria are tested, in the other, fungal contamination is studied. According to the previously reported method, all samples collected were analyzed and screened (Sepehri *et. al*., 2009).

Firstly, sterile gloves were worn when holding the mobile phone. On both sides of the mobile phone, a sterile cotton swab was rotated while being dampened with the sterile (0.85%) normal saline solution. Cotton swabs were immediately transferred to the laboratory within one hour of collection to prevent drying. According to the manufacturer's instructions, the powdered Blood agar, MacConkey agar, and Sabouraud dextrose agar were preparation and sterilized. Agar that was molten was allowed to cool to around 47 C°. before pouring, blood (7%) was carefully mixed with blood agar. And 50 mg of chloramphenicol per liter of Sabouraud dextrose agar were added. followed by being poured into sterilized plastic petri dishes. After solidifying, they were stored at 40°C in the refrigerator for later use.

Samples Cultivation

In the laboratory, according to the standard methods of microbiological tests sampling, swabs were spread on the surface of blood and MacConkey agar culture plates. Then, plates were incubated aerobically in an inverted position at 37 °C for 48 hours. The plates were then observed for the presence of isolated colonies. The second sample of each mobile phone to identify fungal contamination was inoculated on Sabouraud dextrose agar (SDA) and incubation of this culture was done at 25°C. The cultures were examined every two days for evidence of growth (development of colonies 3-4 days). Colonies were again sub-cultured on agar in petri-plates to isolate pure culture. After which, the plates were examined for growth and the plates with growth were selected for necessary identification of the isolates.

Identification of Isolates

Bacterial isolates were identified using standard techniques as briefly follow:

Identification of Gram-negative bacteria:

Morphological characteristics, grams stain and motility test were performed. To check the growth pattern MacConkey agar was used. For biochemical characteristics, sugar fermentation, IMVIC test (Indole, Methyl Red, Voges Proskauer test and Citrate utilization test), KIA, urease and nitrate test were performed (Emmanuel, 2002; Cruickshank *et. al*., 2006).

Identification of Gram-positive Bacteria:

Morphological characteristics and gram stain were performed. To check the growth pattern on Blood agar, chocolate agar, and Mannitol salt agar were used. For biochemical characteristics, sugar fermentation, coagulase (A slide coagulase test was performed to differentiate between *Staphylococcus* and *Streptococcus*), catalase, oxidase test was performed (Emmanuel, 2002; Cruickshank *et. al*., 2006; Suganya and Sumathy, 2012).

Identification of the filamentous fungi

The identification of the filamentous species was carried out through macroscopic observation of the colonies and examination of the microstructural characteristics by microscopic examination was done to identify the colonial morphology of fungi and a comparative analysis with parameters established in the conventional taxonomy, in accordance with the revised literature. Specific original descriptions were used with the objective of confirming the identification and the taxonomical validity. After the identification, the colonies were transferred to test tubes containing specific culture medium (Koneman *et.al.,* 2014).

STATISTICAL ANALYSIS

Chi-square analysis was used for the statistical analysis. $P < 0.05$ values were acceptable as a significant value. Descriptive statistics and percentage were employed.

RESULTS

A total of 90 mobile phones were examined for the presence of bacteria and fungi, which owned and used by medical and health staff. All of the examined mobile phones (100%) were contaminated with either single or multiple organisms.

Five bacterial isolates were detected including: (46.67%) Coagulase negative *Staphylococci* (CoNS), (43.33 %) each *Staphylococcus aureus* and *Streptococcus spp.*, (4.44 %) *E. coli* and (3.33 %) *Pseudomonas spp.*, were found in least percentage. Gram-positive bacteria were isolated more often than Gram-negative bacteria (P= 0.036). There were also fungal isolates include (3.33%) *Aspergillus spp.* and (1.11) *Penicillium spp.*as shown in Table (1). 81(61.83%) of these bacterial isolates were known nosocomial pathogens.

In case of non-health care workers, 90 mobile phones were found contaminated. The commonest organism isolated was Coagulase negative *Staphylococcus species* 35 (38.89%) followed by *Staphylococcus aureus* 25 (27.78%), *Streptococcus spp.* 41(45.56%), *E. coli* 10 (11.11%), *Pseudomonas spp.* 2 (2.22%), *Aspergillus spp.* 1 (1.11%) *and Penicillium spp.* 1 (1.11%) in that order. In this group, 68(59.13%) isolates were known pathogens. The distribution of different bacteria obtained from mobile phones of study group and control group is as given in Table (1).

Table (1): Distribution of different microbe obtained from mobile phones of HCW's and non-HCW's

Microorganisms type	Healthcare personnel No. [n=90] %	Non-healthcare personnel No. [n=90] %
Coagulase Negative Staphylococci	42 (46.67%)	35 (38.89%)
Staphylococcus aureus	39 (43.33%)	46 (27.78%)
Streptococcus spp.	39 (43.33%)	41 (45.56%)
E. coli	4 (4.44%)	10 (11.11%)
Pseudomonas spp.	3 (3.33%)	2 (2.22%)
Aspergillus spp.	3 (3.33%)	1 (1.11%)
Penicillium spp.	1 (1.11%)	1 (1.11%)

In case of HCW's, 81(61.83%) bacterial isolates were clinically significant nosocomial pathogens whereas in non-HCW's 68(59.13%) isolates were potential pathogens. Table (2) shows distribution of clinically significant pathogens which can cause hospital acquired infections among study group and control group.

Table (2): Distribution of clinically significant pathogens between mobile phone of HCW's and non-HCW's

	Significant pathogens	Non-pathogens	No. of bacterial isolates
Healthcare workers	81(61.83%)	50(38.17%)	131
Non- healthcare workers	68(59.13%)	47(40.87%)	115

The prevalence rate of isolated bacteria due to professions, from mobile phones of doctors, the highest percentage of isolation was Coagulase Negative *Staphylococci* (CoNS) which was about (41.46%), then *Streptococcus spp.* represented (31.70%), S*taphylococcus aureus* (21.95%), while *E. coli* and *Pseudomonas spp.* represented (2.43% each).

Regarding Medical lab technicians; the most frequently encountered isolates was Coagulase Negative *Staphylococci* CoNS. (33.96%), then *Streptococcus spp*. represented (30.18%). On the other hand, *Staphylococcus aureus* was the most commonly isolated organism from nurses 'cell phones (43.24%), followed by *Streptococcus spp* (24.32%) and Coagulase Negative *Staphylococci* (21.62%), as shown in Table (3).

The current study revealed that the majority of isolated bacterial from mobile phone of medical lab technicians were mixed with more than one organism- [multiple microbes], which was about (53.33%) as (23.33%) and (20%) for doctors and nurses respectively, as shown in Table (4). There were significant differences between the microbial growth and medical staff.

Table (3): Distribution of isolated microorganism depending on professions

Microorganisms type	Medical Staff					
	Doctors		Medical Lab. technicians		Nurses	
	No.	%	No.	%	No.	%
Coagulase Negative Staphylococci	17	41.46	18	33.96	8	21.62
Staphylococcus aurous	9	21.95	14	26.41	16	43.24
Streptococcus spp.	13	31.70	16	30.18	9	24.32
E. coli	1	2.43	1	1.88	2	5.40
Pseudomonas spp.	1	2.43	1	1.88	1	2.70
Aspergillus spp.	0	0	2	3.77	1	2.70
Penicillium spp.	0	0	1	1.88	0	0
Total	41	100	53	100	37	100
P value				0.04		

Table (4): Percentages of isolated microbe culture type related to occupations

Profession	Growth No. [Percentage %]					
	Single Microbe		Multiple Microbe		Total	
	No.	%	No.	%	No.	%
Doctors	23	76.67	7	23.33	30	100
Medical Lab. technicians	14	46.67	16	53.33	30	100
Nurses	24	80	6	20	30	100
Total	61	67.78	29	32.22	90	100

The percentage prevalence rate of isolated bacteria agents (single or multiple organisms) from the mobile phones of medical staffs by gender where: single growth for females was (75.56%) and for males (60%), as shown in Table (5).

Table 5. Percentage of isolated microbial type regarding to gender.

Gender	Growth No. [Percentage %]					
	Single microbe		Multiple microbe		Total	
	No.	%	No.	%	No.	%
Male	27	60	18	40	45	100
Female	34	75.56	11	24.44	45	100
Total	61	67.78	29	32.22	90	100

But the highest isolated single bacterial cultures (45.90%) found in age group (31 – 40) years mixed bacterial cultures found in higher percentage (34.48%) in group aging (25 – 30) years as shown in Table (6).

Table (6): Distribution of single and mixed microbial cultures isolate depending to the age of medical and health

Age	Growth No. [Percentage %]					
	Single microbe		Multiple microbe		Total	
	No.	%	No.	%	No.	%
<25	7	11.48	5	17.24	12	13.33
25 – 30	11	18.03	10	34.48	21	23.33
31 – 40	28	45.90	9	31.03	37	41.11
41 – 50	11	18.03	4	13.79	15	16.67
≥ 51	4	6.56	1	3.45	5	5.56
Total	61	100	29	100	90	100

DISCUSSION

Mobile phones are widely used on the wards by both healthcare workers and non-healthcare professionals since they are an effective source of communication for both groups. However, neither healthcare professionals nor non-healthcare workers give much thought to maintaining personal hygiene standards or disinfecting cell phones. Numerous studies have demonstrated how mobile devices used by healthcare professionals can serve as a breeding ground for a variety of bacteria connected to nosocomial illnesses (Brady *et.al.*,2009) Our findings support the strong correlation between the frequency of positive tests for the colonization of mobile phones, seen for all the identified bacteria.

In our study, it was shown that 90 (100%) of the mobile phones of HCWs who are actively involved in patient care had bacterial contamination, compared to 90 (100%) of the mobile phones of non-HCWs. According to research by Srikanth *et al*, 71% of HCWs' mobile phones were contaminated with microbes, compared to 78% of corporate workers (Srikanth *et.al*, 2009). In a different study by Akinyemi *et al*., 15.3% of HCWs' mobile phones were discovered to be contaminated in comparison to non-HCWs, including marketers and food vendors (37%), lecturers and students (30.6%), and public servants (16.9%) (Akinyemi *et. al*.2009). During our study the most common bacterial agent isolated from mobile phones of both HCWs and non-HCWs was a coagulase negative *Staphylococcus* species. (Akinyemi *et a*l., 2009 and Srikanth *et al*., 2009) also highlight the common occurrence of Coagulase Negative *Staphylococcus* (CoNS) as the most frequently isolated organism from cell phones (Srikanth *et.al,* 2009; Akinyemi *et. al*.2009; Galazzi *et. al*. 2019; Sedighi *et. al*. 2015; Qureshi *et. al.* 2020). CoNS are a normal part of the skin flora and are generally harmless in healthy individuals. However, they can pose a risk and have been implicated in several healthcare-associated infections (HAIs) such as, bacteremia in immunocompromised patients, neonates, and surgical wound infections in patients with implanted valve prosthetic devices and catheters (Becker *et, al*, 2014; Naaz *et. al*, 2019). In addition, CoNS have been shown to be resistant to drying (on inanimate surfaces they can remain viable for months), and in warm environments, they multiply rapidly (Brady *et. al*. 2006; Borer *et.al*. 2005).

The *S. aureus* isolation percentage (43.33%) from HCWs' mobile phones was consistent with findings from other research carried out in Ethiopia and India, which recorded rates of 40.5% and 39.4%, respectively. (Bodena *et. al.* 2019; Misgana *et. al.*2015). On the other hand, a study done in Ethiopia revealed a greater rate of *S. aureus* isolation, according to the authors, it was the predominant organism isolated (Chaka *et. al* 2016). (Heyba *et al.* 2015) discovered a substantially lower prevalence of *S. aureus* (1.9%) on mobile phones in Kuwait. Healthy people typically carry *S. aureus* on their skin and mucosal membranes. (Bodena *et. al.* 2019; Chakolwa *et. al.* 2019). An earlier study on *S. aureus* carriage in the hands and nasal passages at the University

Teaching Hospital in Lusaka discovered an overall carriage incidence of 17.1%. (Chakolwa *et. al.* 2019). It is carriers who are a source of infection to themselves and others, for example, through direct contact or contamination with fomites. (Brady *et. al.* 2016; Debnath *et. al.* 2018). *S. aureus* is one of the most frequent causes of HAIs, frequently of surgical incisions or bacteraemia linked to catheters (Morubagal *et. al*. 2017).

In a study conducted by (Srikanth *et al.*, 2009) 65% of the isolates from HCWs' mobile phones were recognized pathogens as compared with 54% from corporate workers (Srikanth *et.al.*,2009; Bodena *et. al.*, 2019; Heyba *et. al.*, 2015) Also, our study found that mobile phones of HCWs had a higher contamination rate with nosocomial pathogens than those of non-HCWs. There are no standardized guidelines regarding mobile phone disinfection in healthcare settings, which may account for the difference, leading to improper disinfection of mobile phones, as well as the reliability of participants' responses.

Among the least isolated microorganisms in this study were *E. coli* (4.44%), *Pseudomonas spp*. (3.33%), *Aspergillus spp*. (3.33%) and *Penicillium sp*. (1.11%). These results are consistent with a study carried out in Nigeria. (Nwankwo *et. al.* 2014) Additionally, in numerous clinical settings, these bacterial species have been identified as the most typical cause of HAIs. (Demissie and Lulseged., 2009; Rosenthal *et. al.*, 2016) *Pseudomonas* isolation from HCWs' mobile phones is really concerning, as these organisms are known to be multidrug-resistant healthcare-associated pathogens. The presence of *E. coli* suggests faecal contamination (a direct indicator that other *Enterobacterales* could be carried on mobile phones) (Karabay *et. al*., 2007; Tolera *et. al.*, 2018).

The widespread usage of mobile phones by hospital staff members who work in medicine and healthcare is having a significant impact on our lives and contributes to the spread of harmful organisms in the hospital environment. In the current study, (100%) of the examined mobile phone samples were contaminated with bacterial agents and less with fungal agents.

One or more organisms were present in all of them, Different levels of awareness regarding the use of mobile phones may be the cause of these significant variances. A hospital staff members should keep good hand hygiene during use their cell phone frequently especially while dealing and caring for patients. In Egypt, (Hadir, 2017) conducted a study that revealed that [100%] of the mobile phone handsets they tested were contaminated with either one or more bacterial agents. On the other hand, according to a Nigerian study by (Amala and Ejikema, 2015) It was reported that 80.60 % of isolates from medical care workers' mobile phones were bacteria. In Iraq, (Al-Ani *et. al.*, 2013) found that [78.4%] of 80 samples had single and multiple contaminations by bacteria and/or fungi.

In this study, the factors that affected the bacterial contamination of mobile phones included profession, gender, age group, mobile phone disinfection, and work environment. This result supports other studies have found a significant correlation between mobile devies contamination and factors such as age, gender and use of mobile phones in the work environment (Brady *et. al.*, 2006, Goldblatt *et. al*., 2017), as well as disinfection practices and limiting mobile phone use at work (Banawas *et. al*., 2018). One of the most prevalent professions with multiple organisms was medical laboratory technicians (53.33%). Because they are exposed directly to infected specimens, there might be a reason for the high prevalence, the slightly higher incidence rate may be caused by the aerosols produced in labs and users' contact with the lab benches while using their mobile phones. It is apparent that taking calls and answering them while at work allows for the spread of germs. As well as, (Trivedi *et. al*., 2011; Tambe and Pai, 2012; Akinyemi *et. al*. 2009) also reported the same tendency. And additional studies supported the reverse, revealing that medical staff had a higher carriage rate than paramedical employees. (Arora *et. al,* 2009; Panchal, *et. al.*, 2012).

CONCLUSIONS

Mobile phones may act as an important reservoir of infection in hospital settings as these are contaminated by pathogenic organisms especially in case of HCW's. Though it is not possible to completely stop their use in hospitals by the HCW's, it is important to disinfect them frequently. Strict adherence to infection control practices and precautions such as hand washing and good hygienic practice among the users of mobile phones are of most importance as this indispensable device may act as a source of hospital associated infections. Restriction of mobile phone use in clinically sensitive areas, such as operating environment and ICU is also recommended. Moreover, screening of mobile phones for microorganisms should also be done whenever environmental screening is undertaken in the hospitals.

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