Carriage of Antibiotic Resistant Biofilm Producing Bacteria on Mobile Phones Used By Health Care Professionals (HCP) in a Hospital in Ras Al Khaimah, UAE

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Abstract

Cell phones are the most common gadgets used in today's world. Studies from different countries demonstrated that these electronic gadgets can carry different bacterial species, including potential pathogenic strains. These gadgets are in the hands of every health care professionals (HCPs) and can even be found in the operation theatres (OT). Moreover, healthcare workers tend to neglect the potential infectious threat that these gadgets carry. Hence, we investigated the microbial profile present on cell phones used by HCPs in United Arab Emirates (UAE). Standard microbiological procedures were used for collection and identification of bacterial species. Disk diffusion assay and crystal violet dye binding spectrophotometric assay were used for determining antibiogram and biofilm forming potential, respectively. *Staphylococcus epidermidis* was present in 64.1% of the samples, followed by *Micrococci* (22.3%), *Streptococcus viridians* (2.2%), *Diphtheroids* (2.9%), *Bacillus* spp. (5.2%), *Enterobacter* spp. (1.4%) and *Pseudomonas* spp. (1.4%). The tested strains exhibited varied degree of antibiotic resistance and biofilm producing potential. Our data highlights that mobile phones may just not be carriers for normal skin flora but also for antibiotic resistant, biofilm forming potential opportunistic pathogens and thus may serve as transmission vectors for bacteria. This is the first report from UAE analyzing carriage of bacteria in mobile gadgets used by HCPs. Furthermore, this would help to raise awareness among the HCPs about these electronic gadgets serving as a vehicle of transmission of bacterial pathogen.

1 Introduction

Mobile phone is an indispensable communication tool, connecting the people all over the globe and is by far the most commonly used gadget by people, irrespective of their profession. With all the features and benefits of the mobile phone (connectivity, social media), it is easy to overlook the health hazard it might pose to its users, especially in healthcare settings. These mobile phones are increasingly becoming an important means of communication among HCPs in hospitals, as in people of other professions. HCPs carry the mobile phones everywhere even in the operation rooms. The contaminated hands of medical staff play a major role in spreading infections in healthcare

settings^{1,2}. The constant handling of mobile phones by users in hospitals (by patients, visitors and HCPs, etc.) makes it an important vehicle for transmission of microorganisms, thus constitute it as a means of spread of health care-associated infections (HAIs)^{2,3}. This is especially true with those bacteria associated with the skin due to the moisture and optimum temperature of human body especially the palms. These factors and the heat generated by mobile phones contribute to harbouring of bacteria on the device at alarming levels^{4,5}. When we consider a phone's direct skin contact with the face, mouth, ears, and hands, the dire health risks of using germ-infested mobile devices are obvious⁴.

Unlike our hands, which are easily disinfected using alcohol-based hand rubs that are made available readily across all hospitals and medical facilities, our mobile phones are cumbersome to clean and their cleanliness is often neglected. As a result, these devices may have the potential for harbouring various pathogens and can serve as a source of contamination and hospital cross infections^{6,7}.

According to a study from Turkey, 94.5% of phones demonstrated evidence of bacterial contamination with different types of bacteria. The gram negative strains that were isolated from mobile phones was 31.3% and the ceftazidime resistant strains from the hands were 39.5%. Pathogenic strains of *Staphylococcus aureus* isolated from mobile phones of 52% and 37.7% of these were methicillin resistant². Estimated number of bacteria found on the hands of medical personnel ranges between 3.9×10^4 and 4.6×10^6 bacteria per square centimetre³. According to Banawas *et al*⁴ cell phones were contaminated with, *S. aureus*, Coagulase Negative *Staphylococcus* (CoNS), *S. hominis*, *Alloiococcus otitis*, *Vibrio fluvialis* and *Pseudomonas stutzeri*. Moreover, CoNS proved to be resistant to benzylpenicillin, erythromycin, rifampicin and oxacillin. Additionally, one isolate proved to be hetero-vancomycin intermediate-resistant *S. aureus*, was resistant to antibiotics commonly used to treat skin infection which raises significant concerns^{8,9}.

It has been estimated that one third of all infections are caused by organisms acquired within the hospital environment¹⁰. HAIs are becoming increasingly common due to the expansion of the population at risk. Patients in intensive care units (ICUs) and infants in neonatal care units (NCUs) are at highest risks to get HAIs. Among the mobile phones carried by clinicians in ICUs and NICUs, 1.4% were contaminated by MRSA, 62.9 % as *coagulase negative Staphylococcus aureus* (CoNS), 28.6% by *Micrococcus* and 2.8% with *Acinetobacter* species. This is significant because CoNS has been reported to cause early neonatal sepsis in Canada and late onset neonatal sepsis in developed countries and Kuwait^{11,12}.

Healthcare workers tend to neglect the potential infectious threat that these gadgets carry. It was reported that among the emergency department workers, 1.9% of mobile phones had *Staphylococcus aureus*; 0.9% of which was Methicillin Resistant *Staphylococcus aureus* (MRSA)^{2,13}. The same study also showed nasal *S. aureus* carriage rate was 18.1% and 2.9% of which was MRSA, hence, making them likely to be important as vectors in transmission of MRSA and causing Hospital acquired infections (HAIs)¹³. Survey of literature showed that no study was carried out on carriage of bacteria on electronic gadgets (mobile phones) in UAE. This prompted us to undertake this study to determine to the presence of bacteria on mobile phones used by HCPs in Ras Al Khaimah, UAE. We also carried out antibiotic resistance profile and biofilm forming potential of the isolates.

2 Materials and Methods

This study was conducted as a cross sectional study carried out during December 2018 to May 2019. It included medical students, doctors and nurses from Saqr hospital, in Ras al Khaimah, UAE. Sixty-five candidates were chosen by convenient sampling technique. Sample size was calculated using the software Raosoft Inc. (<http://www.raosoft.com/samplesize.html>).

2.1 Questionnaire based survey

The study was approved by institute's ethical committee board and Ministry of Health and Prevention of Ras al Khaimah (MOHP/RAK/SUBC/No: 28-2017-UG-M) and procedures were followed as instructed in the guideline. A questionnaire was given to all the candidates who agreed to be part of this study. Microsoft Excel program was used for statistical calculations.

2.2 Isolation and identification of bacterial strains

The surfaces of the mobile phones were swabbed with saline soaked swab sticks, aseptic techniques were used and careful attention was paid over the keypad and back side of the mobile phones. These swabs were then plated onto blood agar (BA) plates and incubated at 37°C under aerobic condition for 24-48 hours. Identification of bacterial isolates was carried out using standard microbiological techniques such as Gram staining, growth on selective media, and use of a panel of biochemical identification tests (API Biomerieux), latex agglutination tests and diagnostic PCR (Fig 1).

2.3 Antibiofilm analysis of bacterial isolates

For determination of antibiotic resistance profile, Kirby Bauer disk diffusion method was used. The antibiotics used were Penicillin, Oxacillin, Cefoxitin and Erythromycin (Hi-Media, India). The test bacterial suspensions (0.5 McFarland standard) were spread on Mueller Hinton agar plates (MHA) with sterile swab sticks, the antibiotic discs were placed by using sterile forceps and the plates were incubated for 24 h at 37°C¹⁴.

2.4 Determination of biofilm formation

Crystal violet dye binding procedure was used to determine biofilm production potential of the bacterial isolates as described earlier⁸. Bacterial isolates were grown overnight in trypticase soy broth (TSB) and 20 µl culture was added to 200 µl of fresh TSB contained in the wells of the microtiter plates. The plates were then incubated at 37°C for 24-48 hours as required for biofilm formation¹⁴.

Biofilms attached to the wells of the plates were gently washed with normal saline to remove unbound bacteria and the surface bound biofilm was stained with 0.1% (w/v) crystal violet solution for 10 min at room temperature. The stained biofilms were then washed (3X) gently with water. The bound dye was extracted with 100 µl of 95% ethanol, transferred to a fresh 96 well plate and the absorbance of the dye released was determined at 570 nm using

an ELISA reader. The optical density at 570 nm (OD 570) values for each wells were subtracted from those of the blanks (un-inoculated TSB) and these values represented quantitation of biofilm formation. When tube method of biofilm assay was used, bacteria were grown in 1 ml volumes for 24 hours or 48 as needed. The spent media was gently poured off and the biofilm attached to the surface of the tube was gently washed three times with normal saline. The crystal violet staining of the tube biofilm was carried out as described for the plate biofilm as described above. The OD of extracted dye was determined using a spectrophotometer at 570 nm. A strain of *Staphylococcus aureus* which produced robust biofilm was used as positive control in all experiments. The biofilm forming potential of the strains was evaluated on an arbitrary scale of 0 to 4+ using the robust biofilm producer *Staphylococcus aureus* as positive control (producing 4+ biofilm).

3 Results

Among the 65 candidates included in our study, 56.9% (n=37) were doctors, 18.4% (n=12) were nurses, 16.9% (n=11) were medical students and 7.6% (n=5) were technicians. Majority of the candidates 24.6% (n=16) were in the young age group between 18 to 25 years of age. Sixty on percent (n=40) confessed of using mobile phones during medical procedures, 69.2% (n=45) were aware that phone can be contaminated with bacteria and 83.0% (n=54) agreed that mobile phones can be responsible for nosocomial infections (Fig 2).

Fig 1: Flow diagram of the methodology followed in this study

It was a great observation that 36.9% (n=24) of HCPs clean their mobile phones regularly and but only 19.5% (n=8) cleaned it with disinfectants. Moreover, during study we also identified the frequency of cleaning done; 10.7% (n=7) cleaned their mobile phones once in a week, 4.6% (n=3) once in 2 weeks, 15.3% (n=10) once in a month, 32.3% (n=21) once in 3 months and 36.9% (n=24) cleaned it irregularly (Fig 3).

On comparing professions, it was observed that majority of doctors and nurses at least clean their device once in 3 months, whereas, medical students / hospital trainees and technicians were not regular in cleaning their devices (Fig. 2). Mobile phones were frequently kept in pockets by 49.2% (n=32) of study participants, 38.4% (n=25) in pockets or desk, 7.6% (n=5) mostly on desk and 4.6% (n=3) carry it in handbag or backpack during hospital duties.

Fig 2: Awareness among the HCPs about their gadgets being contaminated and are a source of transmission of bacteria

The samples collected from the mobile phones revealed the presence of bacteria producing colonies of different size, shape and color. On staining the bacteria and visualizing them under the microscope, we isolated numerous gram positive cocci in cluster/tetrad/chains, gram negative bacilli, gram positive bacilli as well as spore forming bacilli. Selected gram positive isolates when cultured on mannitol salt agar (MSA) showed non-mannitol fermenters. Selected Gram negative bacilli when cultured on MacConkey's agar were lactose fermenting and were subjected to biochemical tests such as indole test, urease test, Simmons citrate test and triple sugar iodine agar for identification.

Fig 3: Number of times HCPs clean their devices in a week, month and in 3 months

On the proportion of the bacteria, we observed that 64.1% of mobile phones were contaminated by *Staphylococcus epidermidis*, followed by *Micrococci* (22.3%), *Bacilli* (5.2%), *Streptococcus viridians* (2.2%), *Diphtheroids* (2.9%),

Enterococcus (1.4%) and *Pseudomonas spp.* (1.4%) (Table 1). *Micrococci* was mainly found on doctor's phones. *S. epidermidis* being the most common resident flora of skin, was found resistant to all the antibiotics tested such as such as oxacillin, penicillin,

cefoxitin and erythromycin. Their biofilm assay showed 3+, which raises concern of normal flora acquiring drug resistance and biofilm forming potential, which enables bacteria to efficiently colonize infection sites.

Table 1: Percentages of bacterial species isolated, exhibiting resistance to different antibiotics (5 of total isolates and their biofilm forming potential

Total Isolates = 134	<i>S. epidermidis</i>	<i>Micrococci</i>	<i>S. viridians</i>	Diphtheroids	<i>Bacilli</i>	<i>Enterobacter</i> sp.	<i>Pseudomonas</i>
Isolates	85	30	3	4	7	2	2
Percentage	64.1%	22.3%	2.25%	2.9%	5.2%	1.4%	1.4%
Penicillin	58.8	17.8	33.3	75	57.1	50	100
Oxacillin	14.1	0	0	0	0	50	50
Cefoxitin	5.8	0	0	25	0	0	50
Erythromycin	23.5	10.5	33.3	25	14.2	50	100
Biofilm prod.	2-4+	0-2+	0-2+	0-2+	0-2+	0-2+	1-4+

4 Discussion

This study aimed to investigate the bacterial contamination of mobile phones used by the medical students, doctors, nurses and technicians in Saqr Hospital, a government hospital in Ras Al Khaimah, UAE. Our study inferred that mobile phones used by HCPs may carry potential pathogenic bacteria. Hands, instruments, mobile phones or other inanimate hospital objects used by HCPs may serve as vectors for the nosocomial transmission of microorganisms. Unlike fixed phones, mobile phones are often used in hospital areas (wards, emergency rooms, ICU, NICU, OTs) close to the patients and make in-patients more vulnerable to HAIs¹⁵.

This is the first report from UAE on investigating carriage of bacteria on mobile phones used by HCPs. Based on the questionnaire data in our study, 69.2% agree that phones carry pathogenic bacteria; we found that 10.7% clean their mobile phones once in a week, 4.6% once in 2 weeks, 15.3% once in a month, 32.3% once in 3 months and 36.9% clean it irregularly, whereas, in another questionnaire based study found similar results on frequency of cleaning of mobile phones³. In our study we found that mobile phones were frequently kept, mostly in pockets by 49.2% of candidates, 38.4% in pockets or desk, 7.6% mostly on desk and 4.6% carry it in handbag or backpack, which is in contrast to other studies, i.e., majority 54.9% carry it in handbag, 43.4% in pockets and 14.3% kept on desks^{9,12}. Health care professionals, being advisors and care providers to patients, should be aware of risks associated with carrying contaminated mobile phones. One report showed that over 90% of healthcare worker's cell phones were contaminated with micro-organisms, and 14.3% of cell phones were contaminated with bacteria that

can cause nosocomial infection; thus, cleaning mobile phones regularly and properly should also be brought to awareness¹⁰. According to our study, 36.9% (n=24) of HCPs cleaned their mobile phones irregularly and from the remaining 63% (n=41) who clean regularly, only 19.5% (n=8) clean it with disinfectants. Hence, awareness regarding cleaning gadgets with disinfectants should be raised among HCPs

This study found that out of 65 mobile phones tested, 64 mobiles were contaminated with mixed organism which is similar to those reported from Egypt¹, Saudi Arabia^{4,5}, and Kuwait¹². Bacterial species isolated in this study were *S. epidermidis*, *Micrococci*, Aerobic spore formers, *S. viridians*, *Diphtheroids*, *Enterococcus* spp and *Pseudomonas* which was also found in other studies^{1,4,6,9}. A high proportion of our isolates were resistant to all the antibiotics tested in this study, which were oxacillin, penicillin, cefoxitin and erythromycin.

Contamination of the healthcare environment coupled with nosocomial infections can lead to contamination of the cell phones of healthcare workers. The hands of healthcare workers can be contaminated with different bacterial pathogens, and healthcare workers utilize cell phones in laboratories, hospital halls, operating rooms, and intensive care units. Through every phone call, SMS, or other use, there is a risk that the cell phone comes into contact with contaminated areas of the human body by hand-to-hand contact or by hand to other areas, such as the mouth and ears⁴. It is important to note that no methicillin resistant *Staphylococcus aureus* (MRSA) or multi drug resistant bacteria was isolated from any of the mobile phones sampled, indicating less presence and transmission of these super bugs in our hospital community. This is in contrast to other studies from

Egypt and India observing 50% & 25% of MRSA strains present mobile phone surfaces respectively^{1,11}.

A new finding in our study is that *S. epidermidis* isolates which are part of normal skin flora was found to be resistant to penicillin, cefoxitin, erythromycin and oxacillin. These isolates also produced higher amount of biofilm; produced biofilm in the range of 2+ to 4+ as compared to *S. aureus* ATCC positive control strain (graded as 4+ biofilm producer). *S. epidermidis* is nowadays regarded as the most frequent cause of nosocomial infections and indwelling medical device-associated infections^{16,7}. It causes approximately 20% of all orthopedic device-related infections (ODRIs), increasing up to 50% in late-developing infections¹⁰.

S. epidermidis group are still considered the most frequent cause of early prosthetic valve infective endocarditis (PVIE), being responsible for 37 to 47% of early cases and about 25% of late cases, a fatal early PVIE secondary to *S. epidermidis*, with a very aggressive progression, has been reported. In nosocomial drain-associated cases of meningitis / ventriculitis, *S. epidermidis* group were responsible for 73% of documented infections, with two-thirds of isolates found to be oxacillin resistant¹³. In a study enrolling culture-proven, adult bacterial meningitis caused by a single pathogen, 14/127 (11%) cases were caused by coagulase negative staphylococci (CoNS) strains, comprising *S. epidermidis* (71%) and *S. haemolyticus* (29%). In several studies, CoNS of the *S. epidermidis* group were shown to represent the most frequent cause of peritonitis, accounting for around 30% of all episodes, including recurrences^{13,18}.

Streptococcus viridians are normal flora of humans, especially in the oral cavity, upper respiratory tract and all parts of the gastrointestinal (GI) tract. The oral mucosa is the most common portal of entry. It causes sepsis and pneumonia in the neutropenic host and sepsis and meningitis in the neonate¹⁹. *Pseudomonas* account for 80 percent of opportunistic infections. *Pseudomonas* infection is a serious problem in patients hospitalized with cancer, cystic fibrosis, and burns; the case fatality is 50 percent. Other infections caused by *Pseudomonas* include endocarditis, pneumonia, and infections of the urinary tract, central nervous system, wounds, eyes, ears, skin, and musculoskeletal system²⁰. CoNS and *Pseudomonas* spp are opportunistic pathogens and transmission of these to immunocompromised hosts via mobile phones may cause a serious health threat.

Therefore, by simply cleaning our mobile phones we can reduce such infections, especially in immunocompromised patients²¹. Production of biofilm by pathogenic bacteria is considered as a virulence associated attribute of bacteria as bacteria in biofilm usually exhibit enhanced resistance antimicrobial agents and reduced clearance by the host immune system²².

5 Conclusion

In conclusion, the findings of this study indicate that the mobile phones used by HCPs may carry antibiotic resistant and biofilm producing bacteria. This constitute a cause of public health concern as the mobile phones may serve as a vehicle of transmission of infectious agent to immunocompromised patients in critical care settings and also in the community. Although most microorganisms isolated in our study were opportunistic pathogens, they can cause potential harm in immunocompromised patients in ICU and NICU settings, where patients are extremely vulnerable to infections caused by resident flora. Based on our study findings, we recommend HCPs especially doctors, interns and residents to follow simple measures like cleaning of mobile phones with 70% isopropyl alcohol which can bring down the rate of hospital acquired infections. During the ongoing Covid-19 pandemic, such practices are of utmost importance.

6 Conflicts of interest

The authors declare no conflict of interest

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8 Author's contributions

SS & OS: Data collection, Lab experimentation, data analysis, manuscript writing

MM: Technical support and laboratory work,

HA & AH: study design, planning and manuscript editing

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