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Isolation of bacteria from mobile phones before and after decontamination: Study carried out at King Abdulaziz University, Jeddah, Saudi Arabia

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Different fomites which are in regular contact with humans can play an important role in the transmission of microorganisms. Mobile phones have become indispensable in all walks of life; nevertheless their potential role in transmission of infections is of great interest. A cross-sectional study was done (April to June, 2015) at King Abdulaziz University, Jeddah, Faculty of Medicine (female campus), in order to detect the prevalence of bacterial contamination of mobile phones by students and staff, to investigate the most frequent habits associated with the use of mobile phones and effective cleaning of mobile phones with 70% alcohol for decontamination. A total of 168 swabs from 84 mobile phones derived from 80 volunteers were sampled at random. At the same time during sampling, a self-administered questionnaire was developed. All 84 mobile phones sampled were contaminated with bacteria, before decontamination. Coagulase-negative staphylococci were isolated frequently (32.3%), followed by *Staphylococcus aureus* (18.1%), viridans streptococci (15.7%), *Bacillus* spp. (13.4%) and *Corynebacterium* spp. (11.8%). Gram-negative bacilli and other Gram-positive cocci were also isolated but at lower levels. Mobile phones belonging to students had the highest rates of contamination (65.35%), followed by doctors (47%) and administrators (8.67%). Whilst, the lowest rate of bacterial contamination (5.5%) was observed among laboratory technicians, McNemar's analysis indicated that decontamination with 70% alcohol significantly decreased the rate of contamination from 100 to 47.6% (*P*<0.000). This study shows that all mobile phones examined were heavily contaminated with bacteria and the use of 70% alcohol for decontamination was effective in reducing bacterial colonization on these devices. Educating users on hygiene practices while using either mobile phones or other fomites in daily life aspects can help to reduce cross-transmission with microorganisms.

Key words: Medical campus, mobile phones, bacteria, decontaminations, hygiene, contamination, Saudi Arabia.

INTRODUCTION

Bacteria comprise an extremely diverse and widespread group of organisms, capable of inhabiting ubiquitous environmental niche. They grow rapidly as a result of their simple structure and genetic organization (Barer, 2002). Many have simple growth requirements and can withstand harsh environmental conditions, adapted to

growth on the skin of individuals (normal flora) and environmental surfaces. As consequence, there is a continuous exchange of flora between individuals and their environment (Engelkirk and Engelkirk, 2011).

Normal human bacterial flora was previously considered to be non-pathogenic and disregarded. In recent years their clinical importance as opportunist pathogens is increasing. These organisms can cause community and hospital-acquired infections, frequently producing disease when transferred from healthy individuals to susceptible hosts. Both direct and indirect contact has been implicated in such instances for a variety of different organisms (Soto et al., 2006; Arora et al., 2009; Elkholy and Ewees, 2010).

Indirect transmission via numerous objects such as objects, which have prolonged contact with the skin and those that are handled for extensive periods of time can transmit bacteria in health-care settings (Karabay et al., 2007; Kawo et al., 2009; Kilic et al., 2009; Ulger et al., 2009; Singh et al., 2010). Mobile phones (MPs) have recently become common in daily life aspects throughout the world, which require extensive human contact. Although, phones are important communication means in hospitals, their widespread use raise public health concerns as they may be implicated in the transmission of infections (Goldblatt et al., 2007; Karabay et al., 2007; Tagoe et al., 2011; Julian et al., 2012).

Several studies have shown that, MPs may be contaminated with pathogenic bacteria and serve as a vehicle for their transmission (Karabay et al., 2007; Tagoe et al., 2011). Further, it has been established that contamination of various other user interfaces can differ geographically and also within different institutions or communities (Oluduro et al., 2011). This is probably associated with variation in usage habits and implementing of hygiene practices.

Literature on bacterial contamination of MPs in the Kingdom of Saudi Arabia (KSA) till date remains scanty (Al-Abdalall, 2010; Zakai et al., 2016). Therefore, this study was initiated in order to establish the importance of MPs as possible vehicles for infectious bacteria, amongst preclinical female students and staff at a medical campus in KSA to investigate the effective cleaning of mobile phones with 70% alcohol for decontamination.

MATERIALS AND METHODS

Sampling

A cross-sectional study was conducted (April to June, 2015) at the King Abdulaziz University (KAU), Faculty of Medicine (female campus). Two samples were collected from each mobile phone. The first swab was taken before decontamination and the second after cleaning the device with 70% alcohol wipe. A total of 168 swabs from 84 MPs derived from 80 volunteers (4 participating staff had two MPs) were randomly sampled. The study groups included; 52 preclinical medical students (2nd and 3rd year), 8 nursing students, 11 doctors, 5 laboratory technicians and 4 administrative staff.

The samples were taken with a sterile cotton swab which was moistened with sterile saline solution and the target phone was wiped off the surface on both sides of the mobile (that is over the keypad and back of the mobile phones, in case of mobile phones with covers, swab taken from the outer surfaces of the cover) using aseptic techniques (sterile gloves were used to avoid cross-contamination).

Data collection

During sample collection, a self-administered questionnaire was used to collect information regarding the socio-demographic data relating to the nature and frequency of use, cleaning habits, contact with animals, use in toilets and regular sharing of their MPs. Written informed consents for participation were obtained from all of the volunteers who allowed us to collect samples from MPs for this study.

Bacteriological analysis

Samples were inoculated immediately and aseptically into 10 ml of brain-heart infusion broth (Saudi Prepared Media Laboratory, SPML, Riyadh) and shaken using a vortex mixer for 1 min. All tubes were labeled with specimen number and incubated at 37°C for 24 h aerobically. After incubation, specimens were sub-cultured on 5% sheep blood (SPML, Riyadh) and MacConkey (SPML, Riyadh) agar plates at 37°C for 24 to 48 h. After this, plates were examined for growth and colonial morphology of the isolates.

Preliminary identification of bacteria was based on Gram reaction, colony characteristics (colonial morphology), and change in physical appearance of different media, and presence of catalase and oxidase (Oxoid Limited, UK) enzymes. Gram-positive, catalase-positive cocci were tested for mannitol fermentation and coagulase development by using mannitol salt agar (SPML, Riyadh) and coagulase test (Oxoid Limited, UK), respectively.

Antimicrobial susceptibility testing

All *Staphylococcus aureus* (*S. aureus*) and enterococci strains were screened for oxacillin (1 µg) (Oxoid Limited, UK) and vancomycin (30 µg) (Oxoid Limited, UK) resistance using the Kirby-Bauer disk diffusion method on Muller-Hinton agar (SPML, Riyadh), according to the Clinical and Laboratory Standards Institute Guidelines criteria (CLSI, 2012).

The test strain was suspended in a nutrient broth (SPML, Riyadh) and incubated for 30 min to make it comparable with 0.5%

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McFarland standard. After incubation, a sterile cotton swab was dipped into suspension and bacteria were inoculated on Muller-Hinton agar (SPML, Riyadh). Antibiotic discs were placed by using a disc dispenser and plates were incubated for 24 h at 37°C.

Statistical analysis

Data was entered and analyzed using Statistical Package for Social Science (SPSS, version 21). Comparisons of data were performed using McNemar's test; *P*-value of less than 0.05 was considered as statistically significant. Statistical analysis was carried out in Statistics and Information Processing Unit, King Fahad Medical Research Center, in KAU, Jeddah, Saudi Arabia.

RESULTS

Epidemiological survey

Demographic results showed that the age range of the participants was between 19 to 55 years; all were female. About 70% of participants used "iPhones" rather than other smart phones and 83.75% used their phones extensively (several hours). Almost half of those surveyed (57.5%) used their phones for both work and personal use. The most common use for smart phone was sending or receiving texts and making or receiving calls.

In addition, individuals indicated using social networking websites, internet, e-mail for studying and downloading lectures. Few reported use of their device to take, send and receive photos or to record, send, receive and play videos. Many participants indicated that in the absence of a watch, they use their phones to keep time.

About 8.75% reported that they never decontaminated their devices; while about half of the participants (52.5%) decontaminated their phones when visibly dirty. Others clean their phones at different intervals. About 11.25% of participants decontaminated their mobile with alcohol wipe and 33.75% stated they just wiped with their sleeve or cloth. About 47.5% reported that they used their phones in toilet and 93.75% indicated they washed their hands after using toilet. About 78.75% of participants had no pets whilst, 26.25% of those responding stated they share their cell phone with friends or family members.

Overall bacteriological results before decontamination of mobile phones

All 84 phones screened in this study showed bacterial growth before decontamination. The findings indicated that coagulase-negative staphylococci (CNS) (n=41), *S. aureus* (n=23), viridans streptococci (n=20), *Bacillus* spp. (n=17), *Corynebacterium* spp. (n=15), Gram-negative bacilli (GNB) (n=8), *Enterococcus* spp. (n=2) and *Micrococcus* sp. (n=1) were most frequently associated with mobile phones. The recovery rate was between 0.8 and 32.3% (Table 1).

Distribution of results according to occupation

Mobile phones belonging to students had the largest variety of bacteria with highest rates of contamination (83/127; 65.35%), followed by doctors (26/127; 20.47%) and administrators (11/127; 8.67%) whilst, the lowest rate of bacterial contamination (7/127; 5.5%) was observed among laboratory technicians.

Pathogenic bacteria such as *S. aureus* were mostly isolated from MPs of medical students (19/23; 82.6%) (Table 2). Neither methicillin-resistant *Staphylococcus aureus* (MRSA) nor vancomycin-resistant enterococci (VRE) were isolated from MPs in this study.

Overall bacteriological results after decontamination of mobile phones

All 84 MPs sampled in this study were contaminated with bacteria before decontamination, and this made an isolation rate of 100%. When the rate of bacterial isolation was evaluated after decontamination with 70% alcohol from the MPs, assessed growth was observed in 40 (47.6%) and about 44 (52.4%) of mobile phones did not show any growth after decontamination (Table 3).

Figure 1 shows type and frequency of bacteria isolated from MPs of medical students and staff in Faulty of Medicine (female campus) at KAU before and after decontamination with 70% alcohol.

In this study, 70% alcohol showed a significant reduction in the rate of mobile phone contamination with McNemar's test (*P*-values) of 42.023 (<0.000).

DISCUSSION

Mobile phones due to their personal nature and proximity to delicate parts of our bodies in usage such as faces, ears, lips and hands of users could become important modes of transmission for pathogens that could result in infections (Karabay et al., 2007; Kilic et al., 2009).

Bacterial contamination was found on all MPs investigated in this report. Other workers in Nigeria (Ilusanya et al., 2012), Ghana (Tagoe et al., 2011), Egypt (Selim and Abaza, 2015) and in India (Kumar and Aswathy, 2014) have also similarly reported contamination on all devices investigated. Reporters have documented varying levels of contamination ranging from 43.6 to 98% (Akinyemi et al., 2009; Sadat-Ali et al.,

Table 1. Bacteria isolated from mobile phones.

Bacterial isolate	Number recovered	Percentage
Coagulase-negative staphylococci (CNS)	41	32.3
Staphylococcus aureus	23	18.1
Viridans streptococci	20	15.7
Bacillus spp.	17	13.4
Corynebacterium spp.	15	11.8
Gram-negative bacilli (GNB)	8	6.3
Enterococcus spp	2	1.6
Micrococcus sp.	1	0.8
Total	127	100

More than one type of bacterial growth was seen in some mobile phones.

Table 2. Distribution of bacteria isolates from mobile phones according to occupation.

Bacterial isolate	Students (n=60)	Doctors (n=11)	Lab technicians (n=5)	Administrator (n=4)
Coagulase-negative staphylococci (CNS)	26	9	3	3
Staphylococcus aureus	19	2	2	-
Viridans streptococci	12	3	1	4
Bacillus spp.	10	4	1	2
Corynebacterium spp.	11	2	-	2
Gram-negative bacilli (GNB)	3	5	-	-
Enterococcus spp.	1	1	-	-
Micrococcus sp.	1	-	-	-
Total	83	26	7	11

Table 3. Bacterial growth after decontamination of mobile phones with 70% alcohol.

Cell phone	Growth positive	Growth negative	Total	*P* value
Before	84	0	84	42. 023
After	40	44	84	

2010; Elmanama et al., 2015; Roy et al., 2013; Gashaw et al., 2014). These differences in microbial contamination can be attributed to varied usage habits and frequency of cleaning the device (Ovaca et al., 2012; Mark et al., 2014).

This study showed that participants were using their MPs extensively each day, with majority (83.75%), stating that their daily usage totaled at many hours each day. This is much higher than a previous report stating that 25% of the participants did not use their device at work and a further 52% used their phones on less than 10 occasions in a day (Mark et al., 2014). These high contamination rates can be attributed to several factors; such as extensive use (many hours each day), frequent use in toilets as reported by almost half of the volunteers and sharing the device with family or friends also reported in about a quarter of those investigated.

A previous investigation in Kuwait documented that 33.5% of their participants “Never” cleaned their MPs and 73% of these devices yielded microbial growth (Heyba et al., 2015) whilst other workers from Egypt reported that 96.5% of those surveyed “Never” cleaned their device and 92.5% of those MPs were contaminated (El-Ashry and El-Sheshtawy, 2015). During the course of this work, 8.75% of those volunteering stated they “Never” cleaned their device. For the majority of our volunteers however, cleaning constituted simply wiping their MPs on their clothes and sleeves. The use of alcohol wipe for cleaning

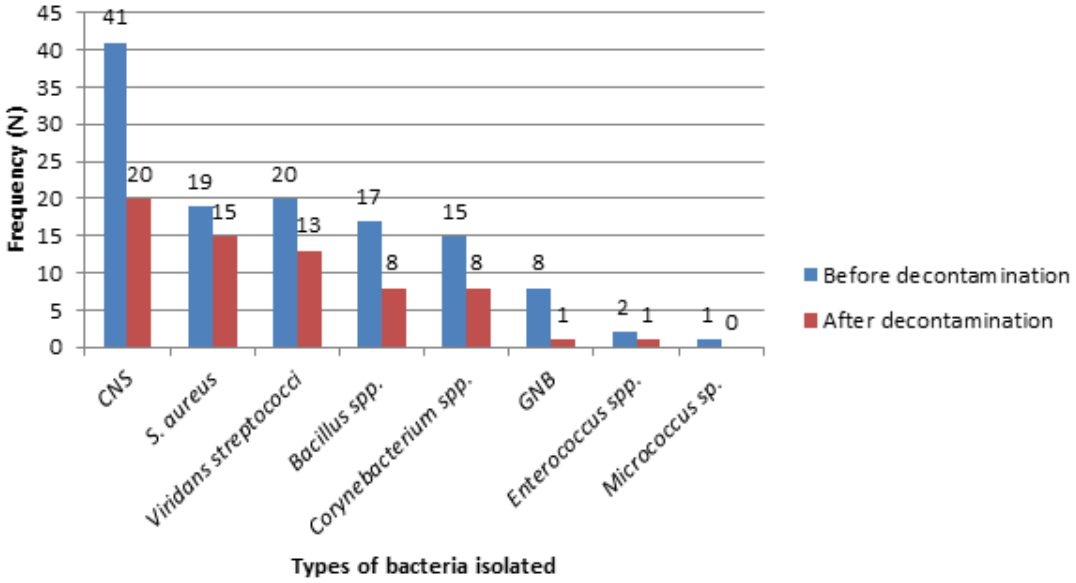

Figure 1. Type and frequency of bacteria isolated from mobile phones before and after decontamination.

was reported by only 11.25% of our subjects. It is possible to speculate that dry-wiping methods (on clothing) do not reduce microbial contamination of the MPs which may even enhance it.

Gram-positive bacteria were isolated more often (93.7%) than Gram-negative bacteria (6.3%) in this study. Similar results have been reported previously (Arora et al., 2009; Zakai et al., 2016). Most normal microbial skin flora, are Gram-positive bacteria (Roth and James, 1998), a fact that explains their predominance on MPs. Coagulase-negative staphylococci (32%), *S. aureus* (18.1%), viridans streptococci (15.7%) *Bacillus* spp. (13.4%) and *Corynebacterium* spp. (11.8%) were the most frequently isolated organisms in this experience; these findings are in line with other reports (Akinyemi et al., 2009; Arora et al., 2009; Roy et al., 2013; Heyba et al., 2015; Zakai et al., 2016).

In addition, it has been previously established that frequent contact with skin microbial flora and sustainable temperatures for bacterial growth attained on the device while in use provide a favorable environment for the growth of these microorganisms (Roth and James, 1998). Storage of MPs in pockets, handbags and brief-cases is likely to further encourage bacterial growth with warm and protected surroundings environment (Brady et al., 2006).

In this study, CNS (32%) was the most prevalent species. Other research has similarly shown CNS often, ranging from 22 to 68% of all isolates (Roy et al., 2013; El-Ashry and El-Sheshtawy, 2015; Heyba et al., 2015; Zakai et al., 2016). Although non-pathogenic in normal circumstances, their presence in high numbers on objects involving frequent hand contact like MPs in settings like intensive care units (ICUs) may pose a risk of bacteremia in immunocompromised patients (Brady et al., 2006). In addition, diseases such as late-onset neonatal sepsis, endophthalmitis and urinary tract infections have been documented (Rogers et al., 2009; Sgro et al., 2011). *S. aureus* isolated from 18.1% of MPs investigated are recognized pathogens, frequently isolated as the causative agents from a wide range of infections, ranging from simple skin infections (pimples and boils) to serious life threatening pneumonias and meningitis (Engelkirk and Engelkirk, 2011). The presence of *S. aureus* on MPs as on other fomites in hospital settings therefore is of significant concern. Our results show that *S. aureus* were mostly isolated from MPs of medical students (19; 82.6%). Other studies have also concluded that *S. aureus* was detected very often (Akinyemi et al., 2009; Ilusanya et al., 2012; Zakai et al., 2016). *S. aureus* is a major component among the normal flora of the skin and nostrils. Its predominance in the bacterial contaminants on MPs may be because it is easily discharged by numerous human activities such as sneezing, coughing, talking and other actions involving skin contact (Itah and Ben, 2004)

Bacillus spp. was commonly associated with MPs in this study (13.4%). This finding is explained by the ubiquitous nature of this organism in the environment, since it can survive harsh conditions being one of the few organisms that can sporulate and spread when met with sub-optimal conditions (Brooks et al., 2013). *Bacillus* spp.

like CNS although generally considered to be of low virulence are known to be opportunist pathogens in patients predisposed to infections.

By contrast, a previous report from KSA has documented higher levels of GNB than our current findings (Al-Abdalall, 2010). Presence of GNB in high proportions suggests contamination of MPs with faecal flora; such organisms often originate from soil, clothing, food and/or on the hands of the users (Al-Abdalall, 2010) can result in community-acquired infections. When GNB are detected frequently in fomites, special attention is advocated to hand washing and hygienic practices. In conjunction with this view, the use of the MPs in toilet facilities has also been a subject of some interest. In the present study, 47.5% reported the use of MPs in toilets, while other workers have documented 59% of their participants (Zakai et al., 2016). However, encouragingly regular hand washing practice was reported by 93.75% of our subjects but was not investigated in the previous study (Zakai et al., 2016). Similarly, the efficacy of good hand hygiene in reducing contamination of MPs was reported previously (Goldblatt et al., 2007). This seems to be corroborated by the finding that we did not isolate faecal flora on the MPs which were investigated very often. Hence, the importance of hand washing can be emphasized further.

Neither MRSA nor VRE were isolated from MPs in this study. These findings corroborate other reports both from Saudi Arabia (Al-Abdalall, 2010) and some other countries (Akinyemi et al., 2009; Singh et al., 2010). However, other investigators have previously detected MRSA from MPs, this may have been a reflection of the fact that these reports originated entirely from healthcare settings (Julian et al., 2012) and the higher prevalence of MRSA generally in hospital settings is well known (Barer, 2002; Ulger et al., 2009).

Mobile phones belonging to students had the greatest variety of bacteria with highest rates of contamination (83; 65.35%), followed by doctors (26; 20.47%) and administrators (11; 8.67%) whilst, the lowest rate of bacterial contamination (7; 5.5%) was observed among laboratory technicians. The level of contamination varied among different occupational groups; as this could be related to differences in hygiene level and sanitary practices together with education, extent of mobile use, environmental pollution and sharing mobile phone with friends or family members (Rusin et al., 2002; Akinyemi et al., 2009; Kawo and Musa, 2013). The variation in sample size could have been the reason for this observation.

It is possible to suggest that students generally spend more time handling their devices for different purposes (including time consuming research tasks) and may have a tendency to pass their MPs between friends, to share information with lack of professional recommendations on how to clean the mobile phones to meet hygiene standards. Laboratory workers on the other hand due to the nature of their work are unlikely to handle MPs for extended periods of time during working hours and are trained to wash their hands more frequently following their laboratory work. Most laboratories have posters informing staff about the importance of hand washing in designated areas and have facilities for washing within the laboratory area.

A high rate of bacterial contamination of mobile phones (100%) was recorded in this study before decontamination. The efficacy of decontamination with 70% alcohol at 52.4% was statistically significant (McNemar's test =42.023; *P*-value <0.000). This suggests that the use of a decontaminating agent such as 70% alcohol, play an important role in reducing bacterial colonization on MPs. Other workers have reported the efficacy of 70% alcohol in decontaminating MPs at 47% (Gashaw et al., 2014) and 98% (Arora et al., 2009).

Previous work has shown that the use of “antibacterial putty” is effective in reducing microbial contamination of phones (Ovaca et al., 2012). It is pertinent to suggest that in hospital settings such antibacterial agents or stronger ones are required to effectively decontaminate MPs. Other investigations have shown that implementation of regular cleaning with isopropyl alcohol wipes or 0.5% chlorohexidine and 70% isopropyl alcohol successfully reduced contamination rates of MPs (Beer et al., 2006; Goldblatt et al., 2007; Jayalakshmi et al., 2008).

Further work using different agents for decontamination of MPs is required in order to recommend standard cleaning practices especially in hospital settings. Hospital Infection Control Units must review policies regarding the use of MPs by personnel in patient contact and draw up suitable guidelines for use, stipulating cleaning policies and periodic sampling of MPs, in order to differentiate between transient and resident MPs flora. We envisage that guidelines such as those presently in existence for hand washing and food handlers are warranted for MPs. In addition, further research into the materials used for MPs manufacture with a view of finding those which discourage bacterial growth may be relevant. The use of “disposable MPs covers” in hospital settings in areas where other infection control methods such as gloves, aprons and masks are usually required may be stipulated.

Conclusion

Results in this study shows that all MPs samples carried numerous bacteria, of which some are known as opportunist pathogens. Application of 70% alcohol which resulted in significant reduction of bacterial contamination, suggest a potential decontaminating agent for MPs. In

addition, it is an easily accessible, safe and cheap agent.

Other factors such as personal hygiene and hand washing in particular are instrumental in preventing the transfer of microorganism from user hands to fomites such as MPs and vice versa. These findings substantiate the need for future investigations in order to monitor the transfer of pathogenic bacteria mediated by MPs and to educate users on the potential health-risk that may be posed by contaminated fomites such as transmission of infections.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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