

Original Article

The bacterial colonization of healthcare workers' mobile phones in a large tertiary care teaching hospital in Saudi Arabia

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Abstract

Introduction: The use of mobile phones by healthcare workers is a risk factor for microorganism transmission in healthcare settings. Pathogenic bacteria such as methicillin-resistant *Staphylococcus aureus* and gram-negative bacteria like *Escherichia coli* that are known to cause nosocomial infection have been isolated from mobile phones. In this cross-sectional study, we assess the burden and related risk factors of the bacterial colonization of healthcare workers' mobile phones.

Methodology: We collected samples from the mobile phones of 130 healthcare workers' in a Saudi Arabian teaching hospital, using moistened cotton swabs. The isolated organisms were identified using an automated identification and susceptibility system. Multiple logistic regression analysis was used to test the data.

Results: Of 130 swabs collected, 45 (34.6%) grew one species and 48 (36.9%) grew two or more. *Staphylococcus epidermidis* was the most commonly isolated bacteria (52.3%), followed by *Micrococcus* and related species (25.4%), *Staphylococcus hominis* (13.8%), and *Bacillus* species (6.9%). Clinically significant microorganisms such as *S. aureus* and *Pseudomonas* sp. were identified in 2 (1.5%) samples, respectively. The odds of mobile phone colonization were 8.5 times higher (95% CI = 3.2-23.1) in the laboratory, neonatal intensive care unit, and medicine departments. Mobile phones owned for more than one year were more likely to be culture positive (OR = 2.9, 95% CI = 1.1-7.6).

Conclusions: In our study, the prevalence of bacterial colonization among healthcare workers' mobile phones was high. Our findings suggest that high-risk groups for mobile phone colonization—such as laboratory, neonatal intensive care unit, and medicine department staff—should be a priority for preventative measures, to improve infection control.

Key words: colonization; healthcare workers; microorganism; mobile phone; *Pseudomonas* spp.

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Introduction

There is no denying that mobile phones have become ubiquitous, particularly since the emergence of smartphones, and they have played an essential role in improving communication, collaboration, and information sharing among healthcare professionals. However, the extensive use of these devices in the hospital setting is also increasingly a matter of concern, as they have been identified as a source of nosocomial infection, especially in critical areas such as intensive care units and operating rooms [1-3].

In hospitals and other healthcare facilities, the mobile phones of healthcare workers (HCW's) have been found to be colonized with potentially pathogenic microorganisms that could be transmitted to patients through the hands of the HCW's. Correspondingly, it has been suggested that appropriate cleaning and

sanitization of these mobile phones could reduce the load of those potential pathogens [4].

A recent study investigated the types and amount of bacterial genera found on cell phones and on the shoes of people attending community events in the United States, and concluded that these two sites have two distinct taxa of bacteria. The cell phones were found to harbor bacteria that are common in the skin and oral flora of humans, while the shoes' microbiomes represented bacterial taxa normally present in the environment [5]. These types of bacteria tend to multiply in high temperatures, and mobile phones turned out to be ideal for such multiplication, stored as they typically are in warm environments such as handbags, briefcases, and pockets. Such organisms are known to cause opportunistic infections in humans, given suitable conditions [6]. A review article published

in 2009 emphasized the role of mobile phones as reservoirs of nosocomial pathogens [7], but there remains a lack of literature specifically pertaining to microorganism colonization of mobile phones in hospital settings in Saudi Arabia. Therefore, in the present study, we propose to identify the burden and related risk factors for the bacterial colonization of HCW's mobile phones in one of the major teaching hospitals in the Kingdom.

Intensive care HCW's mobile phones have been documented as being colonized with pathogenic bacteria such as *Staphylococcus aureus* even after sanitization [8]; likewise, other studies have isolated multidrug-resistant gram-positive and gram-negative bacteria like *S. aureus* and *Klebsiella pneumoniae*, respectively, from the mobile phones of HCW's [9].

Table 1. Demographic characteristics of the HCW's and medical students, and their hygiene practices with respect to mobile phone use in the hospital.

Characteristics	N (%)
Gender	
Female	91 (70)
Male	39 (30)
Department	
Laboratory	30 (23)
Medicine	44 (34)
Surgery	16 (12.3)
MICU/CCU	10 (7.7)
NICU	10 (7.7)
PICU	10 (7.7)
SICU	10 (7.7)
Specialty	
Nurse	66 (50.1)
Medical students	30 (23.1)
Technician	15 (11.5)
Intern/residents	12 (9.2)
Consultant	7 (5.4)
Length of mobile phone ownership	
One year or less	37 (28.5)
More than one year	93 (72)
Using the mobile phone in the hospital	
Yes	117 (90)
No	13 (10)
Using the same mobile phone at home	
Yes	129 (99)
No	1 (1)
Using the mobile phone inside the patient's room	
Yes	52 (40)
No	78 (60)
Regularly cleaning mobile phone	
Yes	65 (50)
No	64 (49.2)
Washing hands after using the mobile phone	
Yes	27 (21)
No	103 (79)

CCU: critical care unit; MICU: medical intensive care unit; NICU: neonatal intensive care unit; PICU: pediatric intensive care unit; SICU: surgical intensive care unit.

The source of the bacteria on these mobile phones—that is, whether it is acquired from within or outside of the hospital setting—is still not clear, but research has found that there is no significant difference of type or burden of colonization with gram-positive bacteria, including methicillin-resistant *S. aureus* (MRSA), between the beginning or the end of the HCW's shifts [10].

The bacterial colonization of mobile phones has been investigated in various research settings in different countries of the world, and a recent review showed that bacterial pathogens are more commonly isolated than fungal or viral pathogens and bacterial pathogens [11,12]. In prior studies, *S. aureus* and coagulase-negative *Staphylococci* are the most commonly isolated bacteria, including MRSA, while *Escherichia coli*, *Acinetobacter*, and *Bacillus* species have also been reported.

Methodology

Our cross-sectional study was conducted at King Saud University Medical City, a tertiary care center in Riyadh, Saudi Arabia. HCW's (whether directly or indirectly involved in patient care) and medical students were recruited from several departments to participate in our study during the period from October to December 2018. All HCW's present in the hospitals various wards (Table 1) at the time of the survey were recruited. Written consent was obtained prior to administering an electronic questionnaire to and collecting swab samples from the mobile phones of participants. This study was approved by the Institutional Review Boards of the College of Medicine, King Saud University.

A self-administered questionnaire was used to collect demographic data such as gender, occupation, and the department in which the participant worked. Questions pertaining to mobile phone ownership and usage referred to how long a currently used phone had been owned, the use of phones at the hospital and specifically in patients' rooms, and whether the same phone was used at home. Furthermore, participants were asked whether they cleaned their phones regularly and if they washed their hands following the use of their phone.

Samples were collected by rotating a sterile gel swab dampened with saline on all the surfaces of each participant's mobile phone, with an emphasis on the phone's buttons. The swabs were then cultured on sheep blood agar and MacConkey agar. The samples plated on the blood agar media were incubated at 35–37 °C in a CO₂ atmosphere for 48 hours, to allow for

better growth of facultative anaerobic bacteria such as *Enterobacter* (gram-negative) and *Streptococcus* (gram-positive) species. Samples plated on the MacConkey agar were incubated aerobically for a similar period of time. Readings were performed in the first 24 hours, and plates showing no growth or no clear growth were read after 48 hours. MicroScan was used to identify growth.

Statistical analyses were conducted using IBM SPSS Statistics for Windows, version 21.0 (IBM Corp., Armonk, NY, USA). Descriptive statistics were used to characterize the sample. Pearson’s chi-squared or Fisher’s exact tests were used to evaluate associations between categorical variables. Variables with a *p* value of less than .10 were included in a multiple logistic regression model. Statistically significant variables (*p* < 0.05) were kept in the final model.

Results

Nurses accounted for 66 (50.1%) of the study’s participants, medical students 30 (23.1%), and technicians 15 (11.5%), intern residents 12 (9.2%) and Consultants 7 (5.4%). All participants reported that the swabbed mobile phone was their primary phone, and the duration of mobile phone ownership was more than one year in most of the respondents (72.6%)—findings that tally with those from a similar local study [13]. The use of mobile phones inside the hospital was confirmed by 117 (91.4%) of the participants, while 61 (46.9%) advised that they used their mobile phone inside patients’ rooms, and 65 (50%) reported regularly cleaning their mobile phones. A significant number of participants (93, representing 73.8%) did not wash their hands following mobile phone use. Table 1 presents the study participants’ characteristics and the hygiene practices they reported.

Table 2. Isolated microorganisms from the mobile phones of HCW’s.^a

Microorganisms	Frequency of isolation (%)
<i>Staphylococcus epidermidis</i>	68 (52.3)
<i>Micrococcus</i> and related species	33 (25.4)
<i>Staphylococcus hominis</i>	18 (13.8)
<i>Bacillus</i> species	9 (6.9)
<i>Staphylococcus aureus</i>	4 (3.1)
<i>Staphylococcus warneri</i>	4 (3.1)
<i>Staphylococcus haemolyticus</i>	3 (2.3)
Other <i>Staphylococcus</i> species	7 (5.4)
<i>Streptococcus mitis</i> / <i>Streptococcus oralis</i>	6 (4.6)
Other microorganisms ^b	7 (5.4)

^a *n* = 130; ^b 2 *Pseudomonas stutzeri* (medical ward); 1 *Enterobacter agglomerans* (medical ward); 1 *Acinetobacter lwoffii* (surgical ward); 2 *Rothia dentocariosa* (surgical ward/pediatric intensive care unit); 1 fungus yeast-like organism (*Candida*) (pediatric intensive care unit).

Out of 130 collected swabs, 93 (71.5%) grew microorganisms. Of these, 45 (34.6%) swabs grew one species, 35 (26.9%) grew two species, 9 (6.9%), and 4 (3.1%) of the swabs grew three and four species, respectively. *Staphylococcus epidermidis* was the most commonly isolated bacteria, at 68 instances (52.3%), while *S. aureus* was isolated from just 4 samples (3.1%). Other isolated bacteria are shown in Table 2.

In univariate analyses, the risk of having a culture-positive mobile phone was found to be higher among the study’s male participants. Respondents from the laboratory, NICU (neonatal intensive care unit), and medicine departments had a greater chance of owning culture-positive mobile phones, compared to those from the SICU (surgical intensive care unit), MICU (medical intensive care unit), CCU (critical care unit), PICU (pediatric intensive care unit), and surgery departments. The mobile phones of residents, interns, students, and technicians were more likely to show growth, compared to those of consultants and nurses. Owning a mobile

Table 3. Factors associated with owning culture-positive cell phones.

Factor	Culture positive <i>n</i> (%)	Unadjusted OR (95% CI) ^a	<i>p</i> value	Adjusted OR (95% CI) ^a	<i>p</i> value
Gender					
Male	29 (85.3)	2.9 (1.0, 8.1)	0.042	—	—
Female	63 (67.0)	Reference		—	—
Department^b					
Laboratory/NICU/Medicine	57 (89.1)	8.1 (3.2, 20.8)	< 0.001	8.5 (3.2, 23.1)	< 0.001
SICU/MICU/CCU/PICU/Surgery	30 (50.0)	Reference		Reference	
Occupation					
Resident/Intern/Student/Technician	51 (91.1)	7.7 (2.8, 21.6)		—	—
Consultant/Nurse	41 (56.9)	Reference	< 0.001	—	—
Length of mobile phone ownership					
More than one year	68 (75.6)	2.2 (0.9, 5.0)		2.9 (1.1, 7.6)	
One year or less	20 (58.8)	Reference	0.067	Reference	0.036

^a CI: confidence interval; OR: odds ratio; ^b CCU: critical care unit; MICU: medical intensive care unit; NICU: neonatal intensive care unit; PICU: pediatric intensive care unit; SICU: surgical intensive care unit.

phone for more than one year was shown to be a risk factor for bacterial colonization too.

In a multiple logistic regression analysis (Table 3), the odds for the bacterial colonization of mobile phones was found to be 8.5 times higher (95% CI = 3.2-23.1) in the hospital's laboratory, NICU, and medicine departments, compared to its SICU, MICU, CCU, PICU, and surgery departments. In addition, cell phones that had been owned for more than one year were more likely to be culture positive (OR = 2.9, 95% CI = 1.1-7.6) than those owned for less than a year.

Discussion

There is strong evidence from the published literature that contamination of the healthcare environment with microorganisms is a source of nosocomial infections [7,14,15]. In recent years, the use of mobile devices has increased, and this carries a subsequent risk that they too may be colonized by multidrug-resistant microorganisms from the clinical setting. Several gram-positive pathogenic bacteria, such as *S. aureus* and *Enterococcus* species, as well as gram-negative bacteria like *Acinetobacter* species, *E. coli*, *K. pneumoniae*, and *Pseudomonas* species that are known to be significant causes of nosocomial infection have been isolated from mobile phones, while the rate of multidrug resistance in gram-negative bacteria—especially *Pseudomonas* species, *K. pneumoniae*, and *Citrobacter* species— isolated from mobile phones is reported to be 70% and the rate of MRSA isolation in another study was found to be 26% [16,17].

In the present study, more than 70% of all swabs collected from the mobile phones of the HCW participants grew microorganisms. In our analysis, a single *Acinetobacter* species and four *S. aureus* strains were isolated, but no MRSA was detected. The most frequent isolates were *S. epidermidis*, *Micrococcus* and related species, and *Bacillus* species. These results are similar to those of a recent study based in Pakistan that found similar isolates, but higher rate of colonization, at 93% [18]. On the other hand, an older study found cultures of at least one potentially pathogenic organism in 75% of samples obtained from HCW's, including methicillin-sensitive *S. aureus* (MSSA), MRSA, and *Acinetobacter* species [19]. Still other reports have found mobile phone colonization ranging from 59% to 72%, depending on the HCW roles in three different hospitals, comprising both potentially pathogenic bacteria like MSSA, MRSA, and *Acinetobacter*, *Pseudomonas*, and *Enterobacter* species, as well as non-pathogenic bacteria such as *Bacillus* and coagulase-negative *Staphylococcus* [20].

The variability of the findings between the studies may be explained according to the different populations of HCWs included, the sample sizes, and the study designs employed, as well as the geographic areas that were covered. For example, locally, researchers at the College of Medicine in the eastern region of the Kingdom reported a lower rate than we did of microorganism colonization of HCWs' cell phones (43.6%), which were found to carry coagulase-negative *Staphylococcus*, MSSA, MRSA, *Streptococcus*, *E. coli*, *Enterobacter*, *Acinetobacter*, and *Pseudomonas* species, among others [21]. Furthermore, an earlier report from a western region of the Kingdom showed the highest rate of colonization (77%) of *Proteus* bacilli isolated in 19% of the sample, and *E. coli* in 20%, as well as fungi, while other studies from the same region have reported a higher rate of bacterial colonization of the mobile phones of medical students (96%), with high prevalence of viridans streptococci and *Pantoea* bacteria [22,23]. The rate of mobile phone contamination reported can vary from 80% to 92%, but medical staff and laboratory technicians consistently are found to have the highest rate of colonization, compared to other non-medical subgroups, and much less than other HCWs. Similarly, other investigators have found there to be a significant difference in the percentages between HCW's and non-HCW's—87% versus 56%, respectively— with 6% extended-spectrum beta-lactamases and 6% to 16% MRSA [16,24-26]. In addition, fungal isolates like *Aspergillus* and *Candida* have been identified on mobile phones [22,27,28].

The clinical significance of isolating pathogenic bacteria from the mobile phones of HCW's in terms of their causing nosocomial infections depends on many factors, such as microorganism virulence and host susceptibility, as well as the compliance of the HCW's with infection control measures— especially hand hygiene. For example, it has been found that the *S. aureus* isolates on the hands or phones of physicians did not match those grown from specimens sampled from patients within the clinical environment [29-31].

In cases of multidrug-resistant organism outbreaks investigation in hospitals, it is sometimes challenging to identify the source of the microorganism. One supposition is that the source of an outbreak may be the environment surrounding the patients, such as beds, linens, and curtains, which have susceptibility patterns similar to the outbreak strain [32].

Additionally, while coagulase-negative *Staphylococcus* and *Micrococcus* bacteria are generally considered to be normal skin flora and to have very low

virulence, they have been isolated in clinical samples from patients with serious infections, in patients with foreign bodies such as catheters or prostheses, and in immunocompromised hosts, and have been found to be resistant to many commonly used antibiotics [33-36]. Enterobacteriaceae, a family of bacteria that includes *E. coli*, *Klebsiella*, and others, is among the multidrug-resistant organisms prioritized for attention by World Health Organization (WHO), as they harbor genes encoding resistance to many commonly used antibiotics [37]. These organisms can colonize in the gastrointestinal tracts of patients and HCW's, and have also been documented to be the source of infection in a susceptible host [38-40]. In our study, we isolated one of those Enterobacteriaceae (i.e., *Enterobacter*); others have reported *E. coli*, raising the possibility of a fecal origin of these pathogenic bacteria [22].

In most prior studies, as well as in the present work, the research methods used are relatively straightforward. A sterile moistened cotton swab is typically used to collect specimens from the sample mobile phones, with each swab rotated across the entire surface of the device [23,41]. The identification of organisms is most often performed using an automated system according to the standard protocols [42]. Almost all studies that have investigated this topic have confirmed that mobile phones harbor contaminants. The particularly high yield of growth in the mobile phone samples in our study may correspond to the rapid transportation of the samples to the laboratory and the immediate processing of the samples [43].

There are several limitations to the present study, including the lack of any investigation of the viral contamination of the HCW's mobile phones, or the fact that we did not perform susceptibility testing in respect of bacterial isolates, as the majority of them were considered to be either environmental or normal skin flora. The strength of this study, though, is that it increases knowledge and awareness for HCW's concerning appropriate hand hygiene and infection control measures that should be taken to prevent and control nosocomial infection. Already, the rate of the hand hygiene in our institution has improved tremendously over the year's endemicity in relation to Middle East respiratory syndrome-related coronavirus and empowering infection control practice [44,45].

Regarding the current coronavirus disease 2019 (COVID-19) and the possibility of environmental contamination and transmission from the hospital service to its patients and HCW's, stricter policies and regulations have been implemented in our institutions, as new evidence indicates that COVID-19 can be viable

on environmental surfaces even longer than influenza and respiratory viruses. During the COVID-19 pandemic, HCW's have become more knowledgeable about and aware of the risk of transmission of infections through devices such as mobile phones, and there has been a change in the attitudes and behaviors regarding the implementation of infection control measures [46-50].

Because of the ease of use, utility, and other evolving benefits of mobile phones, people often forget about their potential health hazards. An education campaign should therefore be undertaken to emphasize the importance of handwashing after mobile phone use [51], and the use of mobile phones should be restricted in certain areas, accompanied by strict policies being put in place concerning the regular cleaning and sanitizing of mobile devices used in hospital settings [21,52]. With respect to the role of mobile phones in the transmission of infection, we believe that further studies are required to substantiate this hypothesis.

Conclusions

In conclusion, in our study, the prevalence of the bacterial colonization of mobile phones belonging to HCW's was found to be high. Moreover, clinically significant microorganisms such as *S. aureus* and *Pseudomonas* species were identified on participants' devices. Our findings suggest that groups at particularly high risk of mobile phone contamination — laboratory, NICU, and medicine department staff, according to our results — should be a priority for the application of preventative measures, in order to improve infection control. In addition, the duration of mobile phone ownership by HCW's was found, in the present research, to be a significant factor and so should be considered in the context of future guidelines as well.

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