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Prevalence of methicillin-resistant *Staphylococcus aureus* on cellphones of healthcare workers in Najran University hospital, Najran City (Saudi Arabia)

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ABSTRACT

Aims: Mobile phones are used extensively by healthcare workers (HCWs) who are unaware of the amount of contamination these phones carry and act as reservoirs for organisms causing hospital-acquired infections. This investigation was aimed to find the prevalence of methicillin-resistant *Staphylococcus aureus* (MRSA) contamination and antimicrobial resistance patterns of isolates from HCW's cellphones.
Methodology and results: This study was a hospital-based cross-sectional study. A total of 120 samples were isolated from HCWs' cellphones and subjected to culture and sensitivity as per the standard guidelines. Five (18.1%) out of 120 collected samples were from 11 lab technicians' phones and were positive for *S. aureus* and 6.25% were obtained from 48 nurses' cellphone swabs.
Conclusion, significance and impact of study: The findings of this study reveal that HCWs' cellphones could be a possible source of infection since a high prevalence of MRSA was found on lab technicians and nurse cellphone sample swabs. On the other hand, all *S. aureus* isolates were resistant to methicillin and ceftazidime. Also, no significant relationship between the prevalence of MRSA was detected.

Keywords: Antibiotic resistance, cellphone, healthcare, MRSA, *Staphylococcus aureus*

INTRODUCTION

Using cellphones in hospitals can lead to an improved quality of healthcare, especially in terms of more rapid communication between hospital departments during an emergency. However, with all the benefits of cellphones, their potential role in microorganism transmission must be emphasized (Kotris *et al*., 2017). This is especially so with those associated with the skin due to the moisture and optimum temperature of the human body, especially our palms (Tagoe *et al.*, 2011). When we consider a phone's daily contact with the face, mouth, ears and hands, the dire health risks of using germ-infested mobile devices are apparent (Singh and Purohit, 2012).

A previous study reported that more than 90% of healthcare workers (HCWs) cellphones are contaminated with microorganisms and more than 14% carry pathogenic bacteria that commonly cause nosocomial infections (Zakai *et al*., 2016). Healthcare-associated infections (HAIs) are frequently occurring but often-preventable events and caused by multidrug-resistant organisms (MDROs), which necessitates treatment with broad-spectrum antibiotics, further contributing to the potential for antibiotic resistance (Cohen *et al*., 2015; Montoya *et al*., 2019).

Infections with multidrug-resistant pathogens are a significant cause of morbidity and mortality worldwide, primarily among immunocompromised and elderly people, especially if the causative organism has developed resistance to many antimicrobial agents Lai *et al.* (2013) and Al Asmari *et al.* (2015) reported that patients infected with multidrug-resistant organisms such as methicillin (oxacillin)-resistant *S. aureus* (MRSA) have morbidity and higher mortality rate.

In Saudi Arabia, three studies in the healthcare setting, including wards and intensive care units (ICUs), have shown that 43.6%-96.5% of mobile phones that belong to clinicians were contaminated by bacteria and/or

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other microorganisms. The most common isolated organisms were also coagulase-negative staphylococci (CONS), but 8% to 14% of the clinicians' mobile phones harboured other organisms known to cause HAIs, including *Staphylococcus aureus*, enterococcus, and Gram-negative bacilli (Al-Abdalall, 2010; Sadat-Ali *et al*., 2010). Also, Banawas *et al*. (2018) observed 38.3% of cellphones were contaminated with MRSA and CONS reported that the cellphone of healthcare workers could be contaminated by a wide range of MRSA and may be easily adhere to the surface of cellphones and the heat emitted enhances bacterial growth.

These bacteria can then be transferred to the owner of the cellphone, patients and the community. Additionally, abundant isolates *of S. aureus*, CONS and Gram-positive bacilli from cellphones of medical students. Therefore, training programs at an early stage in medical schools on guidelines about restricting the use of cellphones in the clinical environment must be implemented (Ibrahim and Elshafie, 2016; Zakai *et al.*, 2016; Lubwama *et al.*, 2021). Hence the present study was carried out to screen the mobile phone of healthcare workers, which can act as a source of infection by methicillin-resistant *S. aureus.*

MATERIALS AND METHODS

Sampling

In this study, 120 cellphone sample swabs were considered, from which 31 were taken from doctors, 11 from lab technicians, 48 from nurses, 10 from pharmacists, 10 from X-ray technicians and 10 from nutrition personnel. All samples were collected from the cellphones of HCWs in Najran University Hospital (Najran Province, Saudi Arabia) between September 2021 and November 2021 as part of a cross-sectional study. Also, a questionnaire was filled out after ethical approval was obtained from Najran University's hospital administrator to ensure their awareness that cellphones can be a source of infection.

Sample size was calculated according to the formula (Arora *et al.*, 2009; Tagoe *et al*., 2011; Panchal *et al*., 2012):

$$n = [(Z\alpha/2)2 \times P(1 - P)]/E2 = [(1.96)2 \times 65(35)]/(9.75)2$$
$$95.1 = 8739.64 = 92 + 10\% = 101$$

For convenience, more than 101 samples had to be obtained.

The samples were collected using a sterile cotton swab moistened with sterile normal saline and swabbing the top buttons and rotated over the surface of both sides of the tested mobile phone and the keypad in non-touchscreen phones. Aseptic practices were followed during collection.

Isolation and detection of *S. aureus*

At the laboratory, swabs were inserted into sterile universal containers with 10 mL Brain Heart Infusion Broth (BHIB), after which the prepared cultures in BHIB were incubated for 24 to 48 h at 37 ºC. After incubation, cultures were streaked on a selective medium such as Mannitol Salt Agar (MSA), MacConkey agar and Nutrient agar. Then, incubated aerobically at 37 ºC for 48 h. The MSA plates were examined visually for the detection of yellow colonies. The MacConkey plates were then visually examined to detect lactose and non-lactose ferment colonies. Purification was done by repeated sub-culturing of yellow colonies onto new media. Pure culture isolates were identified according to conventional methods, such as gram stain, microscopic characters, and biochemical tests such as catalase test, coagulase test, oxidase, indole, citrate, triple sugar iron test was performed according to Olutiola *et al*. (2000).

Antimicrobial susceptibility test

Staphylococcus aureus isolates were tested for 13 antibiotics (Hi-media) and disk diffusion method as the Clinical and Laboratory Standards Institute CLSI (2018) suggested. One mL of an overnight nutrient broth *S. aureus* culture was transferred on Mueller Hinton agar (MHA). Excess fluid was aspirated, spread the suspension by swab and the plate could dry for 30 min. Using sterile forceps, the antibiotic disc was gently applied on the plate and incubated at 37 °C for 24 h. Thirteen standard antibiotics were used and included penicillin-G (P), oxacillin (OX), cefixime (CFM), methicillin (MET), vancomycin (VAC), erythromycin (E), tigecycline (TGC), gentamicin (G), amikacin (AK), meropenem (MRP), ceftazidime **(**CAZ), aztreonam (ATM) and imipenem (IMI) (Siddiqui *et al.*, 2018). The *S. aureus* ATCC25923 strain was used as a control monitor quality control of each batch of plates.

Statistical analysis

Statistical analysis was performed by using a statistical package for social scenes (SPSS) version 23. The chi-squared test was applied to determine the cross-tabulation of study variables. The crosstab was considered significant at $P<0.05$.

RESULTS

Five out of 120 collected samples (4.16%) were detected as S. *aureus* isolates, consisting of 18.1% from 11 lab technicians' cellphone samples and 6.25% from 48 nurse cellphone sample swabs. Other cellphone sample swabs from HCWs showed no growth for *S. aureus* (Table 1). A chi-squared test of independence was used to determine whether the statistical difference in *S. aureus* prevalence occurred between conventional samples. The prevalence of *S. aureus* did not differ significantly between samples ($P<0.05$). On the other hand, the overall majority of

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Table 1: Prevalence of *S. aureus* collected from different types of samples.

Source of cellphone sample swabs	No. of samples	Gender		No. of *S. aureus* in samples	P-value
		Male	Female		
Doctors	31	21	10	0	0.127
Lab technicians	11	3	8	2 (18.1%)*[a]	
Nurses	48	1	47	3 (6.25%)*[a]	
Pharmacists	10	5	5	0	
X-ray technicians	10	4	6	0	
Nutrition services	10	4	6	0	
		38	82		
Total	120			5 (4.16%)	

*No. of *S. aureus* isolates/No. of samples; [a]Percentage within column are not significantly different (P<0.05).

Table 2: Bacterial contamination of cellphones isolated from different types of samples.

Source of cellphone sample swabs	No. of samples	Growth of contamination	Percentage*	P-value
Doctors	31	26	83.9%[a]	
Lab technicians	11	6	54.5%[a]	
Nurses	48	21	43.8%[a]	
Pharmacists	10	4	40%[a]	0.023
X-ray technicians	10	5	50%[a]	
Nutrition services.	10	5	50%[a]	
Total	120	67**	55.8%	

*****No. of contamination/No. of samples of each; ******Growth of contamination in Male cell pho 23 (34.3%), Female 44 (65.7); [a]Percentage within the column are significantly different (P<0.05).

Table 3: Distribution of bacterial isolates from cellphones in different types of samples.

Organisms	Doctors	Lab technicians	Nurses	Pharmacists	X-ray technicians	Nutrition services	Total	Percentage %*	P-value	Male	Female	P-value
S. aureus (MRSA)	0	2	3	0	0	0	5	7.5%[a]	0.00	1	4	
CONS	21	2	16	4	4	3	50	74.6%[a]	0	11	39	
Escherichia coli	2	1	1	0	0	0	4	5.9%[a]		1	3	0.27
Pseudomonas spp	1	0	0	0	0	0	1	1.5%[a]		0	1	
Klebsiella spp	1	0	1	0	0	0	2	2.9%[a]		0	2	
Bacillus spp	1	1	0	0	1	2	5	7.5%[a]		2	3	
Total							67			15 22.4%	52 77.6%	

*Total No. of each organism/Total No. of organism's contamination (67); [a]Percentage within the column are significantly different (P<0.05); MRSA: Methicillin-resistant *S. aureus*; CONS: Coagulase negative *Staphylococcus*.

cellphone contamination was found to be 55.8%. All cellphone sample swabs from doctors were highly contaminated 83.9% followed by samples from lab technicians (54.5%), as shown in Table 2. Most contamination on the cellphones of healthcare personnel showed the growth of a single species. Contamination of more than one type of species was a common feature of cellphone sample swabs of all HCWs, such as Coagulase Negative *Staphylococcus* (CONS; 47.6%) followed by *Escherichia coli* (5.9%), *Pseudomonas* spp (1.5%), Klebsiella spp (2.9%) and *Bacillus* spp (7.5%). The details of bacterial isolates obtained from the cellphones of healthcare personnel are shown in Table 3.

Five *S. aureus* isolates (two and three from lab technicians' and nurse's cellphone sample swabs, respectively) were subject to antimicrobial resistance profiling against 13 different antibiotics. The overall percentages of resistance of the five *S. aureus* isolate to methicillin, erythromycin, meropenem, ceftazidine and aztreonam were 100%, 20%, 20%, 100% and 40%, respectively, are shown in Table 4. The results demonstrate that these *S. aureus* isolates were sensitive

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Table 4: Antibiotic susceptibility against *S. aureus* (methicillin-resistant *S. aureus* MRSA) isolates.

Antibiotic	Concentration (µg)	*Staphylococcus aureus* isolates			Resistance %*
		R*	I	S	
Penicillin-G (P)	IU	0	0	5	0
Oxacillin (OX)	5	0	0	5	0
Cefixime (CFM)	5	0	0	5	0
Methicillin (MET)	5	5	0	0	100
Vancomycin (VAC)	30	0	0	5	0
Erythromycin (E)	15	1	4	0	20
Tigecycline (TGC)	15	0	0	5	0
Gentamicin (G)	10	0	0	5	0
Amikacin (AK)	30	0	0	5	0
Meropenem (MRP)	10	1	0	4	20
Ceftazidine (CAZ)	30	5	0	0	100
Aztreonam (ATM)	30	2	0	3	40
Imipenem (IMI)	10	0	0	5	0
Ciprofloxacin (CIP)	5	0	0	5	0

Note: I: intermediate, R: resistant, S: susceptible or sensitive; Inhibition diameter zone (mm) corresponding to the Clinical and Laboratory Standards Institute (2018); *No. of resistance isolates/No. of *S. aureus* isolates.

Table 5: Summary of the responses to the questions asked to the healthcare workers (HCWs; n=120).

Questions	Response	Frequency	Percentage %*	P-value
Do you clean your mobile?	Yes	69	57.5[a]	0.137
	Some time	44	36.7[a]	
	Never	7	5.8[a]	
How often do you clean the mobile?	Once per day	55	45.8[a]	0.198
	Continuously	53	44.2[a]	
	Never	12	10.0[a]	
Do you take your mobile to the toilet?	Yes	11	9.2[a]	0.913
	Sometimes	23	19.1[a]	
	Never	86	71.7[a]	
What types of disinfectants do you use to clean your mobile?	Easy clean	38	31.7[a]	0.124
	Sprit	68	56.7[a]	
	Others	14	11.7[a]	
How often do you wash your hands?	Once per day	9	7.5[a]	0.198
	Continuously	59	49.2[a]	
	Before and after any procedure	52	43.3[a]	

*Frequency/ HCWs (n=120); [a]Percentage within column are not significantly different (P<0.05).

to penicillin-G, oxacillin, cefixime, vancomycin, tigecycline, gentamicin, amikacin, meropenem, aztreonam and imipenem.

DISCUSSION

Prevalence of *S. aureus*

Cellphones are used without any restrictions in hospitals. The lack of restrictions in terms of (cellphones) use, makes them a potential source of pathogens. This study evaluated the prevalence of MRSA on the cellphones of HCWs in Najran University hospital. The percentage of MRSA in the present study was 4.16%; this percentage is considered a slightly higher percentage than reported by Banawas *et al.* (2018), who found a lower range (2.6%) although Siddiqui *et al.* (2018) detected a higher contamination rate (37.6%) that was considered dangerous to humans. Zakai *et al.* (2016) found 16.2% of the cellphones of medical students. The presence of MRSA in this study was found on lab technician and nurse cellphone samples and is attributed to the possibility of direct contact with patient specimens. Furthermore, this organism is capable of surviving desiccation (Ulger *et al.*, 2015). On the other hand, the prevalence of MRSA in nurse cellphone samples is attributed to the possibility of sometime touching the mobile phone without taking off the gloves.

Prevalence of other organisms

CONS was observed in this study as 50 out of 120 samples (74.6%) were detected. Twenty-one isolates from doctor's cellphone sample swabs, two isolates from lab technicians, 16 isolates from nurses, four isolates from pharmacists, four isolates from X-ray technicians

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and three isolates from nutrition services cellphones were detected (Table 3). These results agree with results obtained by Banawas *et al.* (2018), Zakai *et al.* (2016), Mark *et al.* (2014) and Selim and Abaza (2015). The higher rate of CONS contamination on doctors' and nurses' cellphones might be due to the frequent use of mobile devices by doctors with possible cleaning at one time. Furthermore, it has been predicted that cellphones can be an active source of nosocomial infection as the hand used to hold the phone comes in close contact with strongly contaminated body areas, such as the mouth and ears (Mark *et al.*, 2014). Also, CONS are normal commensals of the skin and mucous membranes of humans and their species have emerged as the most common cause of healthcare-associated bloodstream infections (BSIs) for many years (Asaad *et al.*, 2016). Also, the study revealed that the highest level of contamination in female's cellphones samples (77.6%) in general compared with males (22.38%) and showed a significantly different (Table 3); this is similar to the finding obtained by Heyba *et al*. (2015) and Lubwama *et al.* (2021).

Other Gram-negative and Gram-positive bacteria consisting of *E. coli* (5.9%), *Pseudomonas* spp (1.5%), *Klebsiella* spp (2.9%) and *Bacillus* spp (7.5%) were identified (Table 3). In addition, *E. coli* was isolated from one mobile phone, which suggests a low level of mobile phone hygiene and hand hygiene since this organism is part of the intestinal flora and among the leading causes of HAIs (Heyba *et al*., 2015).

Antimicrobial susceptibility of *S. aureus* isolates

Five *S. aureus* isolates were subject to antimicrobial resistance profiling. As shown in Table 4, our antimicrobial susceptibility results indicate that all *S. aureus* isolates were resistant to methicillin and ceftazidine (100%). In the present study, the results demonstrated the sensitivity of isolates to penicillin, although this result does not agree with most studies that report the resistance of *S. aureus* to penicillin (Banawas, 2018; Siddiqui *et al.*, 2018). This finding allows reusing penicillin as it has the advantage of being highly successful for prophylaxis and treatment. In this study, all *S. aureus* isolates were sensitive to vancomycin, which is considered the last resort and line of antibiotics in humans. This finding agrees with the results obtained by Banawas *et al.* (2018) and Siddiqui *et al.* (2018). All isolates resistant to methicillin based on an insensitivity test suggest the presence of *mecA* gene, named MRSA (Geo *et al.*, 2007). The emergence of resistance to multiple antimicrobial agents in pathogenic bacteria has become a significant public health threat however, the present of MRSA in our findings consider multidrug-resistance pathogen (Magiorakos *et al*., 2012).

Questionnaire

Despite the finding that approximately 57.5% of HCWs clean their cellphones, 45.8% clean only once per day, 49.2% wash their hands continuously and 43.3% wash their hands before and after procedures (Table 5).

The results demonstrate that just five isolates of MRSA were found on lab technicians' and nurses' cellphones. Chawla *et al*. (2009) obtained a contrary response and found that 82.5% of HCWs did not clean their cellphone and did not wash their hands after using a cellphone. Also, the present study indicated that just 9.2% of respondents take their cellphone to the toilet; therefore, the results revealed the presence of *E. coli* (5.9%), *Pseudomonas* spp (1.5%) and *Klebsiella* spp (2.9%) as described by Bhoonderowa *et al*. (2014) and Banawas *et al*. (2018). Generally, while HCWs were aware of infection prevention, the findings showed that contamination in cellphones, epically in female samples, is similar to what other studies have found (Al Asmari *et al.,* 2015; Banawas *et al*., 2018; Bahekar, 2020) and suggests that the regular decontamination of mobile phones with alcohol-based disinfectant wipes combined with strong hand hygiene measures while working in health care system. Also, other measures that can be suggested for this issue can be production of new generation mobile phones with hand free features which can minimize hand contact, blue tooth operated mobile accessories, antibacterial surface covers, waterproof and washable mobile phones and most important can be the production of more specific antibacterial solutions.

CONCLUSION

In summary, cellphones harbour a wide range of bacterial pathogens. These organisms may be multidrug-resistant and can become an important source of nosocomial infections. Research findings indicate the cellphones of HCWs were contaminated by low rates of MRSA. The prevalence of contamination found in cellphones belonging to doctors and lab technicians could be attributed to CONS, followed by *Bacillus* spp, *E. coli*, *Pseudomonas* spp. and *Klebsiella* spp. On the other hand, no significant relationship between the prevalence of MRSA and the profession of HCWs based on our present data was found, leading to the conclusion that there is a high awareness among HCWs at Najran University Hospital.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

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