Bacterial Contamination and Antimicrobial Resistance Patterns of Healthcare Workers' Mobile Phones in Hospitals at Khartoum City

Abstract

Background: Mobile phones used by healthcare workers (HCWs) have emerged as potential reservoirs for pathogens, posing a risk of healthcare-associated infections (HAIs). This study aimed to investigate the prevalence of bacterial contamination on HCWs' mobile phones, determine the antimicrobial susceptibility patterns, and compare findings with global data.

Methods: We collected swabs from 94 mobile phones of HCWs across two hospitals in Khartoum. We identified bacterial isolates using standard microbiological techniques and evaluated antimicrobial resistance using the Kirby-Bauer disk diffusion method.

Results: Bacterial contamination appeared in 93.6% of mobile phones. Gram-positive bacteria, such as Coagulase-negative staphylococci (36%) and S. aureus (31.8%) were prevalent. Gram-negative organisms were isolated. The predominant organisms were *Klebsiella pneumoniae* 15 (37%) isolates followed by *Pseudomonas aeruginosa* 12 (30%) isolates, Proteus mirabilis 5 (12%) isolates, *Acintobacter baumannii* 4 (10%), Enterobacter spp 3(8%) and *Escherichia coli* 1 (3%). Antimicrobial susceptibility tests revealed high resistance to penicillin among Gram-positive isolates. The tests revealed no multidrug-resistant (MDR) or extended-spectrum beta-lactamase (ESBL) production.

Conclusion: HCWs' mobile phones represent a critical vector for bacterial transmission in hospitals. Stringent infection control measures and regular disinfection should mitigate the associated risks.

Keywords: Bacterial Contamination, Hospital Environment, Healthcare Workers, Nosocomial Infections

Introduction

Nosocomial infections [HAI's] contracted by patients after admission to health care facilities are a concern not only in terms of patient health, as they have a high impact on patient morbidity and mortality [1,2], lengthened hospital stays, as well as increased Health care costs resulting from failed treatments [3]. "Healthcare-associated infection is an increasing global concern for patient treatment outcome and safety" [4]. "In developed countries, between 5% and 10% of patients acquire one or more infections, and 15-40% of

patients admitted to critical care are thought to be affected" [5]. "It affects more than 25% of the total healthcare admissions in developing countries" [6]. "They may occur in different areas of healthcare delivery, such as in hospitals, long-term care facilities, and ambulatory settings, and may also appear after discharge. HAIs also include occupational infections that may affect staff" [7].

The source is usually defined by the transfer of microorganisms between clinicians, patients, devices, general surfaces, and an inanimate object**.** In daily routines, pathogens often contaminate hands of HCWs, and inadequate hand hygiene can allow the transfer that will result in HAIs. Cell phone are rarely cleaned after handling, can be a source of the bacterial cross-contamination and may transmit microorganisms, including Pseudomonas spp, *Staphylococcus aureus*, Coagulase-negativeStaphylococcusand can be source multidrug resistance organisms [MDRs], and may be potential threats to infection control practices, increasing the rate of HAIs after contact with the patient, [8,9].microorganisms on the devices of HCWs have ability to transmitted to patients even if patients do not have direct contact with mobile phones [10]. "A number of studies have consistently reported that 5–21% of healthcare workers' mobile phones provide a reservoir of bacteria known to cause nosocomial infections" [11,12]. "Doctors and healthcare staff working in critical areas as intensive care units (ICUs), microbiology lab and operating units are highly exposed to deadly micro-organisms their mobile phones can serve as reservoirs of healthcare-associated pathogens and other organisms and have been suggested as possible vectors for the transmission of nosocomial pathogens from HCWs to patients as well as severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2)" [13].

There are several studies on the role of MPs as potential sources of HAIs. It has become one of the most important technology of social and professional life [14], MPs are among non-medical devices used routinely all day long but not cleaned properly, as health care workers (HCWs) do not wash their hands as often as they should before and after touching cell phones [15,16]. "[HCWs] have mobile phones and also patients, with approximately 98% of HCWs owning a mobile phone and 84.5% bringing them to work every day. Microorganisms on the devices of HCWs can transmit to patients even if patients do not have direct contact with mobile phones" [17].The constant use of mobile phones by HCWs and the absence of disinfection process make them vehicles routes for transmission of bacterial pathogens, including multidrug-resistant organisms [18] [19], multidrug resistant (MDR) bacteria are commonly implicated in HAIs and can be challenging to eliminate [20]. "Studies have reported the isolation of various bacterial species from the surfaces of mobile phones, with coagulase-negative staphylococci (CoNS), a normal skin commensal, being the most common, also there are pathogenic organisms such as methicillin-susceptible Staphylococcus aureus, methicillin-resistant S. aureus (MRSA., *Enterococcus faecalis, Escherichia coli*, Corynebacterium spp, *Clostridium perfringens*, Klebsiella spp, Enterobacter spp, Pseudomonas spp and Acinetobacter spp have also been reported" [21].

"HCWs do not attach the infection control guidelines in handling their mobile phones in hospitals, and the majority do not disinfect their phones regularly" [22].

"N.A. Mushabati et al. carried out a study in 2019 to determine the bacterial contamination of mobile phones of healthcare workers at the University Teaching Hospital, Lusaka, Zambia. A total of 117 HCWs involved the overall prevalence of mobile phone contamination was 79%. The predominant isolates were coagulase-negative staphylococci (50%), *Staphylococcus aureus* (24.5%) and Bacillus spp. (14.3%). Other isolates were *Escherichia coli* (4.1%), Pseudomonas spp. (3.1%), Acinetobacter spp. (2%), Klebsiella sp. (1%) and Proteus sp. (1%) Most of the isolates were susceptible to first line antimicrobial agents, except penicillin, which showed 100% resistance for all Gram-positive isolates. S. aureus was susceptible to ciprofloxacin (88%), clindamycin (88%), gentamicin (84%), tetracycline (84%), cotrimoxazole (50%) and erythromycin (50%). The susceptibility patterns of CoNS are shown in. Resistance to cefoxitin was detected in 25% (6/24) of S. aureus and 48% (21/49) of CoNS. Two-thirds of Pseudomonas spp. were resistant to ciprofloxacin and gentamicin" [21].

"Dagne Bodena et al carried out a study in 2018 to determinate Bacterial contamination of mobile phones of health professionals in Eastern Ethiopia: antimicrobial susceptibility and associated factors. 216 bacterial isolates were identified by phenotypic characterization. Of these bacterial isolates, Gram-positive bacteria (79.2%) were the major isolates, coagulase-negative staphylococci (CoNS) accounted for 58.8% followed by S. aureus (14.4%). Amongst Gram-negative bacterial isolates, Klebsiella spp. (6.9%) followed by E. coli (5.6%) were the main isolates. Antibiotic showed higher activity against bacterial isolates were ceftriaxone (80.6%), ciprofloxacin (77.3%), and gentamicin (72.7%), while ampicillin and trimethoprim-sulfamethoxazole had less effect with a resistance rate of 61.6% and 56.9%, respectively. There was no significant difference in the activity of those drugs against Gram-positive and Gram-negative isolates. Prevalence of multidrug resistance (MDR) patterns of bacterial isolates were 69.9%. Amongst all the bacterial isolates, Pseudomonas sp. (87.5%), Klebsiella sp. (86.7%), and Citrobacter sp. (75%) showed MDR characteristics, and Pseudomonas sp. exhibited resistance against more than five drugs" [24].

In 2014, Heba Sayed Selim and Amani Farouk Abaza carried out a study to investigate the microbial contamination of mobile phones in a health care setting in Alexandria, Egypt. Work was conducted on 40 mobile phones from patients and HCWs at AUSH ll of the tested mobile phones (100%) were contaminated with either single or mixed bacterial agents. The most prevalent bacterial contaminants were methicillin-resistant *S. aureus* and coagulase-negative staphylococci representing 53% and 50%, respectively, followed by CoNS (50%), Bacillus (43%), Diphtheroids (30%), methicillin-susceptible *Staphylococcus aureus* (MSSA) (18%), *E. coli* and Viridans streptococci (13% each), Micrococci (10%), *Klebsiellapneumoniae* and ESBL *Klebsiella pneumoniae* (8% each). The least encountered

isolates were *Acinetobacter baumanii* and Candida (3% each). In the result, CoNS were the most frequently encountered isolates from doctors' mobile phones (40%), followed by Bacillus spp. (20%), while MRSA, MSSA, diphtheroids and *E. coli* represented 10% each.

"On the other hand, MRSA was the most commonly isolated organism from nurses' cell phones (20%), followed by Bacillus and CoNS (17% each). Regarding laboratory technicians, CoNS showed the highest percentage of isolation (26%), followed by Bacillus spp. and diphtheroids (21% each). MRSA has been isolated from 25% of workers' mobile phones, while Bacillus accounted for 20% of isolates. As for patients, MRSA was the most frequently isolated organism (33%), followed by Viridans streptococci (27%) and CoNS (13%). Bacillus, micrococci and diphtheroids represented 7% each. MRSA were the most commonly encountered bacterial contaminants and were more frequently found in ICU (70%). Three ESBL *Klebsiella* spp. were isolated in the current study from ICU, laboratory, and triage area" [20].

"Tsegahun Asfaw ,Deribew Genetu was conducted to study from January 2020 to January 2021 in Debre Berhan Referral Hospital, North Shoa Zone, Ethiopia to detect High Rate of Bacterial Contamination on Healthcare Worker's Mobile Phone and Potential Role in Dissemination of Healthcare-Associated Infection. From the total of 65 swab sample, 84 bacterial isolates were detected of these bacterial isolate, 46.4% were Gram-positive bacteria while 53.6% were Gram-negative bacteria. The most frequently isolated bacteria were CoNS (14 isolates; 16.7%), S. aurous (13 isolates; 15.5%), and Bacillus spp (12 isolates; 14.3%), respectively, the overall MDR prevalence was found to be 42.9%. All the MP carried by HCWs was contaminated with at least one bacterial pathogen. The high rate of MP contamination was observed in the intensive care unit (ICU) (22.6%) followed by surgical ward (17.8) and laboratory rooms (17.8%). The rate of bacterial contamination of MP was higher among HCWs working in ICU. Bacterial isolates showed a higher resistance rate against penicillin (84%) followed by ampicillin (81%) and tetracycline (42%). However, lower resistance rate against ciprofloxacin (24%), gentamycin (23%), and chloramphenicol (18%). The overall MDR prevalence was found to be (42.9%). Among isolates, (23.8%) were resistant to two antibiotics, (20.2%) were resistant to six and more antibiotics, and (16.7%) were resistant to one antibiotic, while (11.9%) were not resistant to any of the antibiotics tested. The highest rate of resistance to many antibiotics (resistance for more than or equal to six antibiotics) was higher for CoNS (57.1%), *E. coli* and (27.3%), and *Citrobacter* spp (33.33%). In contrast, a lower rate of resistance to many antibiotics (resistance for more than or equal to four antibiotics) was observed among *Bacillus* spp isolates" [25].

"Mohammad Qadi et al carried out surveillance between September 2018 and March 2019 aimed at determining the microbial contamination of HCW MPs and identify and classify bacterial isolates in Palestine. A total of 300 mobile phone samples were examine bacterial contamination was found in swabs taken from 175 HCW MPs (87.5%) and 86 non- HCW

MPs (86%). the total number of bacterial isolates was 628 from both groups. From the 200HCWmobile phones,435 bacterial isolates were obtained and characterized. Four hundred twenty-eight bacterial isolates were found to be Gram positive. Among which, 293 bacteria were CoNS (67.3%), 76 were methicillin-sensitive *Staphylococcus aureus* (MSSA) (17.5%), 13 were non-spore-forming Gram-positive bacilli (3%), 5 were spore-forming Gram-positive bacilli (1.2%), and 34 were other Gram-positive cocci (7.9%). Seven bacterial isolates were found to be Gram-negative bacteria (1.6%), among which 3 were glucose fermenters (0.7%) and 4were non-glucose fermenters (0.9%). Regarding the susceptibility of *S. aureus* in HCW MPs, cefoxitin was the most effective antibiotic (susceptibility =82.1%). Other antibiotics came next: clindamycin (*S* = 67.2%), trimethoprim-sulfamethoxazole (*S* = 64.2%), erythromycin (*S* = 23.9%), and penicillin which was the least influential (*S* = 14.9%). For CoNS, cefoxitin was also the most effective antibiotic (*S* = 91.3%). Trimethoprim-sulfamethoxazole (S = 72.5% followed it), clindamycin (*S* = 64.9%), erythromycin (*S* = 23.5%), and penicillin, which was the least influential (*S* = 19.5%)" [26].

This study aimed to investigate the prevalence of bacterial contamination on HCWs' mobile phones, determine the antimicrobial susceptibility patterns, and compare findings with global data.

Materials and methods:

Descriptive hospital based cross-sectional study; a swab sample was collected from the participant's mobile phone. Before taking a swab, both hands of laboratory technicians were cleaned using an alcohol-based instant hand sanitizer, and powder-free disposable gloves were worn per sample throughout the work to prevent cross-contamination. Sterilized cotton swab moisten by sterile normal saline was rotated to swipe from the overall (screen, keypad, sides, and back) area of the mobile phone. Then, the mobile phone swab was placed immediately into sterile normal saline in a sterile container and transported to the Microbiology Lab within 30 min. Then, under aseptic technique, the swabs were inoculated ontoBlood Agar and MacConkey Agar by following the standard streak plate technique and incubated aerobically over-night. After 24 hours identification of Organisms was carried out depending on colonial morphology, indirect Gram stain and Biochemical tests which include rapid test (oxidase test) and 24hours test (Kligler iron agar (KIA), Indole test, citrate utilization test, motility test and Urease test).

In vitro antibiotic susceptibility testing was carried out using the disc diffusion method (modified Kirby Bauer method [28] on Muller Hinton agar against selected antibiotics

Ethical clearance was taken from the Research Ethical Committee at NUSU and hospitals where the research have been conducted.

Result:

Ninety-four participants were recruited into this study; of these. The majority were laboratory personnel [58 (61.7%)] followed by nurses [25] (27.6%)], and clinicians [10 (10.6%)]. Data on the work area of the participants are shown in (Table 1).

Regarding disinfection, 5 (5.3%) of the participants disinfected their mobile phone occasionally, 87 (92.5%) never disinfected their phone, and only two (2.1%) always disinfected their phone.

Bacterial contamination was found on 88 (93.6%) mobile phones belonging to the study participants. While there were 6 (6.3%) swabs samples there was no evidence of growth. The predominant organisms were gram positive bacterial isolates 44 (50%), followed by gram negative organisms isolates 40 (45.4%) and fungal isolates 4 (4.5%) as shown in figure (1).

Of a gram-positive bacterial isolate. 16 (36.36%) were CONs, 14 (31.8%) were S. aureus, 11(25%) were Bacillus and 3(6.8%) Diphtheroid as shown in figure (2).

Gram negative organisms were isolated. The predominant organisms were *Klebsiella pneumonia* 15 (37%) isolates followed by *Pseudomonas aeruginosa* 12 (30%) isolates, *Proteus mirabilis* 5 (12%) isolates, *Acintobacter baumannii* 4 (10%), Enterobacter spp 3(8%) and Escherichia coli 1 (3%) as shown in figure (3).

Table 1: Frequencies and percentages of healthcare workers in different work areas (N=94):

Work area	Frequency	Percentage (%)
laboratory personnel	58	61.7%
Nurses[ICU]	16	17.1%

Nurses[NICU]	10	10.6%
clinicians	10	10.6%
Total	*94*	100%

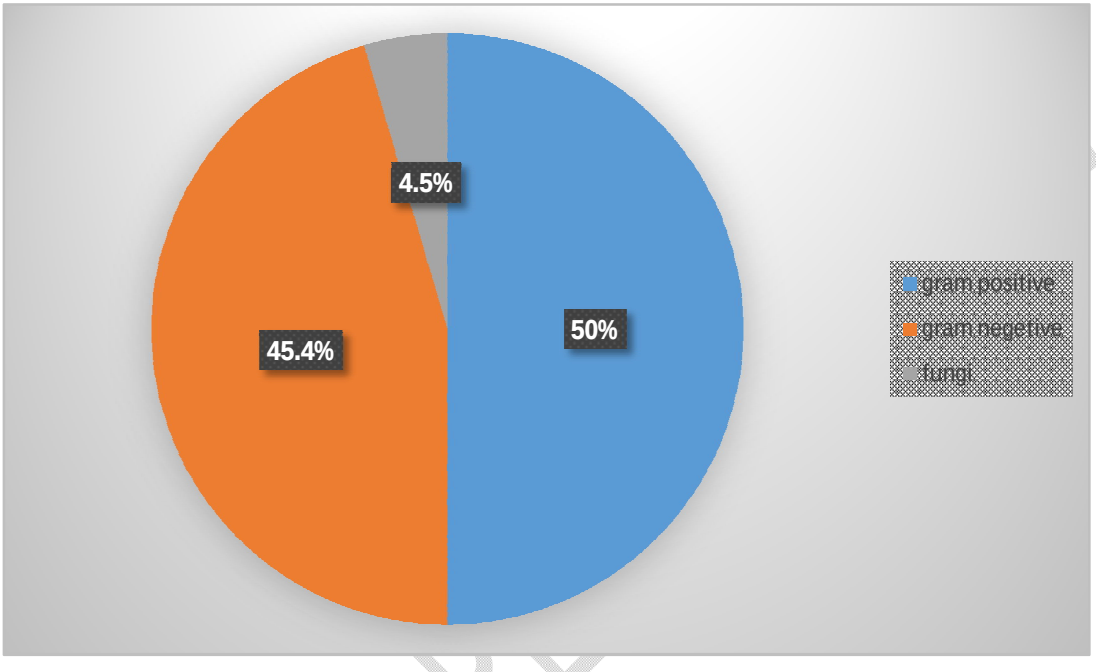

Figure (1); Distribution of organisms isolated from MPs swabs

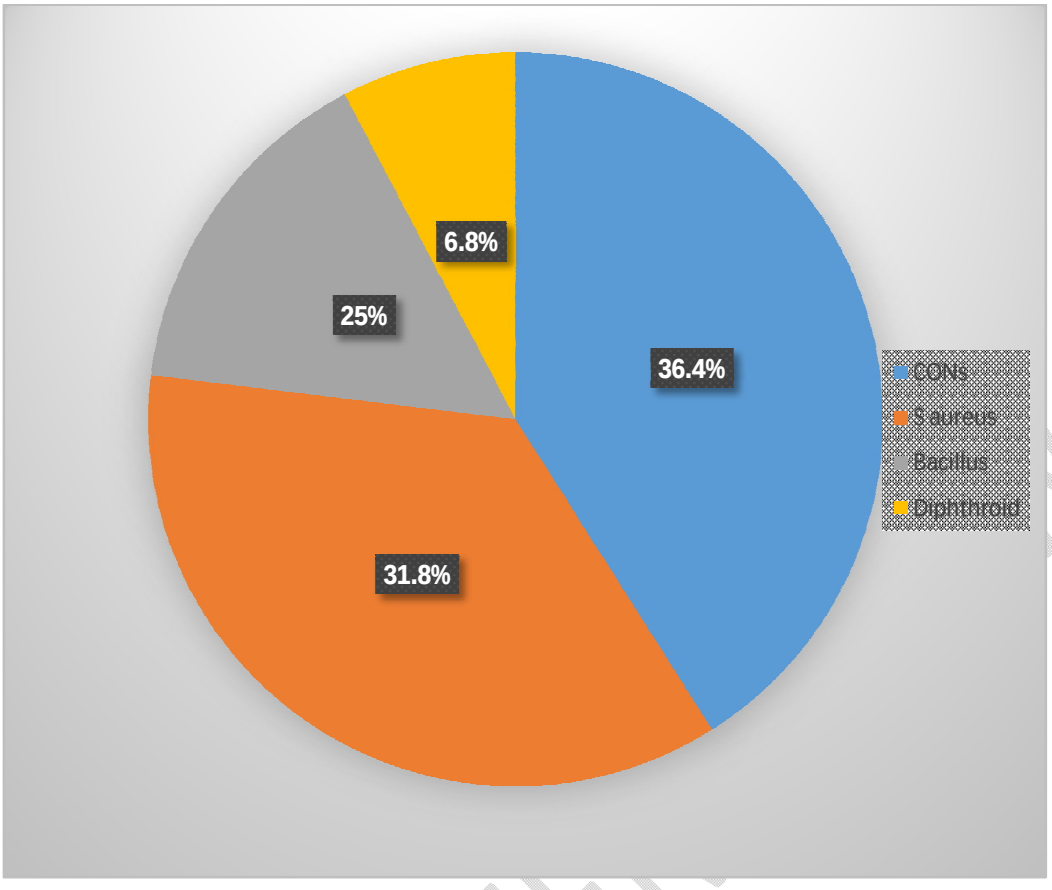

Figure (2): Distribution of gram-positive isolated from MPs Swab

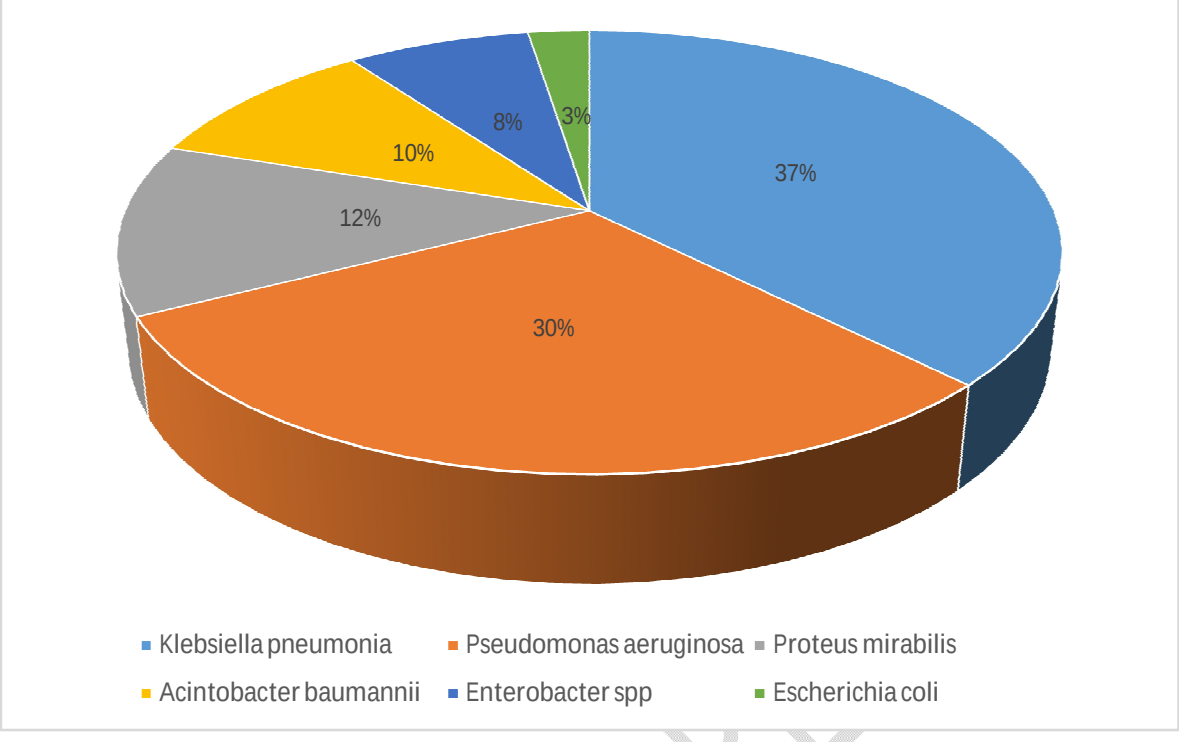

Figure (3): Distribution of gram-negative isolated from MPs Swabs

We show the antimicrobial susceptibility profiles of the isolates in Table 2. Most of the isolates were susceptible to first line antimicrobial agents, except penicillin, which showed 83.4% resistance for all Gram-positive isolates. S. aureus was susceptible to ciprofloxacin (100%), tetracycline (85%), gentamicin (57%), clindamycin (57%), and erythromycin (50%). Resistance to cefoxitin was detected in 35% (5/14) of S. aureus and 37.5% (6/16) of CoNS. All the isolated Pseudomonas spp. were resistant completely to Amoxicillin/clavulanic acid and (50%) to ciprofloxacin. ESBL was not isolated amongisolates revealed from health care worker's mobile phones.

Table 2: Antimicrobial susceptibility profiles of bacterial isolates from the mobile phones.

Antibiotic		**Organisms**							
		CONs [16]	**S aureus [14]**	**Pseudomonas spp [12]**	**Klebsiella spp.[15]**	**E.coli [1]**	**acintobacter spp.[4]**	**Proteus spp[5]**	***Enterobacter spp [3]***
P	S	0 (0 %)	2 (14.2%)	-	-	-	0 (0%)	-	-
	R	16 (100 %)	12	-	-	-	4 (100%)	-	-

			(85.7%)						
AMC	S	10(62.5 %)	14 (100 %)	12 (100 %)	6 (40%)	1 (50%)	3 (75%)	5 (100%)	
	R	6(37.5 %)	0 (0 %)	0 (0%)	9 (60%)	-	1 (15%)	0 (0%)	
CN	S	16 (100 %)	8 (57.1 %)	-	-	-	-	-	-
	R	0	6(42.8 %)	-	-	-	-	-	-
FOX	S	10(62.5 %)	9(64.2 %)	-	-	-	-	-	-
	R	6 (37.5 %)	5(35.7 %)	-	-	-	-	-	-
E	S	14 (87.5%)	7(50%)	-	-	-	-	-	-
	R	2(12.5 %)	7(50 %)	-	-	-	-	-	-
GEN	S	13 (81.3 %)	8 (57.1 %)	9 (75 %)	15 (100 %)	0 (0%)	4 (100%)	5 (100%)	2 (66.7%)
	R	3 (18.7 %)	6(42.8 %)	3 (25 %)	0 (0%)	1 (100%)	0 (0%)	0 (0%)	1 (33.3%)
CIP	S	16(100 %)	14 (100 %)	6 (50%)	15 (100 %)	1 (100%)	4 (100%)	5 (100%)	3(100%)
	R	0 (0 %)	0 (0 %)	6(50%)	0 (0 %)	0 (0 %)	0 (0%)	0 (0%)	0 (0%)
SXT	S	16(100 %)	-	9 (75 %)	0 (0 %)	1 (100%)	4 (80%)	5 (100%)	3(100%)
	R	0 (0 %)	-	3 (25 %)		0 (0 %)	0 (0%)	0 (0%)	0 (0%)
TE	S	16 (100 %)	12(85.7 %)	-	0 (0 %)	1 (100%)	4 (80%)	4 (80%)	2(66.7%)
	R	0 (0 %)	2 (14.2%)	-		0 (0 %)	0 (0%)	1 (20%)	1 (33.3%)
CTX	S	-	-	-	15 (100 %)	1 (100%)	4 (100%)	5 (100%)	3(100%)
	R	-	-	-	0 (0 %)	0 (0 %)	0 (0%)	0 (0%)	0 (0%)
CAZ	S	16(100 %)	(100 %)	12 (100 %)	15 (100 %)	1 (100 %)	4 (100 %)	5 (100 %)	3(100%)
	R	0	0 (0 %)	0 (0 %)	0 (0 %)	0 (0 %)	0 (0%)	0 (0%)	0 (0%)
CRO	S	16(100 %)	(100 %)	12 (100 %)	15 (100 %)	1 (100 %)	4 (100 %)	5 (100 %)	3(100%)
	R	0	0 (0 %)	0 (0 %)	0 (0 %)	0 (0 %)	0 (0%)	0 (0%)	0 (0%)

P= Penicillin **AMC** = Amoxicillin/Clavulanic acid **CN**=Clindamycin **FOX=** Cefoxitin **E =** Erythromycin **GEN** = Gentamicin **CIP** =Ciprofloxacin **SXT** = Cotrimoxazole **TE** = Tetracycline **CTX** = Cefotaxime **CAZ** = Ceftazidime CRO = Ceftriaxone

Discussion:

Bacterial contamination of mobile phones of HCWs was reported in the present study, 88 (93.6%) out of 94 mobile phones of HCWs in various hospitals, which agree with the most of Studies finding, N.A. Mushabati et al. [21], who find that 86 (79%) out of 117 mobile phones to be contaminated with bacteria and Tsegahun Asfaw et al. [24], his result from

total of 65 swab samples, 84 bacterial isolates were detected. The result of bacterial contamination of mobile phones of HCWs in most of these studies appears to be more than or equal (80%) of contamination.

The predominant isolates were CONs 16 (36%) followed by S aureus 14 (31.8%), Klebsiella pneumonia 15 (37%), followed by *Pseudomonas aeruginosa* 12 (30%) Bcillus 11 (25%), *Proteus mirabilis* 5 (12%) s, *Acintobacter baumannii* 4 (10%), and Dipthroid 3(6.8%), Enterobacter spp 3(8%) and *Escherichia coli* 1 (3%), which agree with the finding of Dagne Bodena et al. [24], which found major isolates, coagulase-negative staphylococci (CoNS) accounted for 58.8% followed by S. aureus (14.4%). Amongst Gram-negative bacterial isolates, Klebsiella spp. (6.9%) followed by E. coli (5.6%), But disagree with Mohammad Qadi et al. [26], who found it represent from 435 bacterial isolates 76 were methicillin-sensitive *Staphylococcus aureus* (MSSA) (17.5%), 13 were non-spore-forming Gram-positive bacilli (3%), 5 were spore-forming Gram-positive bacilli (1.2%), and 34 were other Gram-positive cocci (7.9%) and Heba Sayed Selim and Amani Farouk Abaza [20], found that it represents the most prevalent bacterial contaminants were methicillin-resistant S. aureus and coagulase-negative staphylococci representing 53% and 50%, respectively, followed by CoNS (50%). This disagreement may be because of the difference in sample size [20].

The result of antimicrobial susceptibility test showed high resistance rate against penicillin which showed 83.4% resistance for all Gram-positive Isolate and S. aureus was susceptible to ciprofloxacin (100%), tetracycline (85%), Which agree with result of [21]. Most of the isolates were susceptible to first line antimicrobial agents, except penicillin which showed 100% resistance for all Gram-positive isolates and S. aureus was susceptible to clindamycin (88%), ciprofloxacin (88%), gentamicin (84%), the percentage were so close, also Tsegahun Asfaw ,Deribew Genetu [24], were Bacterial isolates showed a higher resistance rate against penicillin (84%) followed by ampicillin (81%) and tetracycline (42%). Where the lower resistance rate against ciprofloxacin (24%). While Dagne Bodena et al. [24], found that there was no significant difference in the activity of those drugs against Gram-positive and Gram-negative isolates.

In the present study, MDR were not isolated among isolates of S. aureus and ESBL were not isolated among isolates which agree with Mohammad Qadi et al. [26], who found it represent effectiveness of most antibiotic, while disagree with finding of Dagne Bodena et al. [20] were the Prevalence of multidrug resistance (MDR) pattern of bacterial isolates were 69.9% and Tsegahun Asfaw [25] represent That overall MDR prevalence was found to be (42.9%). Among isolates, (23.8%)

All bacterial isolates from mobile phones are aerobes or facultative anaerobes. The possibility of other microorganisms like obligate anaerobes and fungi being found on contaminated mobile phones has been excluded.

Conclusion:

Contaminated mobile phones may act as fomites because most people carry mobile phones along with them to places such as hospitals, toilets and kitchens where microorganisms thrive. However, isolated organisms such as coagulase-negative staphylococci which represent of the most bacterial isolates and it emerged as a major pathogen in implant users and severely debilitated patients in hospitals; also S. aureus is a known pathogen, and it's one of the most isolated. Klebsiella pneumonia and other organisms that can cause nosocomial infection. Pseudomonas spp is an opportunistic pathogen has been isolated from the cell phone. We conclude that there is an increasing occurrence of MDRs organisms, which causes an infection that can complicate the treatment and lead to serious complications and finally lead to death.

Disclaimer (Artificial intelligence)

Authors hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

References:

1. Allegranzi B, Bagheri Nejad S, Combescure C, Graafmans W, Attar H, Donaldson L, et al. Burden of endemic health-care-associated infection in developing countries: Systematic review and meta-analysis. Lancet. 2011;377(9761):228–41.
2. Burke JP. Infection control—A problem for patient safety. N Engl J Med. 2003;348(7):651–6.
3. McFee RB. Nosocomial or hospital-acquired infections: An overview. Dis Mon. 2009;55(11):422–38.
4. Center for Disease Control and Prevention. HAI data and statistics. 2016 [cited yyyy mm dd]. Available from: http://1.usa.gov/1CWnvuu.
5. Gastmeier P, Groneberg K, Weist K, Rüden H. A cluster of nosocomial *Klebsiella pneumoniae* bloodstream infections in a neonatal intensive care department. Identification of transmission and intervention. Am J Infect Control. 2003;31(1):424–30.
6. Tagoe DNA, Baidoo SE, Dadzie I, Tengey D, Agede C. Potential sources of transmission of hospital-acquired infections in the Volta Regional Hospital, Ghana. Ghana Med J. 2011;45(1):22–6.
7. Gravel D, Taylor G, Ofner M, Johnston L, Loeb M, Roth VR, et al. Point prevalence survey for healthcare-associated infections within Canadian acute care

hospitals. [Internet]. 2019 [cited yyyy mm dd]. Available from: https://www.ncbi.nlm.nih.gov/books/NBK559312/.
8. Brady RR, Verran J, Damani NN, Gibb AP. Review of mobile communication devices as potential reservoirs of nosocomial pathogens. J Hosp Infect. 2009;71(4):295–300.
9. Jayalakshmi J, Appalaraju B, Usha S. Cellphones as reservoirs of nosocomial pathogens. J Assoc Physicians India. 2008;56:388–9.
10. Selim HS, Abaza AF. Microbial contamination of mobile phones in a healthcare setting in Alexandria, Egypt. GMS Hyg Infect Control. 2015;10(3):1–6.
11. Brady RR, McDermott C, Verran J, Fraise AP, Gibb AP. Healthcare workers' mobile phones are rarely contaminated by MRSA in the non-clinical environment. J Hosp Infect. 2009;72(1):72–3.
12. Ulger F, Esen S, Dilek A, Yanik K, Gunaydin M, Leblebicioglu H. Are we aware how contaminated our mobile phones are with nosocomial pathogens? Ann Clin Microbiol Antimicrob. 2009;8:7.
13. Amanah A, Apriyanto DR, Fitriani H. Isolation of surveillance pathogenic fungal microbial contaminant on mobile phones. Open Access Maced J Med Sci. 2019;7(19):3247–51.
14. Madhuri JR, Saraswathi M, Mahitha G, Bhargavi M, Deepika S, Lakshmi GV. Bacterial contamination of mobile phones and computers in microbiological laboratories. Eur J Biotechnol Biosci. 2015;3(8):26–9.
15. Ramesh J. Use of mobile phones by medical staff at Queen Elizabeth Hospital, Barbados: Evidence for both benefit and harm. J Hosp Infect. 2008;70(2):160–5.
16. Voss A, Widmer AF. No time for handwashing? Handwashing versus alcoholic rub: Can we afford 100% compliance? Infect Control Hosp Epidemiol. 1997;18(3):205–8.
17. Brady RR, Wasson A, Stirling I, McAllister C, Damani N. Is your phone bugged? The incidence of bacteria known to cause nosocomial infection on healthcare workers' mobile phones. J Hosp Infect. 2006;62(1):123–5.
18. Famurewa O, David O. Cell phone: A medium of transmission of bacterial pathogens. World Rural Observ. 2009;1(2):69–72.
19. Banawas S, Abdel-Hadi A, Alaidarous M, Alshehri B, Bin Dukhyil AA, Alsaweed M, et al. Multidrug-resistant bacteria associated with cell phones of healthcare professionals in selected hospitals in Saudi Arabia. Can J Infect Dis Med Microbiol. 2018;2018:1–7.
20. Selim HS, Abaza AF. Microbial contamination of mobile phones in a healthcare setting in Alexandria, Egypt. GMS Hyg Infect Control. 2015;10(3):1–6.
21. Mushabati NA, Samutela MT, Yamba K, Ngulube J, Nakazwe R, Nkhoma P, et al. Bacterial contamination of mobile phones of healthcare workers at the University Teaching Hospital, Lusaka, Zambia. J Hosp Infect. 2020;104(3):200–4.
22. Shahaby A, Awad N, El-Tarras A, Bahobial A. Mobile phone as potential reservoirs of bacterial pathogens. Afr J Biotechnol. 2012;11(7):15896–903.

23. Bodena D, Teklemariam Z, Balakrishnan S, Wondwossen TA. Bacterial contamination of mobile phones of health professionals in Eastern Ethiopia: Antimicrobial susceptibility and associated factors. BMC Res Notes. 2018;11:732.
24. Asfaw T, Genetu D. High rate of bacterial contamination on healthcare workers' mobile phones and potential role in dissemination of healthcare-associated infection at Debre Berhan Referral Hospital, North Shoa Zone, Ethiopia. Antimicrob Resist Infect Control. 2020;9(1):123.
25. Qadi M, Khdour MR, Khalid F, Al-Jabari M, Hamdan Z. Microbes on the mobile phones of healthcare workers in Palestine: Identification, characterization, and comparison. J Infect Public Health. 2020;13(5):692–8.
26. Brown A, Smith H. Benson's microbiological applications laboratory manual in general microbiology. 13th ed. New York: McGraw-Hill Education; 2015.