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Short Communication

Mobile phones of health care personnel as a fertile ground for microorganisms' growth

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ABSTRACT

The objective of this study is to evaluate the bacterial contamination of smartphones of healthcare workers (HCWs), and to estimate the potential risks of transmission of antibiotic-resistant pathogens between patients and HCWs. During the campaign day for hand cleaning awareness, 107 swabs were collected from the screens of personal smartphones belonging to HCWs of the Integrated University Hospital of Verona. All the samples were cultured and grown colonies identified using the mass spectrometry technology Matrix Assisted Laser Desorption Ionization Time-of-Flight (MALDI-TOF MS, Biomerieux®). All smartphones tested were colonized by at least one bacterial genus. Twenty-two different genera were isolated. The majority of isolates were Bacillus species, accounting for 71.96%, coagulase negative staphylococci (CoNS), accounting for 57.01%, other Gram-Positive bacteria (22.43%), and Gram-Negative bacteria (3.74%). Pathogenic bacteria were *Aerococcus viridans* (4.17%), *Klebsiella pneumoniae* (5.26%), *Pseudomonas spp.* (21.05%), *Escherichia coli* (10.53%), *Enterococcus spp*. (20.83%), *Acinetobacter spp.* (42.11%) and *Staphylococcus aureus* (14.02%). All strains of *Enterococcus spp.* did not show any antibiotic resistance. *S. aureus* were Methicillin-sensitive. Unfortunately, *K. pneumoniae and A. baumannii* were resistant to carbapenems. Results showed that HCWs' smartphones were contaminated with different types of bacteria. The personal and daily usage of disinfectant wipes and hand disinfectant gel may help to reduce the risk of transmission and contamination of nosocomial infections in hospitals.

KEYWORDS: hygiene, nosocomial infections, bacteria contamination, hospital, smartphones.

ABBREVIATIONS

HCW, health care workers; CoNS, coagulase-negative staphylococci; AR-ISS, antibiotic Resistance-Istituto Superiore di Sanità; MRSA, methicillin-resistant Staphylococcus aureus; MSA, mannitol salt agar; MSSA, methicillin-sensitive Staphylococcus aureus; MIC, minimum inhibitory concentration; PCR, polymerase chain reaction; NDM, New Delhi metallo-beta-lactamase; VIM, Verona integron-encoded metallo-beta-lactamase; OXA, oxacillinase-type beta-lactamase; KPC, *Klebsiella Pneumoniae* carbapenemase-producer; CFU, colony forming unit; MDR, multi-drug resistant.

INTRODUCTION

Nowadays, approximately 66.5% of the world population owns mobile phones. In Italy this rate is higher than 67.9%, and the clinical environment is no exception [1]. Mobile phones are a fertile ground for bacterial growth, and even though smartphones have outnumbered keypad phones, decreasing the chance for bacterial survival, they still are a major source of contamination [2]. Being in close contact with the body repeatedly

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throughout the day, smartphones act as reservoirs of infection and vehicles for spreading contaminating bacteria across many different clinical and non-clinical environments. The risk of infection associated with the usage of mobile phones in hospital facilities has not yet been determined as there are no cleaning guidelines available that meet hospital standards [3]. Data collected during the Antibiotic Resistance-Istituto Superiore di Sanità (AR-ISS) project stated that Italy is one of the countries with the highest frequency of antibiotic resistance in most of the pathogenic species under surveillance. In particular *Klebsiella pneumoniae* isolates with 32.9% resistant to carbapenems, *Staphylococcus aureus* with 33.6% resistant to methicillin, and *Escherichia coli* isolates with 28.7% and 43.9% resistant to third-generation cephalosporins and fluoroquinolones, respectively were reported [4]. Studies performed in the United States and United Kingdom highlighted the presence of antibiotic-resistant pathogens such as Methicillin-Resistant *Staphylococcus aureus* (MRSA) in at least 10% of mobile phones tested [5, 6]. The persistence of clinically relevant bacteria on smartphones screens can vary significantly from hours to years [7]; therefore, hand hygiene among medical practitioners is crucial to avoid hospital-acquired infections. Nosocomial infections are an important problem in all modern hospitals. Indeed, some epidemiological studies regarding environmental surfaces and the transmission of bacteria demonstrated that pathogenic microorganisms could be transferred to the patients through the contaminated hands of HCWs [3]. Studies from different countries indicate that medical equipments and mobile phones of HCWs are potential sources of nosocomial infections [6, 8]. Smartphones are used routinely all day long but not cleaned properly, as HCWs sometimes do not change gloves during their daily work, or do not wash their hands as often as they should [9], contributing to cross-contamination. For these reasons, this study was performed during a campaign for hand cleaning awareness and is aimed at evaluating the contamination of smartphones for the prediction of potential risks of transmission of antibiotic-resistant pathogens among doctors, patients and HCWs.

MATERIALS AND METHODS

This present study was conducted during a hand cleaning awareness day by the Microbiology Unit of the University of Verona. Swab samples from 107 personal smartphones belonging to HCWs of the Integrated University Hospital of Verona were collected. No ethical approval was needed for this study because all the samples collected were from smartphones of anonymous volunteer HCWs. Moreover, we didn't include any questionnaire in the study to discriminate gender or age in order to maintain anonymity. A sterile cotton swab was moistened in transport media (Amies, Copan ESwab®, Italy) and rotated over the front screen of the smartphones. The same area of the screen was sampled for all 107 devices. To prevent cross-contamination the investigator disinfected his hands with antiseptic gel (Amuchina Gel X-Germ), gloved his hands, performed the swabbing, and changed gloves in between each sample.

After sampling, each smartphone was decontaminated with alcohol-based disinfectant wipes (Neo Sterixidina, Golmar, Italy). Collected samples were assigned unique identification numbers, kept in transport media, carried to the laboratory and cultured.

All the swabs were inoculated onto fresh Blood Agar supplemented with 5% defibrinated sheep blood, MacConkey Agar and Infusion Agar plates, and incubated aerobically at 37 °C for 24 h. Colonies exhibiting β-hemolysis in Blood Agar were subjected to catalase and coagulase tests. The catalase test is primarily used to distinguish among Gram-positive cocci, as members of the genus *Staphylococcus spp.* are catalase-positive, whereas members of the genera *Streptococcus spp.* and *Enterococcus spp.* are catalase-negative. Coagulase test is used to differentiate *Staphylococcus aureus* (positive) from Coagulase Negative *Staphylococcus* (CoNS). Coagulase positive samples were sub-cultured onto Mannitol Salt Agar (MSA) to confirm the presence of *S. aureus*. After biochemical tests all colonies were identified using the mass spectrometry technology (MALDI-TOF MS, Biomerieux®), an automated identification system that uses Matrix Assisted Laser Desorption Ionization Time-of-Flight technology.

Isolates of *S. aureus*, *Enterococcus spp.*, *P. aeruginosa*, *K. pneumoniae* and *A. baumannii* were subjected to susceptibility tests using VITEK® 2 system. From freshly grown colonies 0.5 McFarland suspensions were prepared for inoculation into

dedicated susceptibility miniature cards. The cards present a wide range of antibiotics, each with different range of dilutions. The obtained minimum inhibitory concentration (MIC) values were reported together with the category interpretation in accordance with the European Committee on Antimicrobial Susceptibility Testing (EUCAST) guides lines 2017 (www.eucast.org). Methicillin-resistant (MRSA) and Methicillin-sensitive (MSSA) *S. aureus* were discriminated using a susceptibility test card containing Fluoroquinolones (levofloxacin), Penicillins (oxacillin and benzylpenicillin), Glycopeptides (vancomycin and teicoplanin), Macrolides (erythromycin and clindamycin) and miscellaneous agents (fosfomycin, daptomycin). For *Enterococcus spp*. the card included Penicillins (ampicillin; penicillin, piperacillin), Fluoroquinolones (ciprofloxacin, norfloxacin), miscellaneous agents (fosfomycin, streptomycin), Carbapenems (imipenem), Glycopeptides (vancomycin and teicoplanin), Tetracycline and Gentamycin. On the other hand, the cards used for the discrimination of *P. aeruginosa*, *K. pneumoniae* and *A. baumannii* included Cephalosporins (cefotaxime, ceftazidime, cefepime), Penicillins (amoxicillin- clavulanic acid and piperacillin/tazobactam), miscellaneous agents (fosfomycin, colistin, nitrofurantoin, sulfamethoxazole) and Carbapenems (ertapenem, imipenem and meropenem) to discriminate the resistance to carbapenems. To assess the presence of resistance genes for carbapenems Multiplex polymerase chain reaction (PCR) was performed using primers for New Delhi Metallo-beta-lactamase (NDM), Verona integron-encoded metallo-beta-lactamase (VIM), Oxacillinase 48-like type beta-lactamase (OXA-$_{48like}$) and *Klebsiella Pneumoniae* Carbapenemase-producer (KPC) [10] for *K. pneumoniae* and primers for OXA-$_{23like}$ [11]; OXA-$_{24like}$; OXA-$_{58like}$, OXA-$_{51like}$ [12] and OXA-type beta lactamase for *A. baumannii*.

RESULTS

All 107 smartphones tested (100%) were contaminated with either single or mixed bacterial agents (Fig. 1). As shown in Fig. 2 different microbial genera were found, the average was of 2 microbial genera per smartphone. Twenty-two different bacterial genera were isolated. Gram-positive microorganisms were cultured from all devices (99.0%; 106/107).

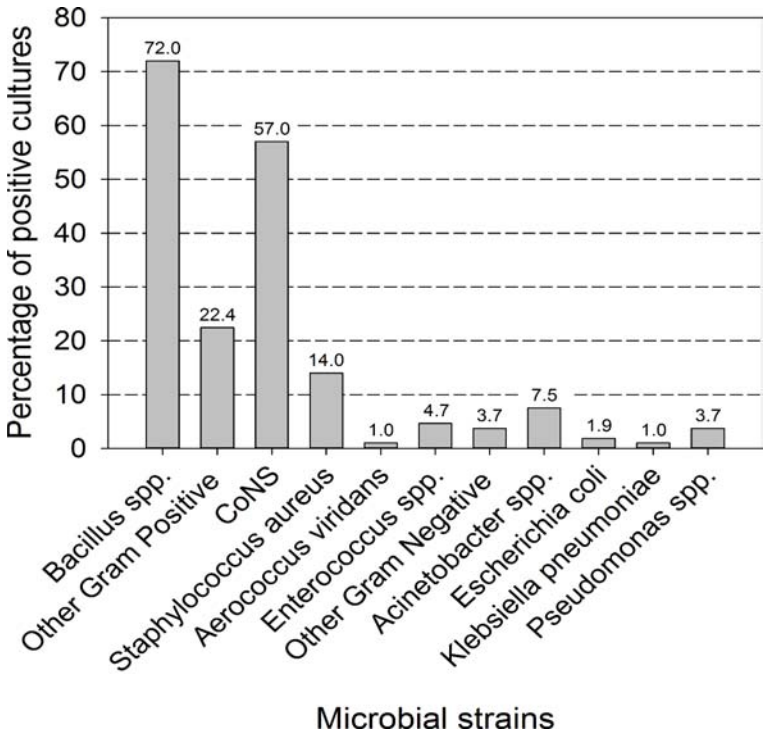

Fig. 1. Microorganisms isolated from smartphone screens (N = 107) (CoNS, coagulase-negative staphylococci).

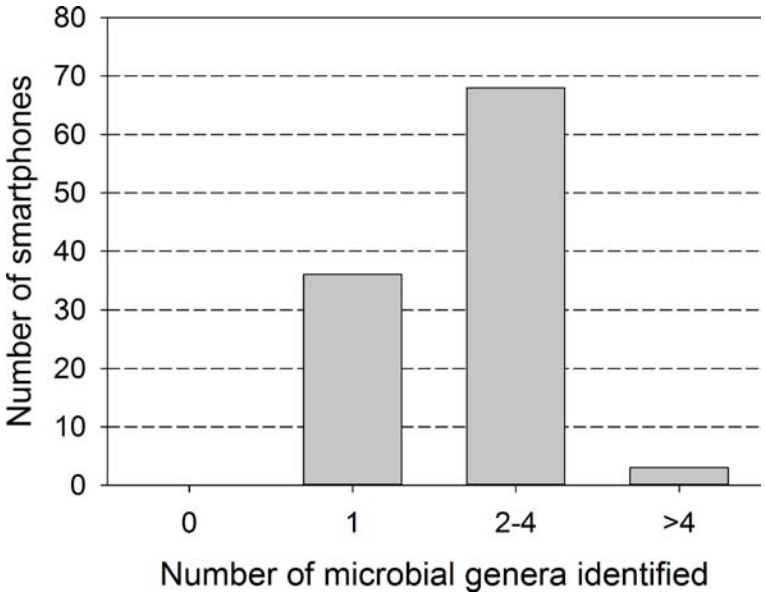

Fig. 2. Number of colonies cultured within the study.

Table 1. Microbiology results.

Bacteria	Smartphones (n = 107) (%)
Gram-Negative organisms	**19 (17.7)**
Gram-Negative pathogens	**6 (5.6)**
Acinetobacter baumannii complex	**2 (33.3)[A]**
Escherichia coli	**2 (33.3)[A]**
Klebsiella pneumoniae	**1 (16.6)[A]**
Pseudomonas aeruginosae	**1 (16.6)[A]**
Gram-Positive organisms	**106 (99.0)**
Gram-Positive pathogens	**20 (18.7)**
Staphylococcus aureus	**15 (75.0)[B]**
Enterococcus spp.	**5 (25.0)[B]**
Bacillus spp.	**77 (71.9)**

[A] Percentage of Gram- negative pathogens (6)
[B] Percentage of Gram- positive pathogens (20)

Gram-negative microorganisms were found on 17.7% (19/107) samples; moreover, the majority of smartphones (71.9%; 77/107) were contaminated with *Bacillus spp.* (Table 1). Antibiotic susceptibility test was performed for *Staphylococcus aureus*, *Enterococcus spp.*, *Pseudomonas aeruginosa*, *Klebsiella pneumoniae* and *Acinetobacter baumannii* using VITEK® 2 System. Fortunately, all 15 strains of *S. aureus* were MSSA, and 5 strains of *Enterococcus spp.* were sensitive to vancomycin, *P. aeruginosa* was sensitive to carbapenems, whereas the other 3 strains were all resistant. Further analysis by Multiplex PCR identified the presence of KPC in *K. pneumoniae* and OXA-$_{23like}$ in both strains of *A. baumannii*.

DISCUSSION

The use of mobile phones is becoming increasingly common in the hospital environment. Answering

patient calls, chatting and reading world news directly on the phone are common. This use of devices during hospital service hours has greatly increased the risk of contamination among HCWs and also between HCWs and patients, facilitating the transmission of multi-resistant bacteria [2, 3, 6]. The regular use of the mobile phones in close contact with the skin allows the spreading of commensal and pathogenic bacteria [7, 8].

Ulger *et al*. [9] reported that microorganisms from HCWs' hands could be transferred to the surfaces of the mobile phones during their use, especially during routine hospital work. Chang *et al*. [13] demonstrated a correlation between the use of mobile phones by HCWs during work time and the presence of pathogenic bacteria. In addition, Cavari *et al*. [14] observed the high risk of viral contamination that could be ascribed to HCWs use of mobile phones. Finally, Zakai *et al*. [15] explained how infections in medical settings are increasing due to the risk of cross-contamination of smartphones that act as reservoir and sources of bacterial transmission. The first study in Italy regarding microbial contamination of touchscreen smartphones was conducted at the University of Chieti-Pescara on the phones of students of a Microbiology Teaching Laboratory [16]. To date there is no data on cross-contamination due to cell phones among HCWs, doctors and patients in Italy. This study is the first survey in Italy among HCWs. As this is a pilot study and since swabbing was performed during the campaign day for hand cleaning awareness, we did not assess the microbial flora on the cell phones before and after decontamination as done by Murgier *et al.* [17].

All mobile phones sampled were contaminated, fortunately all identified strains of *S. aureus* were MSSA and *Enterococcus spp.* were vancomycin sensitive. In addition, only few *K. pneumoniae* and *A. baumannii* isolates exhibited resistance to carbapenems. We encourage periodic cleaning of smartphones with disinfectants like alcohol-based disinfectant wipes (Neo sterixidina, Golmar, Italy) or hand cleaning detergents, as well as frequent hand-washing as a means of preventing disease transmission.

Singh *et al*. [18] reported that in the case of cell phones cleaned with 70 percent isopropyl alcohol, the swabs carried fewer bacteria, and Hosseini *et al*. [19] reported that 98% of bacterial contamination was reduced by using a disinfectant spray. In future work we would like to perform a focused investigation of hospital departments similar to that by Heyba *et al*. [20] who demonstrated a high risk of infection transmission in patients treated by clinicians who overuse cell phone at work. One of the main reasons of for these results is the lack of hygiene and of hand cleaning guidelines to prevent contamination.

CONCLUSION

Constant use of mobile phones in the clinical settings is inevitable. Mobile phone use in hospital facilities represents a risk of transmission of a variety of bacterial agents including multidrug-resistant pathogens such as MRSA and carbapenem-resistant bacteria. The most predominant microorganisms identified in our study were Bacillus species and CoNS. All *S. aureus* identified were methicillin-sensitive, but we found a high number of pathogenic bacteria, some of which showed multidrug-resistance, namely KPC for *K. pneumoniae* and OXA-23like for *A. baumannii*. The surface spread method is an easy and useful tool for detection and estimation of bacterial contamination of mobile phones. Periodic cleaning of smartphones with disinfectants like alcohol-based disinfectant wipes (Neo Sterixidina, Golmar, Italy) or hand cleaning detergents, as well as frequent hand washing should be encouraged as a means of preventing disease transmission. Cell phones represent a serious threat of infection spread between HCWs and patients in hospitals and therefore development of guidelines for hand hygiene and cell phone cleaning is necessary. We strongly recommend avoiding or reducing the use of personal cell phones in daily routines. HCWs should be informed about the role of mobile phones and hospital equipments in spreading nosocomial infections.

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CONFLICT OF INTEREST STATEMENT

No conflict of interest.

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