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Microbial Contamination of Mobile Phones in the Medical Laboratory Technology Department of a Private University in Alexandria, Egypt

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ABSTRACT

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Mobile phones are used worldwide by health care workers and laboratory practitioners, even during working hours and without any restrictions, regardless of their expected high microbial load. Unlike our hands, which are easily disinfected, mobile phones are cumbersome to clean. Thus, these devices have the potential for microbial contamination. This study was conducted to investigate microbial contamination of mobile phones at the medical laboratory technology department: Pharos University, Alexandria, Egypt. Swab samples from 100 mobile phones were cultured. Quantification of bacterial contaminants was performed using both surface spread and pour plate methods. Bacterial strains isolated from 90% of samples were identified and their antibiotic sensitivity pattern was identified using standard microbiological methods. Pour plate method yielded better results for bacterial counts than the surface spread method in highly contaminated mobile phones. The most prevalent bacterial isolates were coagulase-negative *Staphylococci* (CNS):33% and methicillin-resistant *Staphylococcus aureus* (MRSA):24%. Mobile phones usage in health care facilities, specifically laboratories, poses a severe threat for spread of infectious pathogens; both inside the facility and to the community outside.

Introduction

Mobile phones have become integral and indispensable accessories of professional and social daily life. They are increasingly becoming an important means of conversation worldwide; being easily accessible, economical and user friendly (Selim and Abaza, 2015).

Approximately 75 % of adults worldwide have access to mobile phones. Three-quarters of the world's seven billion mobile phone subscribers live in low- and middle- income countries, making the developing world more mobile than the developed world (Kamiset al., 2015).

With all the achievements and benefits of the mobile phone, it is possible to overlook the health hazards it might pose to its many users (Czapiński and Panek, 2011). As it can easily fit in one's pocket, mobile phones have become part of the so-called emotional technology, used frequently even in environments of high bacteria presence as health care facilities.

In medical laboratories, mobile phones are often touched during activities related to sample collection, sample processing, culturing of microorganisms, etc. Therefore, mobile phones are likely to get contaminated

by various micro-organisms, some of which could be pathogenic in nature and multiple drug-resistant at times (Jaya Madhuri *et al.*, 2015).

Frequency of microbial contamination of mobile phones used by health care workers (HCWs) ranges from 20 % to 100%, as recorded by several investigators (Goldblatt *et al.*, 2007; Bobat *et al.*, 2016; Deshkar *et al.*, 2016; Ramesh *et al.*, 2008; Lavanya *et al.*, 2016; Chaka *et al.*, 2016; Ananthakrishnan *et al.*, 2006; Amer *et al.*, 2016; Chawla *et al.*, 2009; Tambe and Pai, 2012; Tiwari *et al.*, 2016; Karthiga and Muralidaharan, 2016; Elkholy and Ewees, 2010; Ustun and Cihangiroglu, 2012; Selim and Abaza, 2015).

Drug resistant pathogens such as methicillin-resistant *Staphylococcus aureus* (MRSA) and vancomycin resistant *Enterococci* (VRE) have been recovered from many of these mobile phones; raising important safety concerns about the use of such devices in health care facilities (Mark *et al.*, 2015). There are no specific mandatory guidelines for disinfection of mobile phones that meet hospital and laboratory standards. Moreover, mobile phones besides being used routinely all day long; including work hours, yet the same phones are still used both inside and outside the health care facilities. Accordingly, mobile phones act as a vector spreading pathogenic microorganisms to different parts of the health care facility and out of it as well (Parhizgari *et al.*, 2013).

The average user of a mobile phone touches its screen around one hundred and fifty times a day causing the frequent migration of bacteria from the mobile phone to the skin and vice versa (Jeske *et al.*, 2007). Mobile phones are also placed on numerous surfaces, countless number of times each day; which causes the microorganisms to migrate from such surfaces that the phone had contact with to the phone itself (Akinyemi *et al.*, 2009).

The constant handling of mobile phones by users (multiple users in some cases) in health care facilities makes it an open breeding place for transmission of microorganisms, especially those associated with the skin due to the moisture and optimum temperature of human body especially the palms. Mobile phones are the reservoir of pathogens as they touch face, ears, lips and hands of different users of different health conditions (Goeland Goel, 2009). Keeping the mobile phones in the pockets, handbags and snug pouches increases the possibility of bacterial proliferation. Warmth, ideal temperature conditions and heat generated by mobile phones contribute to harboring bacterial populations on such devices at alarming rates (Jaya Madhuri *et al.*, 2015; Tagoe *et al.*, 2011).

Despite being used on a continuous basis, these mobile phones are seldom cleaned and the problem is again aggravated by the fact that many mobile phone users do not have regard for their personal hygiene specially that related to their use of such devices (Jaya Madhuri *et al.*, 2015).

This study was conducted to investigate the bacterial contamination of mobile phones among a group of paramedical university students, staff members and laboratory specialists at the medical laboratory technology department, Faculty of Allied Medical Sciences: Pharos University in Alexandria (PUA), Egypt and also to compare the results of Surface Spread technique (SS) versus those of Pour Plate technique (PP) in determining the bacterial count on the tested mobile phones.

Materials and Methods

Study design, sample size and study setting

This cross-sectional study was conducted over a period of 3 months (February to April

2016). The mobile phones of randomly selected 100 paramedical students, staff members and laboratory specialists at the Medical Laboratory Technology Department of the Faculty of Allied Medical Sciences: (PUA), were tested for bacterial contamination.

An oral informed consent was obtained from all the enrolled volunteers. A self-administered questionnaire covering demographic data and data about use of mobile phone and hygiene related to its use was filled in by each participant.

Samples collection and processing

Samples from mobile phones were aseptically collected using sterile cotton swabs. Each swab, moistened with sterile peptone water was rotated over the screen, keys, mouthpiece, earpiece and back-panel of the mobile, together with the keypad in non-touchscreen phones. All swabs were immediately streaked by (SS) method over the surface of blood and Mac Conkey's agar plates. The cotton end of each swab was then cut off and soaked in 10 ml peptone water. Blood and Mac Conkey's agar plates were incubated aerobically at 37°C for 24 hours.

The inoculated peptone water tubes were vortexed and one ml from each tube was transferred to the center of a sterile petri dish, then 15 ml of molten plate count agar medium was poured over the sample portion. The agar was thoroughly mixed with the sample portion and allowed to set and solidify. The plates were then inverted and incubated aerobically at 37°C for 24 hours.

Quantification of bacterial isolates

Isolated colonies on blood and Mac Conkey's agar plates using (SS) method were counted and recorded as number of organisms/phone.

The number of colony forming units (CFU) for each sample tested by (PP) method was then counted using the Quebec colony counter and recorded as CFU/ml.

Identification of isolates

Bacterial isolates on blood and Mac Conkey's agar plates were tested for colony morphology, Gram stained, examined microscopically and accordingly were tested biochemically according to the standard microbiological methods described by Forbes *et al.*, (2007).

For identification of Gram-positive cocci (GPC); isolates that appeared as medium sized, circular, white or golden yellow with smooth convex surface and entire edge, were β -hemolytic or non-hemolytic on blood agar and were positive for catalase, slide and tube coagulase tests and for Voges Proskauer (VP) test were considered as *Staphylococcus aureus* (*S. aureus*). Catalase positive, coagulase-negative and bacitracin-resistant GPC were considered as Coagulase-negative *Staphylococci* (CNS). Non-haemolytic, catalase-positive, coagulase-negative, bacitracin-sensitive GPC were identified as *Micrococcus* spp.

As regards Gram-negative bacilli (lactose and non-lactose fermenters), they were tested for oxidase production and for a set of biochemical reactions using API 20 E (Biomerieux).

The antibiotic sensitivity pattern of all isolates was detected using the disc agar diffusion procedure: Modified Kirby-Bauer antibiotic sensitivity test (Bauer *et al.*, 1966). The inhibition zone diameters were measured and interpreted as recommended by the Clinical and Laboratory Standards Institute (CLSI) (Wayne, 2014). *S. aureus* isolates were further checked for their susceptibility to

methicillin using oxacillin (1 µg) and cefoxitin (30 µg) discs on Mueller Hinton agar plates supplemented by 4% Na Cl.

Gram negative isolates were further tested for being extended spectrum beta-lactamase (ESBL) producers using the double disk diffusion method according to CLSI recommendations. Ceftazidime 30 µg, ceftazidime-clavulanate 30/10 µg, cefotaxime 30 µg and cefotaxime-clavulanate 30/10 µg discs were used. A ≥ 5 mm increase in a zone diameter for either antimicrobial agent tested in combination with clavulanate versus the zone diameter of the agent when tested alone confirmed ESBL producers.

Statistical analysis

Statistical analysis was carried out by using SPSS version 16 (Dniel, 2009). The significance level (0.05 parametric) was used to indicate statistical significance.

Results and Discussion

In the past few years, the mobile phone gradually became more and more involved in our daily life, including its private and work-related capacities. With high level of mobile phone penetration, a mobile culture has evolved, where the phone has become a key social tool. High technology applied in mobile phones has led to a better strategic life with good communication (Akinyemi *et al.*, 2009).

In an attempt to provide better communication and health care facilities, nowadays nearly 100% of HCWs own and use mobile phones. In fact, uncontrolled use of mobile phones by HCWs increases the spread of nosocomial infections (Amer *et al.*, 2016). Actually, not all HCWs clean their hands before or after using their phones which exposes both themselves as well as the others to the risk of transferring infections. HCW scan transfer microorganisms from the patient

himself or from one of the samples taken from him to their own hands, from their hands to their phones, and from their phones to their faces, mouths and ears. In reverse, HCW scan transfer microorganisms from their phones to patients or to other members of the community outside the health care facility (Bobat *et al.*, 2016).

The publicly-expressed worries about using a device harboring microbial contaminants have urged the performance of several related research projects worldwide. Variable contamination rates of cell phones were reported in different countries: USA: 20 % (Goldlatt *et al.*, 2007), UK: 55 % (Brady *et al.*, 2012), Nigeria and Ethiopia: 62 % each (Akinyemi *et al.*, 2009, Tolossa *et al.*, 2016), India: 72.5% (Ananthakrishnan and Gunasekaran, 2006), Australia: 74 % (Chao Foong *et al.*, 2015), KSA: 84 % (Vinod Kumar *et al.*, 2014), Turkey: 94.5% (Ulger *et al.*, 2009), Austria: 95% (Jeske *et al.*, 2007) and Cairo: 96.5% (Elkholy and Ewees, 2010). This variation may be due to differences in mobile phone handling and cleaning and in hand washing practice.

The present work enrolled 100 mobile phones that were randomly selected according to the available volunteers on the days of sampling. The mobile phones belonged to 78 students (78 %), 13 staff members (13%) and 9 laboratory specialists (9%) at the Medical Laboratory Technology Department of Faculty of Allied Medical Sciences at PUA. The majority (80%) of mobile phones were touch screen mobiles while only 20% were keypad mobiles. Only 38% of mobile phones were old (\geq one year) compared to 62% of which that were new mobile phones. As regards covers; most of the mobile phones examined (78%) were not kept in covers while only 22% of which was kept in covers.

The current results revealed that the majority (90%) of the tested mobile phones were

contaminated with bacterial isolates compared to only 10 %; out of which no bacteria was recovered. All the ten sterile mobile phones belonged to paramedical students. No statistically significant difference was found in the rate of bacterial contamination of tested mobile phones based on gender, occupation or frequency of use of mobile phones by their owners.

Nearly similar results were reported by Tiwari *et al.*, (2016), Brady *et al.*, (2006) and Jeske *et al.*, (2007), who reported contamination rates of 88.13%, 89.7% and 90%, respectively, in the mobile phones they examined.

Higher rates of mobile phone contamination (>90%) have been also reported, worldwide, by several investigators (Deshkar *et al.*, 2016; Tiwari *et al.*, 2016, Karthiga and Muralidharan, 2016; Elkholy and Ewees, 2010; Ustun and Cihangiroglu, 2012). Furthermore, a contamination rate of 100% was reported recently in Alexandria by Selim and Abaza (2015). On the other hand, lower contamination rates ranging from as low as 17 % (Al-Mudares *et al.*, 2012) to as high as 83% (Tambe and Pai, 2012; Shakir *et al.*, 2015) have also been reported.

In the present work, a single isolate was detected in 64% of tested mobile phones while more than one type of isolates was detected in only 26% of which. On the other hand, polymicrobial growth was observed in 100% of mobile phones examined by Selim and Abaza (2015) and Tagoe *et al.*, (2011). Also, Srikanth *et al.*, (2010), Chawla *et al.*, (2009) and Ulger *et al.*, (2009) reported polymicrobial growth in 71%, 67.5% and 46 %, respectively of HCW mobile phones.

The present results highlighted that 66% of the participants cleaned their mobile phones frequently compared to 34% who claimed

they never cleaned their phones. The rates of frequent cleaning of HCWs, mobile phones recorded worldwide in previous studies varied from 10.5% in Turkey (Ulger *et al.*, 2009) to 31% in Australia (Shaker *et al.*, 2015). In the gulf zone, 66.5 % of HCWs in Kuwait (Heyba *et al.*, 2015) and 76% of those in KSA stated they never cleaned their mobile phones (Sadat-Ali *et al.*, 2010).

Table 1 illustrates that out of the 66 cell phones which were recorded to be cleaned by their owners in the current study, 54 (81.8%) yielded only one type of organism while 24 (70.6%) of the 34 cell phones which were never cleaned by their owners yielded more than one type of organisms. The difference between these results was found to be highly statistically significant (p-value <0.001).

It has been also noted that the majority (73%) of individuals enrolled in the present study reported that they never perform any hand hygiene practices in relation to the use of their mobile phones. Out of the mobile phones of those 73 participants, 47 (64.4%) grew only one type of organisms compared to 63% (17/27) of those who practiced hand hygiene practices. There was no statistical significant difference between the two groups (P-value=0.587).

Estimation of the bacterial load on mobile phones

In the current research bacterial count on mobile phones was determined by two techniques simultaneously: PP and SS methods. It can be seen in table 2 that a mean bacterial count of 653.73 CFU/ml and a median of 250 CFU/ml were recorded by the PP method while the corresponding figures were 305.71 and 137.50 organisms/phone using the SS method. There was a statistically significant difference between the two methods (p-value <0.001). The current results

showed that PP method yields much higher number of isolates than SS method in count categories of ≥ 100 CFU/phone (mean of 1066.33 and 535.51, respectively). This was found to be statistically significant (p -value < 0.001). On the other hand, there was no statistical significant difference between the two methods regarding the lower count categories of < 10 and 10 - < 100 CFU/ phone (Table 3).

This finding was contradictory to that reported by Selim and Abaza, 2015, who

stated that in low and moderate bacterial counts (< 10 and ≥ 10 , respectively), SS method yielded statistically significant higher numbers of organisms than PP method, while in high counts (≥ 100), though SS method revealed higher numbers of isolates than those yielded by PP method, yet this was not found to be statistically significant. Thus, they recommended SS method as an easier and less laborious technique of bacterial count compared to PP method.

Table.1 Relationship between the count of bacterial isolates on tested mobile phones and different parameters related to their owners: gender, occupation, frequency of use of mobile, mobile cleanliness and hand hygiene practices

| | Number of bacterial agents isolated | | | | | | Total | | Mean | SD. | Median | χ^2 | p-value |
|--|-------------------------------------|-------------|-----------------------|-------------|-----------------------|-------------|------------|--------------|------|------|--------|-------------|-------------------|
| | No isolates | | One type of organisms | | > 1 type of organisms | | | | | | | | |
| | No. | % | No. | % | No. | % | No. | % | | | | | |
| Gender | | | | | | | | | | | | | |
| Male | 4 | 9.8 | 25 | 61.0 | 12 | 29.3 | 41 | 100.0 | 1.20 | 0.60 | 1.0 | 0.389 | 0.823 |
| Female | 6 | 10.2 | 39 | 66.1 | 14 | 23.7 | 59 | 100.0 | 1.14 | 0.57 | 1.0 | | |
| Occupation | | | | | | | | | | | | | |
| Student | 10 | 12.8 | 47 | 60.3 | 21 | 26.9 | 78 | 100.0 | 1.14 | 0.62 | 1.0 | 3.379 | MC p= 0.476 |
| Staff | 0 | 0.0 | 11 | 84.6 | 2 | 15.4 | 13 | 100.0 | 1.15 | 0.38 | 1.0 | | |
| Laboratory Specialist | 0 | 0.0 | 6 | 66.7 | 3 | 33.3 | 9 | 100.0 | 1.33 | 0.50 | 1.0 | | |
| Frequency of use of mobile | | | | | | | | | | | | | |
| ≤ 5 times/day | 1 | 12.5 | 5 | 62.5 | 2 | 25.0 | 8 | 100.0 | 1.13 | 0.64 | 1.0 | 0.460 | MC p= 1.000 |
| 6 – 50 times/day | 9 | 9.8 | 59 | 64.1 | 24 | 26.1 | 92 | 100.0 | 1.16 | 0.58 | 1.0 | | |
| Cleaning of mobile | | | | | | | | | | | | | |
| Yes | 10 | 15.2 | 54 | 81.8 | 2 | 3.0 | 66 | 100.0 | 1.16 | 0.60 | 1.0 | 54.17 3* | < 0.001 * |
| Never | 0 | 0.0 | 10 | 29.4 | 24 | 70.6 | 34 | 100.0 | 1.16 | 0.55 | 1.0 | | |
| Hand wash and disinfection in relation to use of mobile | | | | | | | | | | | | | |
| Yes | 4 | 14.8 | 17 | 63.0 | 6 | 22.2 | 27 | 100.0 | 1.07 | 0.62 | 1.0 | 1.067 | 0.587 |
| Never | 6 | 8.2 | 47 | 64.4 | 20 | 27.4 | 73 | 100.0 | 1.19 | 0.57 | 1.0 | | |
| Total | 10 | 10.0 | 64 | 64.0 | 26 | 26.0 | 100 | 100.0 | | | | | |

χ^2 : Chi square test * statistically significant at $p \leq 0.05$ MC: Monte Carlo for chi square test ** statistically significant at $p \leq 0.01$

Table.2 Descriptive analysis of the positive examined mobile phones according to their bacterial load counted by PP and SS techniques

| | Min. – Max. | Mean ± SD. | Median | P-Value |
|-----------|--------------|-----------------|--------|---------|
| SS method | 2.0 – 2500.0 | 305.71 ± 414.59 | 137.50 | <0.001* |
| PP method | 6.0 – 3200.0 | 653.73 ± 861.62 | 250.0 | |

Table.3 The count of bacterial isolates contaminating the 100 tested mobile phones using SS and PP techniques

| Count categories | Count by SS method (organism/mobile phone) | | | | Count by PP method (CFU/ml) | | | | p-Value |
|------------------|--|---------------|---------------|----------------|-----------------------------|---------------|--------------|----------------|---------|
| | Mean | SD. | Median | Geometric mean | Mean | SD. | Median | Geometric mean | |
| <10 | 4.86 | 2.04 | 6.0 | 4.37 | 6.67 | 0.58 | 7.0 | 6.65 | 0.181 |
| 10 – <100 | 36.47 | 24.73 | 31.0 | 28.53 | 37.39 | 19.77 | 32.0 | 31.98 | 0.867 |
| ≥ 100 | 535.51 | 447.02 | 447.0 | 400.86 | 1066.33 | 901.53 | 725.0 | 713.81 | <0.001* |
| Total | 305.71 | 414.59 | 137.50 | 103.93 | 653.73 | 861.62 | 250.0 | 195.60 | |

P: p value for Student t-test *: Statistically significant at $p \leq 0.05$

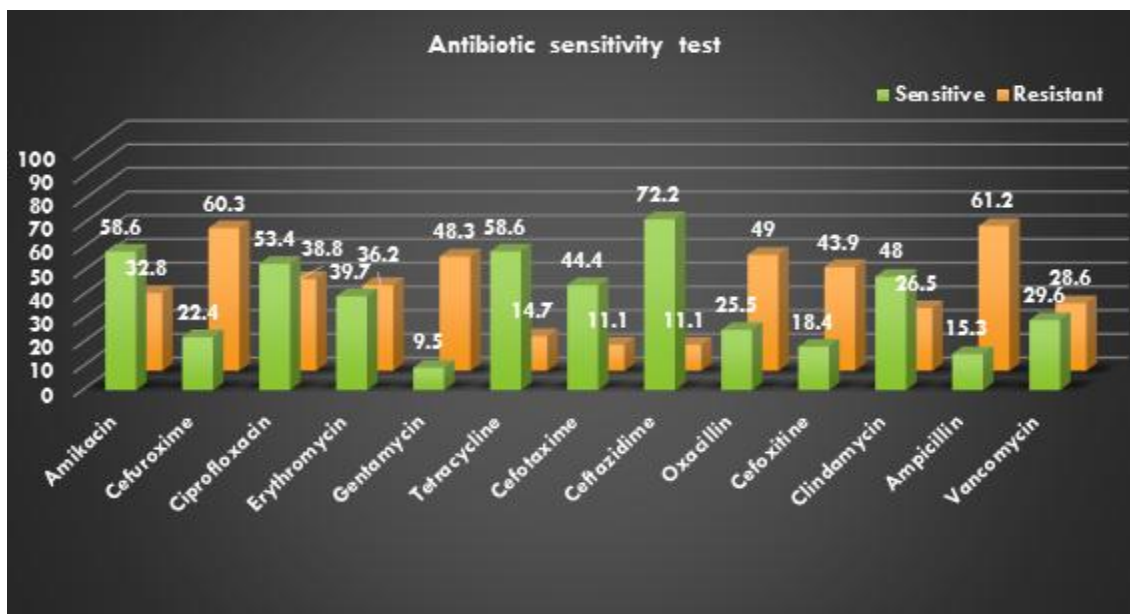
Table.4 Types of Isolates in the 100 Studied Mobile Phones

| Names of identified isolates | No. | % |
|---------------------------------|-----|------|
| • CNS | 33 | 33.0 |
| • <i>S. aureus</i> | 24 | 24.0 |
| • <i>Micrococci</i> | 17 | 17.0 |
| • <i>E. coli</i> | 15 | 15.0 |
| • Viridans <i>Streptococci</i> | 11 | 11.0 |
| • Diphtheroids | 9 | 9.0 |
| • <i>Klebsiella pneumoniae</i> | 5 | 5.0 |
| • <i>Enterobacter aerogenes</i> | 2 | 2.0 |

**S. aureus* isolates: 21 out of 24 (87.5%) were MRSA and only 3 (12.5 %) were MSSA

* All *Klebsiella pneumoniae* isolates (100%) were ESBL strains.

Fig.1 Distribution of the isolated bacteria according to their antibiotic sensitivity patterns (n = 116 isolates)



Previous results by Tagoe *et al.*, (2011), showed much higher levels of bacterial contamination of mobile phones used by students in the University of Cape Coast with an overall mean viable bacterial count of 9.9×10^5 CFU using PP method. This could be attributed to difference in the level of hand hygiene practice in relation to the use of mobile phones. In general; the greater the concentration of the microbe, the longer it survives and survival can range from minutes to months.

On the other hand, in a previous study by Pal *et al.*, (2013), the median colony count for touch screen phones and keypad devices was as low as 0.09 CFU and 0.77 CFU, respectively.

High contamination rates of mobile phones of HCWs could be attributed to several factors as: infrequent cleaning of mobile phones during working hours, low compliance of hand washing and unawareness of the fact that mobile phones can also act as a vector for transmission of pathogenic organisms. As per

the instructions of mobile phone manufacturers that emphasize that contact with water or liquid disinfectant might damage the software of mobile phones, even most of them who are aware of its pathogenic potential also don't clean their phones. Currently in many institutions, strict guidelines have not been implemented to restrict medical staff from carrying mobile phones into the work zones and there are also no cleaning guidelines for mobile phones of HCWs.

Bacteria isolated from contaminated mobile phones

It is clear from table 4 that the most common isolate in the present study was CNS detected in 33% of cases followed by *S. aureus* (24%); 87.5% of which were MRSA and 12.5 % were MSSA, *Micrococci* (17%), *E. coli* (15%), viridans *Streptococci* (11%), Diphtheroids (9%), *Klebsiella pneumoniae* (5%) [All of which were ESBL strains] and *Enterobacter aerogenes* (2%).

The majority of isolates in the current work could be described as normal flora that could naturally be present on human skin. This finding coincides with those of other researchers as Brady *et al.*, (2012), Jeske *et al.*, (2007) and Chao Foong *et al.*, (2015) who isolated normal flora from 85%, 94.7% and 95% of tested mobile phones, respectively.

Although such isolates are considered saprophytic or commensal organisms, yet they can be opportunistic pathogens, particularly in immunocompromised hosts.

Other researchers also isolated CNS at high rates of 43 % to 71.5 % of the tested mobile phones (Lavanya *et al.*, 2016; Amer *et al.*, 2016; Selim and Abaza, 2015; Akinyemi *et al.*, 2009; Kumar *et al.*, 2014; Raghavendra *et al.*, 2014; Karabay *et al.*, 2007 and Bhoonderowa *et al.*, 2014).

MRSA represented 87.5% of *S. aureus* isolates in the current work, while only 12.5 % were MSSA. Higher isolation rates were recorded for *S. aureus* in similar studies as that carried out by Selim and Abaza (2015), Tambe *et al.*, (2012) and Raghavendra *et al.*, (2014) who isolated *S. aureus* from 71.5 %, 54% and 52% of tested phones, respectively. MRSA was also previously isolated from 40%, 53% and 83 % of mobile phones examined by Rana *et al.*, (2013), Angadi *et al.*, (2014) and Jeske *et al.*, (2007), respectively.

Staphylococci evidently have the highest occurrence on mobile phones. These organisms may probably have found their way into the phone through the skin and from hand to hand. It is a well-known fact that organisms like *S.aureus* and CNS resist drying and thus can survive and multiply rapidly in the warm environments like cell phones.

Antibiotic sensitivity pattern of bacterial isolates

As regards the results of the antibiotic sensitivity tests of the isolated organisms in the present study, the highest sensitivity was recorded for ceftazidime (72.2%) while the highest resistance was recorded for ampicillin (61.2%) (Figure 1).

The isolated organisms in this study were resistant to most of the commonly used antibiotics. This may be due to indiscriminate use of multiple antibiotics, intravenous drug abuse, self-medication, and inappropriate use of antibiotics.

The isolation of MRSA and ESBL *Klebsiella pneumoniae* is a matter of concern. It proves the pathogenic potential of the organisms isolated from mobile phones and highlights the risk of mobile phones as vehicles of transmission of serious multiple drug resistant pathogens.

As the restrictions on the use of mobile phones in the health care institutions by medical personnel are impractical since those mobile devices can be considered as essential instruments for healthcare workers, therefore the emphasis should be put on the prevention of the spread of bacteria through mobile phones by proper hand hygiene and disinfection of mobile phones.

Screening of mobile phones for bacterial contamination on regular basis is recommended specially within health care facilities and laboratories. Using hands free mobile phones during work hours is advised for HCWs and proper infection control practices to prevent the spread of bacteria through mobile phones are recommended to be incorporated in students, curricula and as a part of health education sessions for medical and paramedical personnel.

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