Int.J.Curr.Microbiol.App.Sci (2018) *7*(11): 1485-1495

International Journal of Current Microbiology and Applied Sciences
ISSN: 2319-7706 **Volume 7 Number 11 (2018)**
Journal homepage: http://www.ijcmas.com

Original Research Article https://doi.org/10.20546/ijcmas.2018.711.171

Electronic Devices - A Potential Threat to Hospital Infection Control

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Keywords

Disinfection, Electronic devices, Healthcare associated infections, Institutional devices, Source

Article Info

Accepted:
12 October 2018
Available Online:
10 November 2018

ABSTRACT

Electronic devices are increasingly used by the healthcare workers. They can get contaminated with pathogenic organisms and can act as a source of healthcare associated infections. In this study we aimed to determine the bacterial contamination rates of the electronic devices handled by the healthcare workers posted in high risk areas like ICU's, NICU's and operation theatres. Swabs were collected from personal electronic devices of 40 healthcare workers and from 33 common devices used in high risk areas. The participants were divided into 4 groups: doctors, residents, nurses and theatre technicians. The swabs were streaked onto blood agar and MacConkey agar and incubated at 37degree Celsius. The isolates were identified and were subjected to antibiotic susceptibility tests by standard procedures. Of the 45 personal devices including mobile phones and laptops swabbed, 86.7% showed growth of organisms. Coagulase negative staphylococcus species was the most common organism, isolated at the rate of 50.9%. Of the gram- negative bacilli isolated, 16.6% showed ESBL production. The rate of MRSA isolation was 3%. It was found that among the participants 63% and 62.5% were found to be not disinfecting their devices and hands respectively. Electronic devices were found to be carriers of infectious pathogens. Strict guidelines have to be introduced for proper usage and disinfection of the devices and hands.

Introduction

Global usage of electronic devices like mobile phones, laptops, tablets, monitors have increased over the past decade. They are used in medical setting for everyday patient care. Healthcare workers use the devices for gaining access to information, drug references, for reminding patients regarding appointments, drug intake, vaccination and for communication among their colleagues, and during surgical emergencies (Neville *et al.*, 2002; Ferrer-Roca *et al.*, 2004; Vilella *et al.*, 2004; Kaushik, 2005). The increased use of mobile phones is seen against a background rise in healthcare-associated infection rates reported by ecological findings (Sepehri *et al.*, 2009; Brady *et al.*, 2006).

These devices are used in areas requiring high hygiene standards like the operation theatre and the Intensive care units. Health care workers' hands come frequently in contact with patients and can get contaminated with pathogens. Proper hand hygiene before and after handling of electronic devices is not widely practiced. As a result, these pathogens can be transferred to the electronic devices they handle, portable devices as well as fixed devices in operation theatres and intensive care units. These can act as a reservoir of pathogenic organisms because of their heat generation and by their frequent handling by the healthcare workers (Bures *et al.*, 2000). They may thus act as a source of carrier of pathogenic organisms around the hospital setting (Brady *et al.*, 2006). They can play an important role in the spread of healthcare associated infections.

They pose a serious threat to hospital infection control. In a study conducted by Amberkhan et.al the average pathogenic bacterial contamination on portable devices were found to be 25.9% (Khan *et al.*, 2015). In a similar study conducted by Bureus *et al.*, colonization rate on keyboards were found to be 24% (Bures *et al.*, 2000). In studies conducted in USA and UK, higher levels of contamination of electronic devices were seen.

In this study we aimed to determine the bacterial contamination of the electronic devices handled by the healthcare workers in operation theatre, neonatal intensive care units (NICU's) and intensive care units (ICU's) and also determined the level of disinfection practices undertaken by them to clean their devices.

Materials and Methods

Study design and study population

A cross sectional study was conducted among 40 healthcare workers appointed in sterile areas like ICU's, NICU's and operation theatre in a tertiary care hospital. Stratified random sampling method was used to identify the sample population. All the devices used by the healthcare workers were taken for sampling (example; mobile phones, laptops, tabs). In addition, all the common devices (like monitors, workstations) in the above-mentioned areas were included for the study. A structured questionnaire was given for self-administration to the participants to collect information about their demographic details, number of devices, place of device usage, frequency of attending hospital infection control workshop, disinfection practices of the devices and hand hygiene practices.

A written informed consent, explaining the procedure of the study was obtained from the participants before administration of questionnaire and collection of swabs. The study was approved by the institutional ethical committee.

Collection of sample

The samples were collected using sterile cotton swabs moistened with sterile peptone water. The swabs were rolled over the surface of the electronic devices used by the healthcare workers. In case of mobile phones, the screen, touch pad, sides and the back of the device was rolled with cotton swabs. If a cover was present, swabs were rolled over the cover of the mobile phones. In laptops, the screen, keypad, touch surface was rolled with cotton swabs. In common devices, the monitors and the touch pad were swiped with cotton swabs. The hands of the sample collector were sterilised with alcohol rub before collection to prevent contamination of the device. The samples collected were transported to the laboratory in a nutrient broth. The swabs were streaked onto blood agar and MacConkey agar and incubated at 37 degree Celsius for 24 hours. The isolated organisms were identified based on colony morphology, hemolysis, gram stain, and biochemical tests. Tube coagulase test was done to differentiate *Staphylococcus aureus* from coagulase negative staphylococcus (CONS). Gram negative bacilli were identified by triple sugar test and oxidase test. The antibiotic susceptibility pattern of each organism was done following CLSI (clinical and laboratory standards institute) guidelines. (CLSI, 2014) Specific methicillin resistance of *Staphylococcus aureus* and extended spectrum β-lactamase Production (ESBL) of gram negative bacilli was tested.

Cefoxitin disc diffusion test

A 0.5 McFarland standard suspension of the isolate was made and lawn culture done on MHA plate, cefoxitin disc (30µg) were put and plates were incubated at 350C for 18 hr. and zone of inhibition were measured. An inhibition zone diameter of ≤19 mm was reported as oxacillin resistant and ≥ 20 mm was considered as oxacillin sensitive.

Phenotypic confirmatory test for ESBL

A 0.5 McFarland standard suspension of the isolate was made and lawn culture done on MHA plate, Ceftazidime disc (30µg) and cefotaxime disc (30µg) in combination with the discs of Ceftazidime/Clavulanic acid (30/10 µg) and Cefotaxime/Clavulanic acid (30/10 µg) were put and plates were incubated at 350C for 18 hr. and zone of inhibition were measured. An increase in inhibition zone diameter by ≤5 mm around the disc with Clavulanic acid over the disc with cephalosporins alone was confirmed as ESBL producers.

Identification of isolates

For identification of Gram-positive cocci (GPC); isolates that appeared as medium sized circular, white or golden yellow with smooth convex surface, entire edge and were β-hemolytic on blood agar plates and were positive for catalase and tube coagulase were considered as *Staphylococcus aureus* (*S. aureus*). Non-haemolytic, catalase-positive, coagulase-negative GPC were identified as *Micrococcus* spp., while β-hemolytic, catalase-positive, tube coagulase-negative GPC were considered as coagulase-negative staphylococci (CONS).

S. aureus and CONS isolates were further checked for their susceptibility to methicillin using oxacillin discs on Mueller Hinton agar plates by disk diffusion method. (Selim and Abaza, 2015)

For identification of gram negative bacilli, lactose fermentation on MacConkey agar, citrate, urease, triple sugar, oxidase and indole tests were done. They were further tested for being extended spectrum beta-lactamase (ESBL) production by using ceftazidime and ceftazidime-clavulanate discs. A ≥5 mm increase in a zone diameter when tested in combination with clavulanate vs. the zone diameter when tested alone confirmed ESBL producers. (CLSI, 2014)

Results and Discussion

Out of the 40 healthcare workers, 48% were males and 52% were females. Of all the participants in this study, 20% were residents and theatre assistants, 23% were nurses and 37% were doctors. Of all the swabs, 55% were collected from operation theatres, 17.5% from NICU and MICU and 10% from SICU. This is shown in table 1. Along with this, 33 swabs were taken from institutional common devices present in areas like operation theatres, NICU's and ICU's. Of these 39.4% were collected from operation theatres and ICU's, 21.2% from NICU's. A total of 78 swabs were sampled including personal and institutional gadgets.

Of the organisms that were isolated from 40 mobile phones 2.5% were *Streptococcus spp*, 2.5% *Proteus spp*, 2.5% Methicillin sensitive *Staphylococcus aureus* (MSSA), 10%

Acinetobacter spp, 10% *Pseudomonas spp*, 20% *Klebsiella sp* and 60% were CONS. No growth was seen in 12.5% of the swabs taken from mobile phones. Of the organisms isolated from 5 laptops 20% were CONS, 20% *Acinetobacter spp*, 20% Methicillin resistant *Staphylococcus aureus* (MRSA) and 60% were *Klebsiella spp*. No growth was seen in 20% of swabs from the laptops. Of the organisms isolated from 33 institutional common devices 3.03% were *Klebsiella spp*, 3.03% *Acinetobacter spp*, 3.03% MRSA, 3.03% *E. coli* and 12.1% were CONS. No growth was seen in 75.8% of the swabs. This data is shown in Figure 1.

We have checked the antibiotic susceptibility patterns of all the isolates and found that 16.6% were ESBL producers and three percent were MRSA strains. The antibiotic resistant pattern of the gram-positive and gram-negative organisms is given in table 2 and 3 respectively.

From the questionnaire administered, the rates of disinfection of devices and hands of healthcare workers before and after handling of devices, were determined and it was found that 37% were disinfecting their devices as shown in Figure 2.

The percentage of frequency of disinfection of devices was assessed and it was found that 7.5% were disinfecting their devices weekly once as shown in Figure 3.

The various methods of disinfection of the electronic gadgets followed by healthcare workers were analysed and sterilium was the most common substance used as shown in Figure 4.

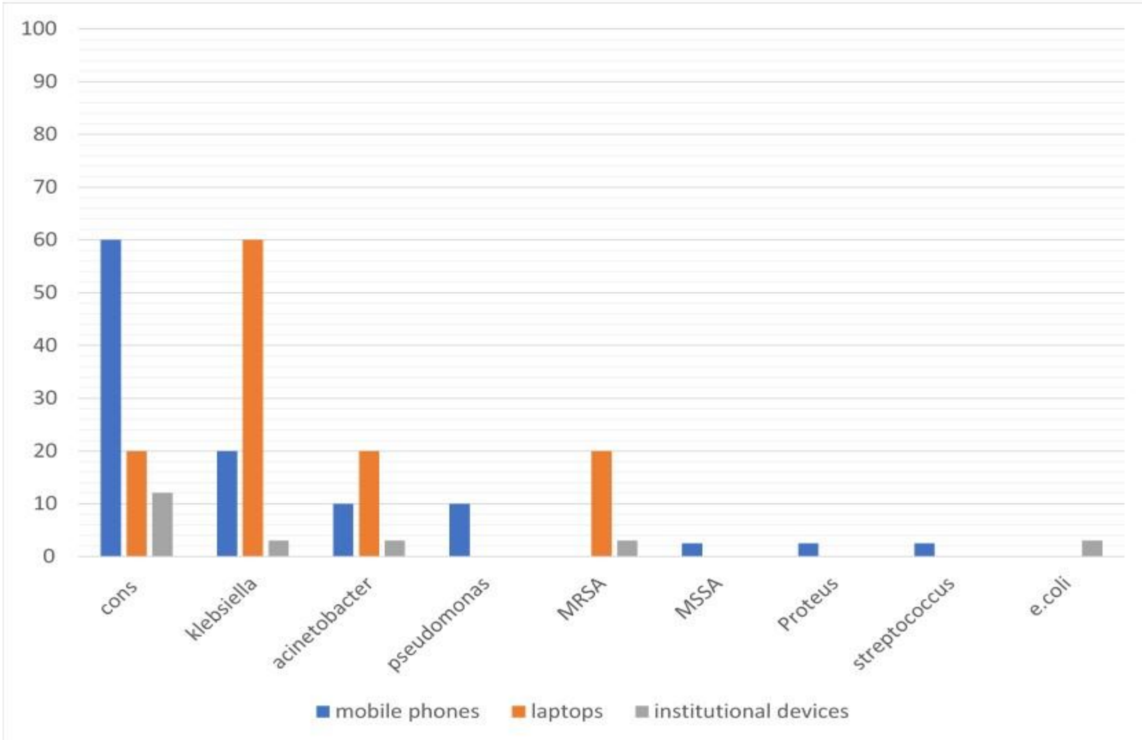
Age group wise analysis of hand hygiene practices showed that 75% of participants in age group of 20-30 years, 61.1% in 31 to 40 age group, 50% in 41 to 50 age group and 100% in above 50 years of age were not following hand hygiene before and after handling their devices. It was seen that among participants with less than 10 years of service, 65.4 % were not disinfecting their hands. The disinfection practices were also found to be less in participants with more than 20 years of service i.e. 83.3%. Among participants with 11 to 20 years, 50% were not disinfecting their hands.

Cadre wise analysis shows that 66.7% of doctors, 55.6% of nurses, 87.5% of residents and 50% of theatre technicians were not disinfecting their hands. Of the swabs collected from participants posted in MICU 42.9% were not disinfecting their hands. From NICU and operation theatres 85.7% of participants and 68.2% of participants were not disinfecting their hands respectively. Fifty percent of participants posted in SICU were not disinfecting their hands before and after handling their devices.

Half of the participants, 20 people, have attended hospital infection control workshops. Of them 30% were found to be disinfecting their hands and 70% were not disinfecting their hands. Hand hygiene was practiced by those who have attended workshops in their recent past. This study was aimed to determine the bacterial contamination of electronic devices used by the healthcare workers. Out of the 45 personal electronic devices swabbed, 86.7% showed growth. Other studies show higher rate of bacterial contamination like Ulger *et al.*, (2009) shows 94.5%, Jayalaksmi *et al.*, (2008) shows 91.6%, whereas Pal *et al.*, (2015) shows 81.8%.

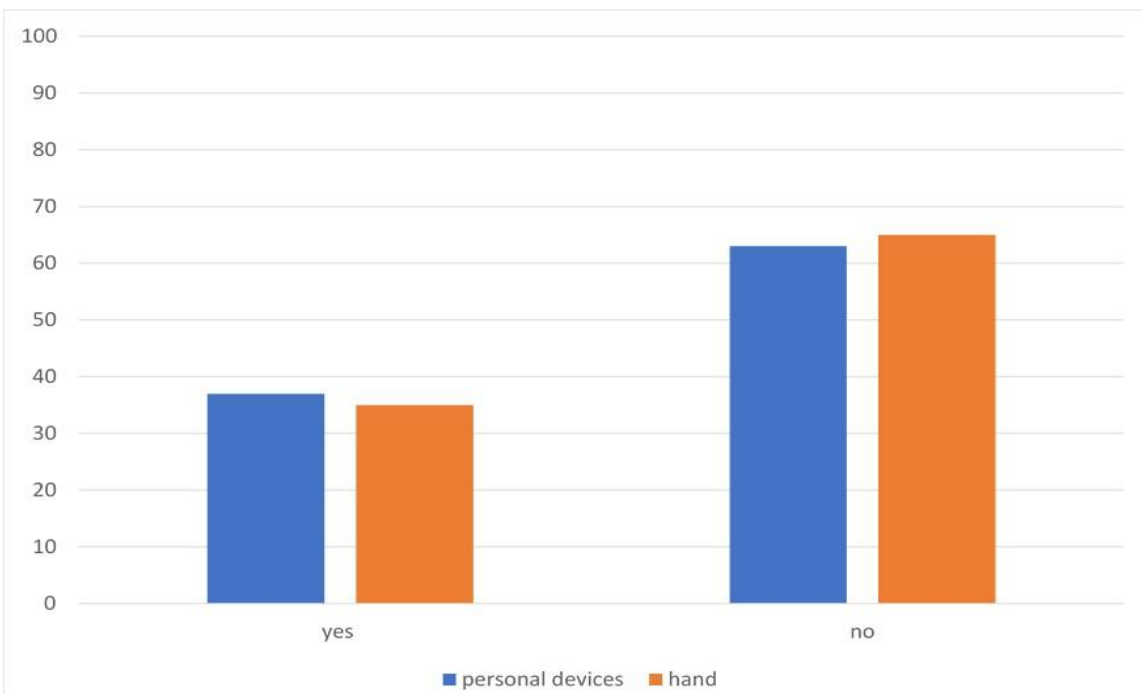
Of the personal gadgets that showed growth, 30.7% showed growth of two organisms. This is close to other studies that shows growth of two different species on a single device like studies done by Ulger *et al.*, (2009) 34%, Nwankwo *et al.*, (2014) 30%.

Figure 1: Isolates from electronic devices (in percentage)



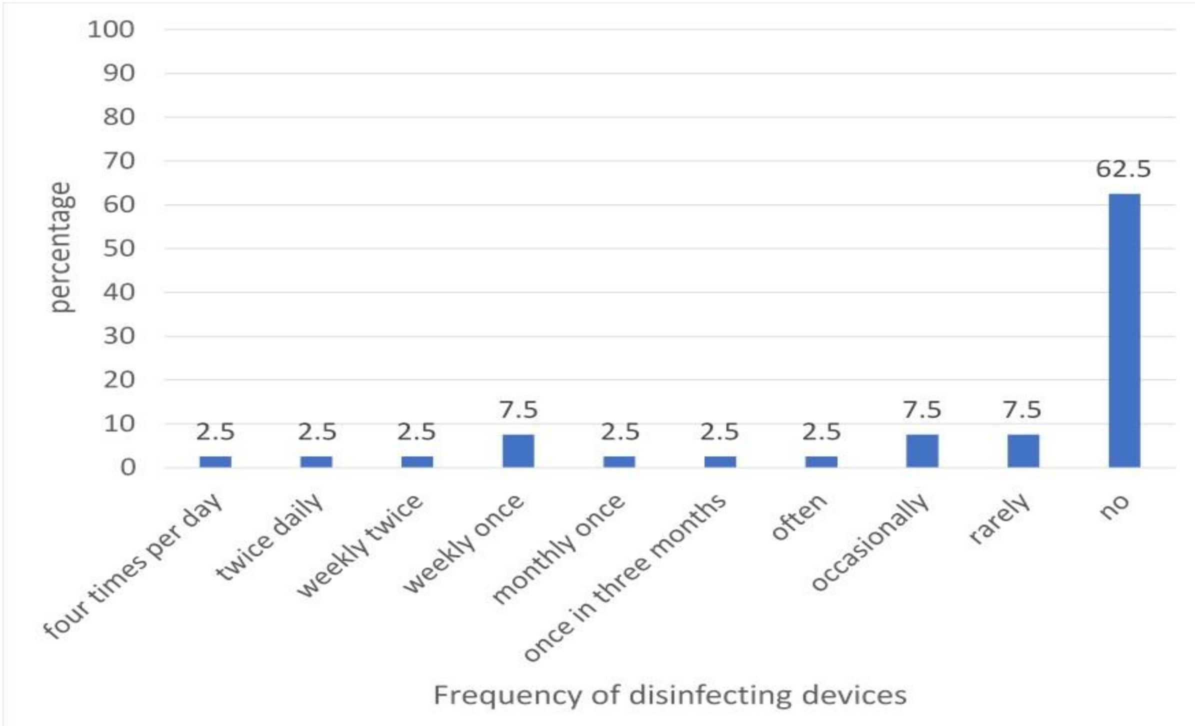
Legend for Figure 1: This figure shows that the majority of organisms isolated from the electronic devices are cons and *Klebsiella spp*

Figure 2: Disinfection of hands and personal electronic devices (in percentage)



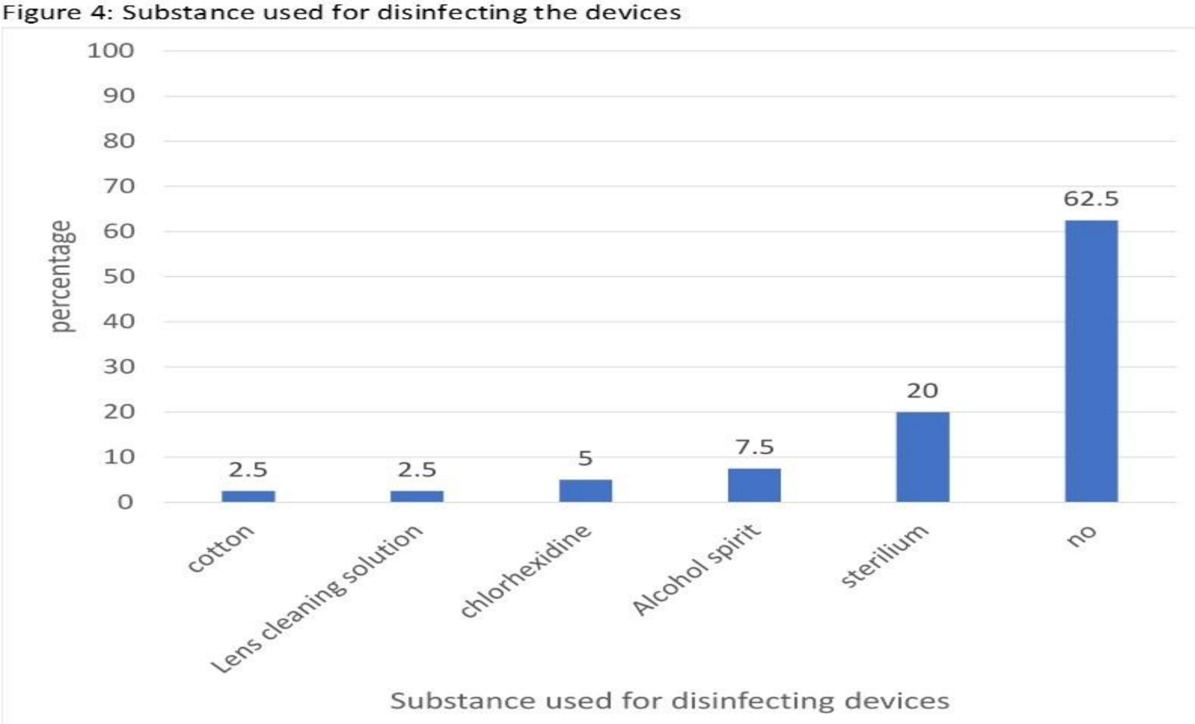
Legend for Figure 2: This figure shows that the majority of participants are not disinfecting their devices and hands.

Figure 3: Frequency of disinfection of devices



Legend for Figure 3: This figure shows that of the participants who are disinfecting their devices majority are disinfecting their devices weekly once.

Figure 4: Substance used for disinfecting the devices



Legend for Figure 4: This figure shows that majority of the participants who are disinfecting their personal devices are using sterilium to disinfect their devices.

Table.1 Distribution of participants with respect to cadre and location in hospital

	OT	NICU	MICU	SICU	Total
Doctor	8	4	1	2	15 (37%)
Resident	5	2	1	-	8 (20%)
Nurses	1	1	5	2	9 (23%)
Theatre technicians	8	-	-	-	8 (20%)
Total	22 (55%)	7 (17.5%)	7 (17.5%)	4 (10%)	40

Table.2 Antibiotic resistance pattern of gram-positive organisms (in percentage)

	Amoxyclav	Cefoxitin	Vancomycin	Linezolid	Clindamycin	Cotrimoxazole
Cons sp (29)	62	93.1	0	3.4	44.8	27.5
MRSA (2)	100	100	0	0	50	100
MSSA (1)	0	0	0	0	0	0
Streptococcus sp (1)	100	0	0	0	0	100

Cons = Coagulase negative staphylococcus sp.

Table.3 Antibiotic resistance of gram-negative organisms (in percentage)

	Amoxyclav	Imipenem	Piptaz	Cefoperazonesulbactum	Ceftaclav	Ceftazidime
Klebsiella sp (12)	25	0	8.3	16.6	8.3	46.6
Acinetobacter sp (6)	33.3	16.6	16.6	16.6	0	16.6
Pseudomonas sp (4)	0	0	0	0	0	25
Proteus sp (1)	100	0	0	0	0	100
E.colisp (1)	100	100	0	0	0	0

In a study conducted by (Badr *et al.*, 2012) showed lesser rates of contamination by two pathogens on the same devices, 6.6%. Study by Srikanth *et al.*, (2008) shows higher rates 58%. This implies that more than a single organism can grow on electronic devices and this increases the risk of transmission of more organisms to the patients handled by the healthcare workers.

In our study, Coagulase negative staphylococcus species (CONS) was isolated in maximum number (50.9%), followed by *Klebsiella sp* (21.1%) and *Acinetobacter sp* (10.5%). Study done by (Karabay *et al.*, 2007) also reveals cons as the most prevalent micro-organism isolated from the mobiles at the rate of 68.4%.

Also in the study by (Selim *et al.*, 2015) 40% cons were isolated. Cons isolated in this study shows 93% resistance to cefoxitin.

These resistant strains are carried by the electronic devices of the healthcare workers and can be transmitted to the immune-compromised patients and to the community and are of vital healthcare importance.

Out of the 24 gram-negative bacilli, 16.6% were multidrug resistant. This was comparatively lower to study by Badr *et al.,* (2012) where 38.5% of gram negative bacilli were multidrug resistant.

The MRSA isolates in this study were 3.5%. This was relatively similar to other studies like Pal *et al.,* (2015) 2% and Jayalakshmi *et al.,* (2008) 2.7%. Some studies reported higher rates of MRSA isolation, like Datta *et al.,* (2009) showing 18% and Badr *et al.,* (2012) showing 14.43%. This is a major concern as methicillin resistant *Staphylococcus aureus* are important organisms in causing healthcare associated infections.

From the questionnaire administered it was found that disinfection of devices was carried out by 37% of participants. This was higher than the studies by (Sham *et al.,* 2011) and (Srikath *et al.,* 2008) where the rate of disinfection of mobile phones was 6% and 11.7% respectively. Sixty three percent of healthcare workers were not disinfecting their devices. High rates were also reported in studies like (El-Ashry *et al.,* 2015) 96.5%, (Pal *et al.,* 2015) 97% and (Ulger *et al.,* 2009) 89.5%.Relatively lower rates was found in studies by (Amberkhan *et al.,* 2015) 17% and (Ramesh *et al.,* 2008) 53%. It was found in this study that 20% were disinfecting their devices with an alcohol based hand rub which is relatively lesser than in the study by (Amberkhan *et al.,* 2015) 33%. In our study 5% were disinfecting their devices with chlorhexidine, lesser than compared to (Amberkhan *et al.,* 2015) 18%. The frequency of contamination of devices were 7.5% weekly once and 2.5% monthly once. (Amberkhan *et al.,* 2015) reported weekly disinfection 34.8% and monthly disinfection 46%. Disinfection of devices is important and a study done by (Albrecht *et al.,* 2013) demonstrated a reduction in colony counts by 98.1% after disinfection with the isopropyl alcohol wipes. This emphasizes the introduction of strict policies for the proper usage and disinfection of the electronic devices and for creating awareness among the health care workers regarding the potential of these devices to the spread of infections.

It was found that 62.5% of healthcare workers were not disinfecting their hands which is higher when compared to studies done by (Pillet *et al.,* 2016) which shows 28% and (Ramesh *et al.,* 2008) 3%. A large proportion of participants were not disinfecting their hands. This may be due to lack of awareness of healthcare-associated infection and its mode of transmission.

Poor hand hygiene practices were noted highest among the doctors (66.6%) and residents (87.5%) in our study. This indicates the need to conduct more training programmes to create awareness. Healthcare workers have to be educated frequently to do regular disinfection of devices and their hands before and after handling electronic devices.

Among the institutional common devices used in high risk areas like ICU,s, NICU and operation theatres, 12.1% showed growth of cons which is comparable to a study by (Okon *et al.,* 2017) in which the rate was 19.7% in ICU setting. This poses a greater threat to infection control as they are handled by many people and could lead to cross contamination of organisms. This implies that better awareness has to be created among people involved in the disinfection of these devices in operation theatres and in ICU's. Frequent disinfection of these devices also needs to be carried out.

The demonstration of bacterial colonisation on personal and common electronic devices calls for a major attention as they can pose a major threat for the outbreak of healthcare associated infections specially in high risk areas. This highlights the need for developing policies and guidelines regarding electronic device usage and disinfection practices. Frequent education of healthcare workers regarding hand hygiene practices has to be carried out.

The evaluation of a substance ideal for the disinfection of the devices is crucial and further studies have to be done to determine an ideal substance that acts as an effective disinfectant and at the same time does not harm the performance of the gadgets. Statistical significance was not attained as sample size was less and multi-level model of sampling were the major limitations of the study.

Electronic devices were found to be reservoirs of multidrug resistant pathogenic organisms and can act as a potential source for the spread of healthcare-associated infections.

The organisms on the portable devices can be taken outside the hospital environment and can spread the organisms even to community members. It is not possible to completely ban the use of mobile phones. However, it is possible to introduce strict guidelines regarding mobile phone usage and their disinfection practices in hospital settings. Better awareness of hand hygiene can be created among the healthcare workers by education. It is recommended that the infection control committee of every hospital ensures regular decontamination of personal and common electronic devices. These measures will ensure patient well-being.

Acknowledgement

We would like to acknowledge the support of Dr. Vijayaprasad Gopichandran, Assistant professor, Department of community medicine for his guidance and assistance in writing the manuscript.

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How to cite this article:

Sowmya Kanthimathinathan and Manisha S. Mane. 2018. Electronic Devices - A Potential Threat to Hospital Infection Control. *Int.J.Curr.Microbiol.App.Sci.* 7(11): 1485-1495.
doi: https://doi.org/10.20546/ijcmas.2018.711.171