

Research Article

Evaluation of the Cell Phone Microbial Contamination in Dental and Engineering Schools: Effect of Antibacterial Spray

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ARTICLE INFO

Article History

Received 11 April 2017

Accepted 18 October 2017

Keywords

Mobile phones
bacterial contamination
nosocomial pathogens
Evernet spray

ABSTRACT

Introduction: The aim of this study was to evaluate the microbial contamination of cell phone in dental and engineering schools and also investigating the effect of an antibacterial spray.

Method and Materials: A questionnaire was completed by participants, including the pattern of using mobile phones and their disinfection. The number of participants was 120 students and professors in each of dental and engineering schools. Swabs from mobile phones of the participants were taken and plated on culture medium. The t-test, Chi-Square with the SPSS 11.5 program were used in data analysis.

Results: In total, 240 mobile phones were cultured for microorganisms, while 65.8% (n = 158) were culture-positive. One hundred percent of professors, 98% of students' dental school and 72% of professors and 62% of students of engineering, believe that mobile can serve as a source of pathogens.

The most commonly cultured organisms were *Staphylococcus Aureus*, *Escherichia coli*, *Enterococcus Faecalis*, and *Pseudomonas*. The current study showed that none of the mobile phones of the professors and students of the engineering university was infected by *Pseudomonas* and *Candida albicans*.

Conclusion: The results of this study showed that mobile phones may act as an important source of nosocomial pathogens.

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1. INTRODUCTION

Today, the use of mobile phones has become general in most areas of Europe, Africa, Caribbean, Latin America, Australia, Canada, United States and wealthy areas of Asia. Mobile phones technology has spread rapidly throughout the world and has caused too many changes in our lifestyles. Statistics demonstrate that 79% of the United States population and 90% of European and Asian teens have personal mobile phones [1,2].

According to the communication through internet, the mobile subscribers have grown from about 110 million subscribers in 2000 to over 303 million subscribers in the year 2010. In the past 5 years, the worldwide mobile phone market has grown to 3.2 billion and now with 5.4 billion subscribers in 224 countries, it represents 146% annual growth rate [3]. In the process of development, number of mobile users has been 73 million in Iran.

Nowadays, mobile phones have become one of the essential accessories in our social and professional life, and the uses of mobile phones with health care workers have increased. Mobile phones

increase the spread of communication and contact within health-care institutions, result in faster and more efficient healthcare delivery. Although, the use of mobile phones in hospitals (that the percentage presence of bacteria is high) may cause in spread of pathogens. Mobile phones are usually stored in bags or pockets and handled frequently and held close to the face. Moreover, the use of mobile phones often occurs in hospitals, by patients, visitors and health care workers [4–6].

However, mobile phones are usually touched during or after the examination of patients without hand washing, but not cleaned and can harbor various pathogens and become a potential source of hospital associated infections among patients and even medical staff [7]. Mobile phones harbor pathogens microorganism, and high temperature cause increasing the amount of microorganisms. On the other hand, there are no guidelines for cleaning and prevention of bacterial contamination of mobile phones [8,9].

Studies reported that hospital-associated infections caused by multidrug-resistant gram-positive organisms such as *Staphylococcus aureus* and *enterococcal* species are increasing as one of the problems in health care institutions. The source of infection may be exogenous, like the air, dental equipments, hands of surgeons and

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other staff, or endogenous, like the bacterial flora in the operative sites. Moreover, transmission of these pathogens by different objects such as hands and mobile phones has reported. In dentistry, in addition to the risk of direct transmission of pathogens via hands or other tools, contamination by airborne microorganisms may be possible [7,10–12].

Studies demonstrated that many infectious agents can survive for extended periods (unless they are eliminated by disinfection of the surface). Moreover the presence of saliva in dentistry and its contamination with hazardous microorganisms, repeatedly exposed patients and health care workers to many pathogens microorganism. As a consequence, the incidence of certain infectious disease is higher among dental professionals than observed for the general population and even other medical staff [8,10–12].

Currently, there are no guidelines for disinfection of mobile phones of health care workers and it seems that emphasis on infection control practices during early dental education is essential. The aim of this study was to determine the role of mobile phone related to the spread of bacterial pathogens and to offer possible control or preventive methods of spread of infection.

2. METHOD AND MATERIALS

This laboratory and cross-sectional study was conducted in Kerman school of dentistry and the faculty of engineering (code of ethics K/25/90). The hundred mobile phones of dental students and 20 mobiles of professors of dental school and 100 students and 20 professors of the faculty of engineering as a control group were studied. The consent was based on the voluntary participation of people. All mobile are gathered in one day and were examined globally at the same time. Those who had used their phones less than three months were excluded.

At first, a questionnaire was completed by participants, including the location and time of usage of mobile phones, methods of disinfection and material used, the time interval from the last cleaning of the mobile phones and washing hands before and after using the phones and then the samples were collected from the surface of mobile phones, specially from the mouthpiece and earpiece. The mobile phones were in the same condition used (without any replacement of their coverage) in aseptic condition (with flame alcohol burner) using moist sterile swab. First, a sample is taken on phone surface by a swab and then all mobile phones are sprayed with spray Evernet (60 ml- M.G Group International S.A.R.L-London- UK) until the surface becomes completely wet. Evernet spray made from 100% herbal ingredients refined on the basis of finest herbal veins theory. Free from acids and alcoholic substances.

This spray isn't expensive and costs about 3 \$, and it was tested on mobile phones before by many investigators. After allowing those to dry (special paper according to the manufacturer's instructions), samples were taken again with a moist sterile swab from surface and back of the phone.

In the laboratory, all the samples were passed through 0.35% Millipore filters. Then 1 mL of each of the diluted samples was spread-plated on medium S (Sabvrd) for mold growth and on blood agar, SS (*Salmonella*, *Shigella*), EMB (Eosin methylene blue) to grow aerobic bacteria; thioglycolate broth was used for review and identification of anaerobic species. The samples were placed at temperatures of 25°C and 37°C for growth of fungi and bacteria, respectively, and to ultimately determine bacterial and fungal species and the number of colony forming units (CFUs). CFU counts (automatically) more than 200 were considered severe contamination [4,7]. Oral flora has also been studied, but the CFU counts more than 200 were not. Therefore, it was not considered as bacterial contamination.

To avoid cross-contamination, the researcher wore a new pair of gloves when sampling each mobile phone.

Data were analyzed using independent sample t-test, Chi-Square and SPSS 11.5. $P < .05$ was considered statistically significant.

3. RESULTS

In this study, 120 mobile phones from dental school (100 mobile phones of students and 20 mobile phones of professors) and 120 mobile phones from engineering school (100 mobile phones of students and 20 mobile phones of professors) were examined.

Table 1 shows the demographic characteristics of the participants. All participants admitted using mobile phones at school. One hundred percent of professors, 98% of students of dental school and 72% of professors and 62% of students of faculty of engineering, believed that mobile can serve as a source of pathogens. According to the participants opinion, the transmitted diseases by mobile phone were cold, digestive problems, hepatitis and skin diseases, respectively. None of the participants believed the transmission of AIDS through their mobiles. Fifty-five of students and 19 of professors of dental school admitted using their mobile phone in the different departments of college. All of the professors and students of the faculty of engineering stated using mobile phone in the college. Almost all of the students and professors (99.8%) reported that there were rules for using mobile phone in the college and laboratory of technical school. However, according to dental student's opinion, 95 percent of professors and 60 percent of students do not perform these rules. Dental professors also stated that about

Table 1 | Demographic characteristics of participants in the study

Demographic	Engineering school		Dental school		
	Student	Professor	Student	Professor	
Age	Age average	21 ± 1.2	45 ± 5.1	22 ± 2.1	40 ± 4.8
	Age range	19–25	40–58	20–30	31–53
Sex	Male	100(100%)	100(100%)	62(62%)	12(60%)
	Female	0(0%)	0(0%)	38(38%)	8(40%)
Rate of phone use	8 ± 0.8	11 ± 2.2	8 ± 3.1	10 ± 5.2	
Rate of daily phone use in college	12 ± 3.8	10 ± 1.5	8 ± 1.9	6 ± 3.2	

90 percent of professors and 45% of students do not perform these rules. According to technical student's opinion, 100% of professors and 80 percent of students do not perform these rules. These percentages for engineering professors were 95 percent and 80 percent, respectively. In response to the question that "do you ever touch your mobile phone with contaminated gloves?" 36% of students (36 students) and 10% of professors (2 professors) responded positive answer. Also, 25% of students reported making or answering calls while attending to patient, this rate was zero among professors. Fig. 1 shows the response of participants to the question "usually for what you use your mobile phone while attending to patients?"

Table 2 shows the participants' responses to questions about infection control in the field of mobiles contamination.

This study showed that 28% of dental students and 38% of engineering students and 10% of professors did not clean their mobile phones. Also, among those who reported to have ever cleaned their phones, 26% used some materials such as glass cleaner, and the other used dry device, such as cotton. Before using the Evernet spray, 17% of dental students and 46% of engineer student's phone had no cultivable bacteria. The difference between the two groups was statically significant ($P = .001$).

The mobiles of dental students demonstrated higher bacterial contamination. On the other hand, 35% of dental professors and 60% of technical professors mobile phones had no cultivable bacteria and the difference between the two groups was significant ($P = .001$) (Table 3).

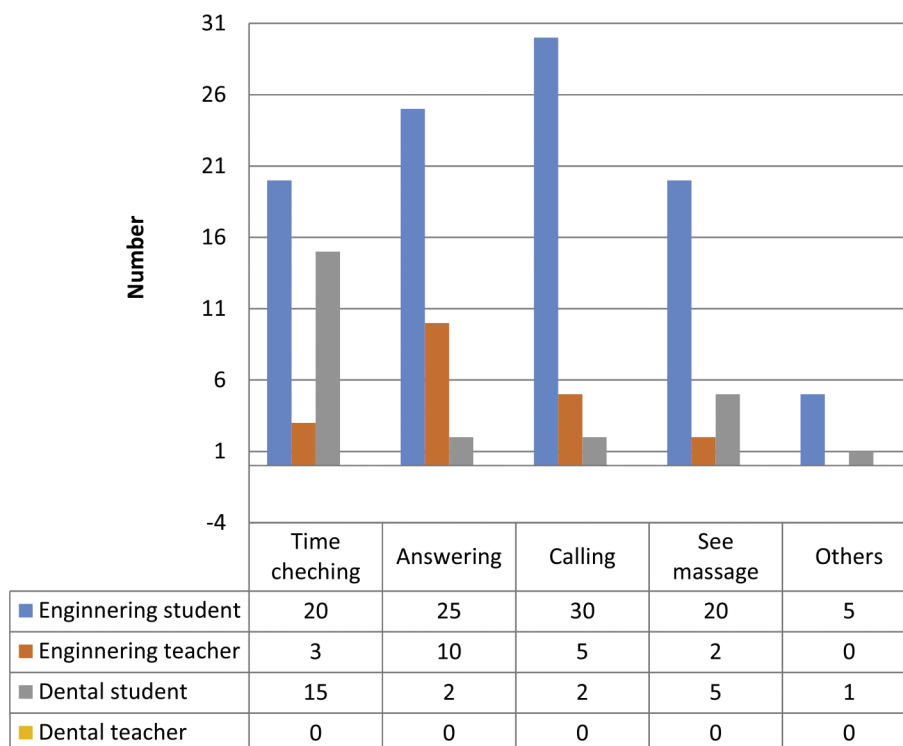


Figure 1 | The response of participant to the question "What you use your mobile phone while attending to patients or laboratories?"

Table 2 | The participants' responses to questions about infection control in the field of mobiles contamination

Question	Engineering school				Dental school				
	Student		Professor		Student		Professor		
	N	%	N	%	N	%	N	%	
Did you wash your hand before using phone in college?	Yes	0	0	0	0	0	0	0	0
	No	100	100	20	100	100	100	20	100
Did you wash your hand after using phone in college?	Yes	0	0	0	0	0	0	1	5
	No	100	100	20	100	100	100	19	95
Did you clean your phone after exit from the college?	Yes	5	5	0	0	10	10	5	25
	No	95	95	20	20	90	90	15	75
How often do you clean your phone?	Once a day	10	10	2	10	20	20	5	25
	Once a month	35	35	15	75	37	37	12	60
	Quarterly	17	17	1	5	15	15	3	15
	Any time	38	38	2	10	28	28	0	0

Table 3 | Level of participant phone contamination

	Students		P value	Professors		P value	Total		P value
	Engineering	Dental		Engineering	Dental		Engineering	Dental	
[†] Level of The pollution	54	83	.001 [*]	8	13	.001 [*]	62	96	.01 [*]
[‡] Overall CFU	28 ± 16.02	12 ± 10.32	.001 [*]	6 ± 11.2	5 ± 23.12	.002 [*]	16.12 ± 13.2	9.01 ± 16.21	.001 [*]

CFU (Colony forming units); [†]Chi-square test; [‡]Independent sample t-test; *P value < .05 is significant.

Table 4 | Type of microorganisms isolated from cell phones

Type of bacteria	Students				[†] P value	Professors				[†] P value	Total				[†] P value
	Engineering		Dental			Engineering		Dental			Engineering		Dental		
	N	%	N	%		N	%	N	%		N	%	N	%	
Staphylococcus Aureus	54	100	83	100	1	8	100	13	100	1	62	100	96	100	1
E coli	45	83.3	60	73.5	.02 [*]	7	87.5	13	100	.01 [*]	52	83.3	73	76.0	.01 [*]
Enterococcus Faecalis	32	59.2	55	66.3	.02 [*]	6	75	13	100	.01 [*]	38	61.2	68	70.8	.01 [*]
Pseudomonas	0	0	12	14.4	.001 [*]	0	0	12	92.3	.00 [*]	0	0	24	25	.001 [*]
Candida	0	0	1	1.2	0.001 [*]	0	0	8	61.6	.00 [*]	0	0	9	0.09	.001 [*]

[†]Chi-square test; *P value < .05 is significant.

Out of 240 cultured Mobiles, bacterial growth was observed in 158 of samples (65.8%), while the majority of phones growth was polymicrobial (74%). It was also found that 48% of mobile phones grew two different species, 26% grew three species or more different species. Polymicrobial growth was found mostly (71%) in the dental students. Numbers of gram-positive bacteria were more than gram-negative, and the most gram positive bacteria were belonging to *Staphylococcus* group. The most commonly cultured organisms were *Staphylococcus Aureus*, *Escherichia coli*, *Enterococcus Faecalis*, and *Pseudomonas*. Moreover, *Candida* was cultured in a number of samples. The current study showed that none of the mobile phones of the professors and students of the technical university were infected by *Pseudomonas* and *Candida albicans*. (Table 4)

Before using the Evernet spray, 17% of dental students and 46% of engineer student's phone had no cultivable bacteria. The difference between the two groups was significant (P = .001).

Based on the findings in the present research work, the Evernet spray was effective at 98% and caused the elimination of bacterial in the medium. (Table 5)

4. DISCUSSION

The global system of telephone communication was established in 1982 in Europe. The applications of mobile technology has increased the speed of communications and mobile have become one of the most essential accessories in our social and professional life. Mobile also increases the speed and efficiency of communication and contact with health care institution, making health-care delivery more efficient [13]. According to Ramesh study, improvement of mobile technology have led to increase use of these portable devices to better and more effectively communicate among health care workers and patients [14]. In recent years, bacterial communication of mobile is an important concern in the field of infection control. Hospitals and clinics environment play a critical role in transmission of the microorganisms associated with acquired hospital infections. Microorganisms can

Table 5 | Level of participant phone contamination before and after using Evernet spray

Participant	Number	Overall CFU (average ± deviation)		[‡] P value
		Before spray	After spray	
		Professors of dental college	13	
Professors of engineering college	8	54.6 ± 11.21	7.1 ± 0.2	.001 [*]
Students of dental colleges	83	145.12 ± 10.32	10.1 ± 1.2	.001 [*]
Students of engineering colleges	54	60.28 ± 16.02	11.1 ± 0.5	.001 [*]
Total	158	15.6 ± 92.36	9.1 ± 0.8	.001 [*]

[‡]Paired sample t-test; *P value < .05: significant.

be transmitted from one person to another or from non-human subject to other, such as a computer, stethoscope and mobile phone [10].

Based on the opinion of experts, mobile phones are more affected than toilets, and the soles of shoes [15-17]. Mobile seldom cleaned and often touched during or after examination of patients without washing hands and can carry different potential pathogens and become an exogenous source of hospital infections among patients [10].

Each year, about 2 million people are infected with hospital infection, which resulted in 90000 deaths and the hand of health care workers plays an important role in the transmission of this infection [18,19]. Jeske et al. [20] found that the microorganisms of the hand of health care workers attached to their mobile phones and Brady et al. [17] demonstrated that the microorganisms of mobile phones are similar with the microorganisms of anterior nasal.

This study showed that all of the participants using their mobile phones in school. One hundred percent of professors and 98% of dental students, 72% of professors and 62% of students of

engineering colleges believed that mobile can act as a source of pathogens. Fifty-five of students and nineteen of professors of dental school admitted using their mobile phone in the different departments of college. All of the professors and students of the faculty of engineering stated using mobile phones in the college. Also, 25% of dental students reported making or answering calls while attending to patients and this rate was zero among the professors. A study conducted by Singh et al. [7] showed that 18% of dental students used their phone while attending to patient and close to 64% of them using their mobile to check the time, which is in agreement with the results of the present study.

This study showed that 28% of dental students and 38% of engineering students and 10% of engineering professors did not clean their mobile phones. Singh et al. [7] reported that 64% of dental students never cleaned their phones. Such different results may be explained by the differences in cultural level about the mobile cleaning.

Out of 240 cultured mobiles in this study, bacterial growth was observed in 158 of samples (65.8%), while the majority of phones growth was polymicrobial (74%), and the most commonly cultured organisms were *Staphylococcus Aureus*, *E coli*, *Enterococcus Faecalis*, and *Pseudomonas*. The first study of bacterial contamination of mobile phone was conducted in the intensive care unit of an educational hospital and one-fifth of the evaluated phones were contaminated with pathogenic microorganisms and among the 50 cultured mobile phones, 98% was positive culture and potentially pathogenic bacteria grew in 34% [4].

In a study conducted by Datta et al. 144 of samples of 200 mobile phones, were infected by bacteria that 36% of them were contaminated by bacteria such as *Staphylococcus Aureus*, which is clearly associated with nosocomial infection, moreover methicillin resistant *Staphylococcus aureus* was isolated from 18% of staff phones [9]. In a similar study by Brady, less than 4.76% of isolated bacteria were gram-negative bacillus bacteria [8]. Khivsara et al. showed that 40% of mobile phones of health care workers were contaminated with *Staphylococcus* and methicillin resistant *Staphylococcus* [21]. One study showed that 40% of mobiles of health care staff and students were positive culture [14]. Another study showed that 40% of the staff hands and 32% of their mobiles were contaminated with bacteria, especially by *Staphylococcus epidermis* [22]. In a research work by Trivedi et al. 46.66% of mobile phones of hospital staff were contaminated with bacteria such as *Staphylococcus Aureus*, *Klebsiella Pneumonia* and *Enterococcus*, while *Staphylococcus Epidermis* was the most common isolated organism (40%) [23].

A study conducted by Mohammadi et al. showed that 25% of isolated microorganisms were *Staphylococcus Aureus* [18]. Karabay et al. evaluated 200 swaps of 3 parts of mobile (keyboard, microphone, and the handset) and showed that 39.6% of mobile phones of patients and 20.6% of mobile phones of staff were positive pathogens. In this study, 94% of mobile phones demonstrated evidence of bacterial contamination [24].

Ramesh et al. reported that 46% of mobile phones of medical staff and students were positive culture that 15% of them were gram-negative pathogens [14]. Ulger et al. reported that 94.5% of mobile phones of health care workers were contaminated with various bacteria and gram-negative bacteria were isolated from 31.3% of mobile phones [25]. Brady et al. showed evidence of bacterial

contamination in 96.2% of mobile phones of health care workers that in 14.3% of mobile phone samples nosocomial infection agents were growth [24]. In a similar study conducted in a hospital in Turkey, only 9% of mobile phones showed contamination by bacteria associated with nosocomial infections [24].

The airborne microorganisms finally settle onto the surface and can survive for a long time, unless they are eliminated by disinfection procedures. Given the volume of aerosols generated by dental procedures and the contamination of surfaces in the dental operatory is a special concern, as surfaces containing viable microorganisms become a source of potential infection.

Health care workers are repeatedly exposed to various microorganisms. Therefore, the incidence of acquiring infection is higher among dental professionals, which requires the use of infection control guidelines. Emphasis on infection control must be developed and maintained during early dental education. Students also should be frequently monitored with these principles [14,25]. The aim of infection control program must be to minimize or eliminate the risk of cross-infection between patients and dental health care workers.

The microorganisms that are settled onto surfaces are the same as the bacteria that are found on the surface of the tooth. So, the source of mobile contamination in dental clinic is not only hands of mobile users, but its origin is also the atmospheric pollution. Dental gloves are used to protect from contamination while being in contact with blood, saliva and mucous membranes. They also protect patients from being infected with therapist pathogens. The use of gloves does not eliminate the need for hand washing, because gloves may be infected due to rupture or contaminated hands after removing gloves. Hand-washing is the most important single factor to prevent transmission of bacteria and viruses [7].

The results of this study showed that Evernet spray is effective in almost 98% cases and caused to elimination of bacteria and their growth in the medium and there was significant reduction in the average number of former colonies after using sterilization spray. Unfortunately, this is currently no clear guidelines for use of mobile of health care workers. Different ways are used by people to clean and sterilize their mobile phones.

The aim of this study was verifying the bacteria on the mobile phones and an available and inexpensive spray was examined for removing the pollutant. The effect of this spray was examined only on mobile and not on human; therefore, the case of antibiotic resistance was not in the present research work.

One of the limitations of the research was the lack of culture of bacteria such as *Staphylococcus epidermidis* or *capitis*. So it is suggested that these bacteria will be culture in future research.

The study has not been done so far and this was the first study. Therefore, it is recommended to do other studies in this field.

5. CONCLUSION

It is revealed in the present research work that 65.8% of mobile phones were infected. The most commonly isolated organism was *S. aureus*. 98% of bacterial contamination was reduced by using the Evernet spray.

CONFLICT OF INTEREST

No conflict of interest.

FUNDING

No funding.

ACKNOWLEDGEMENTS

This study was supported by Kerman University of Medical Sciences, Kerman, Iran (Grant Number: 910213). The authors would like to thank the Research Deputy for their financial support.

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