Original Research

Evaluation of microbial contamination of mobile phones and computer mice and keyboards in a dental school

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Abstract

Introduction: Mobile phones and computers are a reservoir of growth and transmission of microorganisms. This study aimed to evaluate the microbial contamination of computers and mobile phones used by students of an academic dental school, compared to the students of a non-medical school. **Methods:** Sampling was performed on 44 computers and 45 mobile phones in a dental school (test) and a non-medical school (control). Samples were obtained from the E*nter* and B*ackspace* keys of keyboards, the left-click button of computer mice and touch-screen of mobile phones. Afterwards, the samples were cultured, followed by colony count. **Results:** The most frequently detected microbes were coagulase-negative *Staphylococci*, *Bacillus* and *Micrococcus*. In computer samples, pathogenic bacteria including *Staphylococcus aureus* and *Klebsiella*, were found only in the samples of the dental school. *Staphylococcus aureus* and *Micrococcus* were significantly more prevalent in the test group. Microorganisms belonging to human normal flora (e.g., *Bacillus*, *Entrococcus*, *Corynebacterium*, and *Tetragenococcus*) were significantly more prevalent in computers of the control group. In terms of the frequency of pathogenic bacteria found on mobile phones, no significant difference was observed between the study groups. **Conclusion:** The prevalence of normal human flora was higher in the control group (non-medical) relative to the test group (dental). Meanwhile, pathogenic bacteria were more prevalent in the samples of the dental school. Also, computers were more contaminated than mobile phones. Hygiene promotion programs should be implemented in both dental and non-medical schools.

Keywords: Microbial colony count; Equipment Contamination; Cell phone; Computers; Dentistry.

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Introduction

Today, electronic devices, such as mobile phones and computers have become an integral part of our lives, the use of which in different environments is rapidly growing, and teaching hospitals and clinics are no exception (1). Computers are used extensively in healthcare settings as they provide assistance in different aspects of diagnosis and treatment. In addition, mobile phones are widely used because they are fast and efficient.

Mobile phones are carried all day long and must be cleaned properly since people may not wash their hands as often as they should (2). It has been demonstrated that frequent contact with mobile phones exposes individuals to normal flora of skin (3, 4). Moreover, computer mice and keyboards, especially in multi-user ones, are highly contaminated and need proper disinfection (3, 5, and 6). This contamination is a more serious hazard in healthcare environments (1, 7-10).

It seems that mobile phones, as well as computer mice and keyboards of healthcare workers act as a reservoir of nosocomial pathogens and can potentially contribute to cross-contamination, especially if effective disinfection protocols are not applied (11-19). Ramesh et al. reported that more than half of the studied healthcare workers have never cleaned their phones (20). It has also been indicated that 5-81% of healthcare workers' mobile phones are contaminated with nosocomial microorganisms (2, 19, 21-25).

Degree of contamination of mobile phones and computers of dental clinics has not been exactly confirmed and research in this regard is very limited since there are no well-defined cleaning guidelines available for electronic devices in dental environments. With this background in mind, this study aimed to evaluate the rate and typing of contamination by microorganisms found on mobile phones and computer mice and keyboards used in dental and non-medical schools.

Materials and Methods

The research was confirmed by the Research Deputy of Mashhad University of Medical Sciences, Mashhad, Iran. This cross-sectional study was conducted to evaluate the microbial contamination of electronic devices, including computers and mobile phones, in two academic schools in 2015. Samples of the dental school were as the test group, while the control group consisted of samples of the non-medical school. Sample size was 44 computers and 45 mobile phones in each group. The only inclusion criterion was the electronic device having been used for at least three months.

All the selected mobile phones had touch-screen technology and belonged to the students of academic schools. The computers in the test group were randomly selected from the computer center of the dental school and those of the dental clinic. Meanwhile, the computers in the control group were selected from the computer center of the non-medical school. All the computers in both groups were multi-user, whereas mobile phones were personal. Microbial swabs were collected from the center of the touch-screen of mobile phones, the E*nter* and *Backspace* keys of computer keyboards and from the left-click button of computer mice. Surface sampling was performed using a sterile adhesive tape, which was 1 cm in length and attached to the specified surface for one minute. Afterwards, the tape was removed and placed on a Blood Agar medium. After one minute, the tape was removed and the medium was immediately transferred to the microbiology laboratory of an academic hospital for microbial culture. Samples were cultured on blood and chocolate agar plates, which were incubated for 48 hours at 37 °C in 5 % CO_2. Plates which showed no growth were reported as negative, while those showing any growth were reported as positive. Positive growths were subsequently identified using routine microbiological methods. Initially, the morphology of colonies was evaluated and Gram staining was performed. In addition, further microscopic and biochemical tests such as coagulase, oxidase, catalase, bacitracin and optochin, were conducted to identify the type of microorganism. Gram-negative bacteria were cultured in Kligler Iron Agar for further confirmation, followed by enumeration of colony counts.

Total bacterial count was determined by visual counting and then the count was multiplied by 20 to express as colony forming units (CFU)/ml. Finally, the results of microbial culture were reported as units/ml.

Statistical analysis

Statistical analysis was performed in SPSS, version 15, using Kolmogorov-Smirnov (to confirm nonparametric distribution of the data) and Mann-Whitney U test (for pairwise comparison of the differences between the study groups). P-value less than 0.05 was considered statistically significant.

Results

According Kolmogorov-Smirnov Test, normal distribution hypothesis of data was rejected ((P- values were less than 0. 5), so nonparametric tests were used.

Computer results

In this study, all the evaluated computers were multi-user. In the test group, computers were cleaned weekly by window cleaner (70.5%), damp cloth (4.5%), and Deconex solution (4.5%) or they were not cleaned (20.5%) at all. In the control group, the

cleaning process was performed every two or three weeks using a damp cloth. Mean durations of computer use were 1.6 and 5.6 hours/day in the test and control groups, respectively.

Computers of the test group were divided into clinical (81.8%) and non-clinical (18.2%) subgroups. Fungal contamination of the clinical computers was significantly higher than the non-clinical ones (P=0.01). Contaminations of the two subgroups of computers of the test group were not significantly different.

Microorganism culture results of computer samples are provided in Table 1. The most common microorganism in the study group was *Staphylococcus epidermidis*, found in 82% of the samples. While *Staphylococcus aureus* was detected in 3.8% of computers of the test group, this bacterium was not observed in the control group, which was indicative of a statistically significant difference (P=0.02). Moreover, *Micrococcus* contamination was significantly more observed in the test group (P<0.001). In the control group, a significantly higher contamination with *Bacillus*, *Enterococcus*, *Corynebacterium*, *Tetragenococcus*, and fungi was observed, compared to the test group (Table 1). In terms of computer contamination, keyboards were significantly more contaminated, compared to computer mice (P=0.004) (Table 2).

Mobile phone results

Overall, 60% of the mobile phones in the test and 62.2% in the control group were cleaned by dry cloth. Other mobile phones were cleaned by damped cloth with alcohol or Deconex solution, window cleaner, finger alone, or were not cleaned at all. Mean durations of mobile phone use were 4.17 and 3.08 (h/day) in the test and control groups, respectively.

Microorganism culture results of the mobile phone samples are presented in Table 3. According to the results presented in this table, no positive culture results were observed in 13.3% and 11.1% of the mobile phones in the test and control groups, respectively. The most common microorganisms in the test group were *Bacillus* (57.8%) and *Staphylococcus epidermidis* (42%), while they were *Staphylococcus epidermidis* (66.7%) and *Bacillus* (40%) in the control group. Although contamination with *Bacillus* was significantly more common in mobile phones of the test group (P=0.02), *Staphylococcus epidermidis* and *Corynebacterium* contamination was significantly more prevalent in mobile phones of the control group, P=0.03 and P=0.04, respectively (Table 3).

Table 1. Microorganisms isolated from computers and comparison the test (dental) and control (non-medical) groups

Microorganism	Group	Number[1]	Percentage[2]	Median	Mean (±SD)	Min	Max	P-value
Staphylococcus saprophyticus	Dental	42	31.8	0	1.03 (3.16)	0	29	0.08
	Non-medical	28	21.2	0	0.78 (2.39)	0	15	
Staphylococcus epidermidis	Dental	109	82.6	4	6.71 (8.64)	0	61	0.46
	Non-medical	109	82.6	4	5.28 (5.55)	0	27	
Staphylococcus aureus	Dental	5	3.8	0	0.11 (0.7)	0	8	0.024
	Non-medical	0	0	0	0 (0)	0	0	
Micrococcus	Dental	35	26.5	0	0.88 (2.92)	0	27	<0.001
	Non-medical	9	6.8	0	0.15 (0.93)	0	10	
Bacillus	Dental	19	14.4	0	0.18 (0.51)	0	3	<0.001
	Non-medical	49	37.1	0	0.96 (2.09)	0	12	
Entrococcus	Dental	3	2.3	0	0.08 (0.65)	0	7	0.04
	Non-medical	10	7.6	0	0.69 (4.1)	0	33	
Corynebacterium	Dental	1	0.8	0	0.007 (0.08)	0	1	<0.001
	Non-medical	20	15.2	0	0.46 (2.69)	0	30	
Tetragenococcus	Dental	0	0	0	0 (0)	0	0	0.01
	Non-medical	6	4.5	0	0.09 (0.45)	0	3	
Klebsiella	Dental	1	0.8	0	0.007 (0.08)	0	1	0.31
	Non-medical	0	0	0	0 (0)	0	0	
Fungi	Dental	8	6.1	0	0.1 (0.46)	0	3	0.03
	Non-medical	18	13.6	0	0.52 (2.0)	0	15	

[1]Number of contaminated samples

[2]Percentage of contaminated samples

Table 2. Comparison microbial contamination of computer mice and keyboards
[a] Enter & Backspace keys, [b] Mean level of contamination (Mean CFU)

	Mean number of microorganism types (±SD)	median	Min	Max	Mean contamination[b] (±SD)	median	Min	Max
Keyboard[a]	1.89 (0.9)	2	0	4	10.09 (9.56)	8	0	63
Mouse	1.58 (0.73)	2	0	3	6.98 (6.87)	5	0	34
	P-value=0.014				P-value=0.004			

Table 3. Microorganisms isolated from mobile phones and comparison the test (dental) and control (non-medical) groups

Microorganism	Group	Number[1]	Percentage[2]	Median	Mean (±SD)	Min	Max	P-value
Staphylococcus saprophyticus	Dental	5	11.1	0	0.42 (1.51)	0	8	0.94
	Non-medical	5	11.1	0	0.28 (1.23)	0	8	
Staphylococcus epidermidis	Dental	19	42.2	0	1.28 (2.11)	0	9	0.03
	Non-medical	30	66.7	1	2.62 (3.95)	0	16	
Staphylococcus aureus	Dental	0	0	0	0 (0)	0	0	0.31
	Non-medical	1	2.2	0	0.02 (0.14)	0	1	
Micrococcus	Dental	2	4.4	0	0.88 (4.18)	0	22	0.66
	Non-medical	3	6.7	0	1.06 (5.08)	0	30	
Bacillus	Dental	26	57.8	1	2.75 (4.32)	0	20	0.02
	Non-medical	18	40	0	1.2 (2.72)	0	15	
Corynebacterium	Dental	3	6.7	0	0.66 (3.75)	0	25	0.04
	Non-medical	10	22.2	0	2.71 (11.7)	0	62	
Tetragenococcus	Dental	1	2.2	0	0.02 (0.14)	0	1	0.31
	Non-medical	0	0	0	0 (0)	0	0	
Candida	Dental	0	0	0	0 (0)	0	0	0.15
	Non-medical	2	4.4	0	0.62 (3.49)	0	23	
Other Fungi	Dental	0	0	0	0 (0)	0	0	0.15
	Non-medical	2	4.4	0	0.04 (0.2)	0	1	

Discussion

According the results of the present study, three *Staphylococcus* species were found, two of which were *Staphylococcus epidermidis* and *Staphylococcus saprophyticus* (coagulase-negative and belonging to the normal flora on hands) (26). However, *Staphylococcus aureus* is coagulase-positive and pathogenic for humans (26). In addition, a significant rate of *Staphylococcus aureus* contamination was observed in computers of the dental school, which could be indicative of significantly higher contamination of dental settings with nosocomial pathogens, relative to non-medical schools. The number of pathogenic colonies and the rate of contamination in the test group were low and probably do not present a health hazard to individuals with a healthy immune system.

Enterococcus belongs to the normal flora of intestine; however, some of it's subgroups could be pathogenic. On the other hand, *Corynebacterium* is a non-spore forming gram-positive bacterium and belongs to the normal flora of skin and mucous membrane (26). *Bacillus* is gram-positive spore-forming bacilli, mainly found in nature, water and soil and could be a sign of deposition of dust (26). In the current study, normal flora microorganisms, such as *Enterococcus* and *Corynebacterium*, were more prevalent in the computers of the control group, which could be due to less frequent cleaning of computers in non-medical schools (weekly cleaning in the dental school versus every two or three weeks in the non-medical school). Moreover, the mean duration of computer use was longer in the control group, compared to the test group (5.6 versus 1.6 h/day) and the number of computer users (students) was higher in the control group. It seems that non-medical students are less likely to wash their hands, compared to medical students.

In the current study, keyboards were contaminated significantly more than computer mice. It may be due to the fact that cleaning process of keyboard is more difficult and time consuming than computer mice. Furthermore the keyboard surface structure is uneven, making it a suitable surface for accumulation of particles and germs.

Anjumn et al. evaluated microbial contamination of laptops of a dental school (1). In that study, the rates of different types of microbial contamination were higher than our findings, which could be due to the fact that all computers of the dental school were evaluated in the present study, whereas only laptops of clinical sections were assessed in the aforementioned study. In addition, they took samples from the entire keyboard surface, while our samples were obtained only from two keyboard keys. Comparing contamination of clinical and non-clinical computers in dental schools reveals that only fungal contamination was significantly higher in clinical computers. Other contaminations were not significantly different between the two subgroups of computers. It shows that contamination is distributed all over the dental school, and non-clinical sections are not any cleaner than clinical sections in a dental school.

In a study by Patel et al. (7), the most prevalent microorganisms in computers of a dental school were *Staphylococcus* and *Micrococcus*, which is in line with our results. Palenik et al. (27) indicated that oxacillin-resistant *Staphylococcus aureus* was present in 4.5% of computer mice and keyboards in dental clinics, whereas the same bacterium was found in 3.8% of computers in the current study.

A detailed observation of Table 3 demonstrated that contamination with pathogens (e.g., *Staphylococcus aureus*) was rather low in the evaluated mobile phones. However, contamination was mostly higher in mobile phones of the control group. Even though the reported percentage of phone cleaning was similar in both groups, higher contamination was observed in the control group, which could be attributed to the fact that students of medical students are more observant of hygiene principles, including hand-washing.

In a study by Singh et al. (28), 16% of mobile phones of dental personnel were contaminated with *Staphylococcus aureus* and 34% of samples had potentially pathogenic microorganisms. According to the results of the mentioned study, cleaning phones with 70% isopropyl alcohol led to lack of positive culture results in 42% of the samples, which was statistically significant. In this regard, none of the mobile phones of the dental students were contaminated with *Staphylococcus aureus* in the present study.

According to the data presented in tables 1 and 3, computers were generally more contaminated than mobile phones. This could be due to the fact that mobile phones are personal devices and school computers are generally used by all the students. Naturally, people feel more responsible toward their personal items, compared to public devices. In addition, contamination of single-user devices (e.g., mobile phones) was less, compared to multi-user ones (e.g., computers) possibly because of the less frequent dermal contact.

One of the major drawbacks of this study was unequal duration of computer use in the test and control groups. Moreover, sampling was performed only on devices used by students and not by the staff and nurses. Further studies are recommended to evaluate the efficiency of regular application of different disinfectants, such as isopropyl alcohol, in reducing microbial contamination of computers and mobile phones. Protective principles, including regular

hand washing, cleaning of electronic devices and use of covers for computers should be taught in academic schools in the form of infection control courses, particularly in non-medical schools. It is also suggested that computers of academic schools be more frequently cleaned to prevent diseases.

Conclusion

Contamination with some pathogenic microorganisms, especially *Staphylococcus aureus* and *Klebsiella*, was more common in computers of the dental school. However, significant contamination with normal flora microorganisms (e.g., *Bacillus*, *Corynebacterium*, and *Enterococcus*) was observed in computers of the non-medical school. Mobile phone contamination with nosocomial microorganisms was relatively low in both groups, while contamination with some normal flora microorganisms was higher in mobile phones of the non-medical students, compared to medical students**.**

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