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ORIGINAL ARTICLE

Bacterial contamination of frequently touched surfaces in computers in health care settings: a comparative study

Kawther M. Ali[1], Yasmeen S. Ebrahim[1], Nathanael Salako[1], Vincent O. Rotimi[2], Muawia A. Qudeimat[1]

[1] Department of Developmental and Preventive Sciences, Faculty of Dentistry, Kuwait University, Jabriya, Kuwait, [2] Department of Microbiology, Faculty of Medicine, Kuwait University, Jabriya, Kuwait

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Abstract

This study was conducted to detect and compare the presence of bacteria, specifically the pathogens *Escherichia coli* and *Staphylococcus* aureus (meticillin resistant and sensitive), on computer high-touch surfaces (keyboards and mouse) used at a university dental clinic, teaching hospital outpatient clinics, and a university health science centre students' computer laboratories. Moistened sterile swab samples were obtained from 178 computers and cultured on MacConkey and mannitol salt agars, and then incubated for 48 hours at 37˚C. Representative colonies on the media were chosen, sub-cultured for purity and the species were identified using VITEK-2 and confirmed with VITEK MS when necessary. Of a total of 178 computer surfaces screened in the three locations, 97 (54.5%) were contaminated with bacteria. The differences in the total bacterial contamination were statistically significant (P=0.001) between students' computer laboratories (72.9%), hospital outpatient clinics (61.5%), and university dental clinics (32.8%). Staphylococcus aureus was detected on two computer keyboards and mice at two locations, the university dental clinics and the teaching hospital outpatient clinics. In addition, a sample from the teaching hospital's outpatient clinic contained *E. coli*. No meticillin-resistant Staphylococcus aureus (MRSA) was detected in all locations. In conclusion, computer keyboards and mice in various settings were contaminated with bacteria. Dental, medical, and university students' laboratories settings had different overall bacterial contamination on computer keyboards and mice, but no detectable differences in *S. aureus* and *E. coli* was evident. Hence, it is recommended that computer keyboards and mice should be disinfected on regular basis.

Corresponding Author

Dr. Muawia A. Qudeimat

Department of Developmental and Preventive Sciences, Faculty of Dentistry, Kuwait University,

P.O. Box: 24923, Safat 13110, Kuwait.

Email: mqudeimat@hsc.edu.kw

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Introduction

Computers are essential entities in the medical, dental, and educational fields as they are used for saving patients' records and as educational tools. Unfortunately, their increased usage and lack of disinfection may potentially transform this beneficial entity into a disease-causing one, leading to cross-infections. *Staphylococcus aureus* and *Escherichia coli* are pathogenic bacteria that can colonize environmental surfaces and, as a result, humans by means of cross-contamination.[1,2] Approximately 20% of the population is colonized by the gram-positive coccus *Staphylococcus aureus*.[3] The clinical significance of these bacteria is due to the infections it causes, which include wound infections, endocarditis, pneumonia, and septicemia.[4] What adds to the detrimental effects of *S. aureus* is its ability to develop antimicrobial resistance as the mortality is 10-fold higher for meticillin-resistant *S. aureus (*MRSA) strains.[5] A US Centers for Disease Control and Prevention (CDC) study estimated that in the United States there were 31.8 culture-confirmed invasive MRSA infections per 100,000 population, amounting to 94,360 cases in that year.[6] On the other hand, *Escherichia coli* is a rod-shaped, gram-negative, facultative anaerobe that comprises a major part of the normal flora of mammals and is commonly found in human faeces.[7] It can also be found in natural waters, sand, sediment, and soils.[7] This bacterium can cause a variety of clinical diseases such as bacteraemia, urinary tract infections, diarrhoeal disease, haemorrhagic colitis, and haemolytic uraemic syndrome.[8] In a previous study, the number of infections caused by shiga toxin-producing *E. coli* increased from1992 through 2012 with the strain O157 causing up to third (33.6%) of cases.[8] The aim of this study was to detect and compare the presence of bacteria, specifically *E. coli* and *S. aureus* (meticillin resistant and sensitive), on computer high-touch surfaces (keyboards and mouse) used at a university dental clinic, teaching hospital outpatient clinics, and a university health science centre students' computer laboratories.

Materials and methods

Settings

Samples were collected from three areas of interest; (i) Kuwait University-Health Sciences Centre Students' Multi User Computer Laboratories (SMCL), (ii) Teaching Hospital Outpatient Clinics (THOC), and (iii) Kuwait University Dental Clinics (KUDC). The reason behind choosing the three areas is to compare two similar clinical academic settings (outpatient: where the patient does not stay overnight) with a non-clinical academic setting.

Sample collection

Two investigators were trained by a senior technician on a standardized procedure for sample collection and an equal number of computer surfaces were swabbed. All computers in the three areas of interest were sampled; 59 were collected from SMCL, 52 from THOC and 67 from KUDC. Samples were taken within an hour after the last patients' appointments ended at both KUDC and the THOC, and at the end of the day in the SMCL; this ensured that no students or doctors were using the computers at time of sampling. A sterile cotton-wool swab moistened with sterile phosphate buffered saline (PBS) solution for 40 seconds was swiped over the surfaces being tested. The tip was moved from left to right over the keyboards and mice entire surface area. Later, the swabs were kept in Amies transport medium (Oxoid, Basingstoke, UK) and transported immediately to the hospital infection research laboratory in the department of microbiology, Faculty of Medicine, Kuwait University for plating and bacterial species identification, if any.

Microbiological technique

Samples were mixed thoroughly by a Vortex mixer (Scientific Industry, INC., Bohema, NY, USA). Serial 10-fold dilutions of the suspension were thereafter made in Eppendorf tubes containing sterile PBS, ranging from 10^{-1} to 10^{-5} and then inoculated onto MacConkey agar (Oxoid) and mannitol salt agar (Oxoid) within an hour of sampling. The inoculated plates were then incubated under aerobic conditions

Table I. Percentage of bacterial contamination of frequently touched surfaces of computers at different locations

Locations	Total numbers of Investigated Computers	Number (%) with Bacterial Contamination	Number (%) with *E. coli* Contamination	Number (%) with *S. aureus* Contamination
SMCL				
• Females	39	32 (82)*	0	0
• Males	20	11 (55)	0	0
Teaching hospital				
• Internal medicine OPC	19	10 (53)	0	0
• Gastroenterology OPC	6	5 (83)	0	0
• Surgical OPC	15	12 (80)	1 (7)	1 (7)
• Paediatric OPC	12	5 (42)	0	0
KUDC				
• Treatment areas	60	15 (25)*	0	1 (2)
• Non-treatment areas	7	7 (100)	0	0

SMCL: Students' Multi User Computer Laboratories, OPC= Out Patient Clinic, KUDC: Kuwait University Dental Clinic

* Statistically significant (p<0.05) between the two groups

at 37°C for 48 hours. Colonies showing characteristic appearance of *S. aureus* on mannitol salt agar or *E. coli* on MacConkey agar were identified by VITEK-2 ID System (bioMérieux, Marcy, l'Etoile, France) and confirmed with VITEK MS (bioMérieux, Marcy, l'Etoile, France) when needed.

Disinfection

According to the disinfection protocol at KUDC, keyboards were disinfected with a hospital tuberculoidal disinfectant (Unisepta Plus® Unident S.A., Geneva, Switzerland) before, after, and in between patients' treatment sessions. In addition, plastic barriers were placed over the mouse and keyboard throughout patients' treatment sessions. On the other hand, no routine disinfection procedures were applied to the SMCL or the THOC.

Statistical analysis

The statistical analysis was conducted using Statistical Package for the Social Sciences (SPSS) version 17.0 (SPSS Inc., Chicago, Ill., USA). The Chi-square test was used to compare the bacterial contamination of *S. aureus* and *E. coli* on computer keyboards and mice in KUDC with THOC and SMCL. A *p*-value less than 0.05 was considered significant for all statistical comparisons.

Results

Of the total 178 computers' surfaces screened in the various areas, 97 (54.5%) were contaminated with bacteria; of which, two samples were contaminated with *S. aureus* and one was contaminated with *E. coli* and their colony counts were 10 CFU/ml. The remaining 94 samples contained other bacteria. Their identification was not pursued because it was beyond the scope of this study. Of the total bacteria detected, 94.8% were gram-positive, while gram- negative bacteria constituted only 6%. The majority of gram-positive bacteria, 91.7%, were gram-positive cocci. *S. aureus* and *Staphylococcus haemolyticus* were some of the detected bacteria. Four percent of gram-negative bacteria were gram-negative bacilli. When further analyzed, they were identified as *Enterobacter* *cloacae* and *E. coli*. The numbers and percentages of computers contaminated in each of the three locations are shown in Table I.

A statistically significant difference in bacterial contamination was found between the frequently touched surfaces of computers in the three areas of interest (p=0.001). SMCL demonstrated the highest level of contamination (72.9%) compared to that of THOC (61.5%) and KUDC (32.8%). The overall percentage of bacterial contamination was higher in female students' laboratories (82%) compared to male students' laboratories (55%) with a statistically significant p-value of 0.03. However, in SMCL, none of the computers' keyboards and mice were colonized by *E. coli* or *S. aureus*. In THOC, one keyboard (1.9%) was colonized by *E. coli* and one (1.9%) by *S. aureus* (both samples were obtained from the surgical outpatient clinic). Similarly, one computer in KUDC (1.5%) was colonized by *S. aureus*. Analysis of differences in bacterial colonization between the specialty outpatient clinics in the hospital revealed that the highest percentage of contamination was found in the gastroenterology outpatient clinic (83.3%), whereas the paediatric outpatient clinic computers were the least contaminated (41.7%), though this difference was not statistically significant (p=0.3). Although no *S. aureus* was detected in non-treatment areas at KUDC, all computer keyboards and mice (100%) were contaminated by bacteria as opposed to only 25% of computers in the treatment areas (p=0.001).

Discussion

The health care environment is a reservoir of wide varieties of pathogenic and non-pathogenic microorganisms. Several pieces of equipment and instruments used in the critical and non-critical care setting are likely to be colonized with pathogens. Stethoscopes, mobile phones, face masks and gloves, as well as computers handled by health care professionals can also be contaminated by bacteria.[9-12] Therefore, their contamination and the potential role this may play in cross-infections have been the mainstay of many previous investigations.[1,2,13-18]

This study investigated the presence of bacteria, specifically the pathogens *E. coli* and *S. aureus,* on computer keyboards and mice present in various healthcare settings, including medical, dental, and in university students' computer laboratories. The rationale behind choosing these organisms was based on the fact that they are the most common pathogens implicated in healthcare-associated infections and may potentially cause debilitating diseases.[1]

In the current study, the contamination of computers' keyboards and mice was statistically significantly higher in SMCL (72.9%), while KUDC computers were the lowest (32.8%). This difference in the micro-organism count can be attributed to the lack of disinfection protocols for computer surfaces in SMCL. It is also possible that there might be a misconception that disinfecting computers may damage them. Also the overall percentage of bacterial contamination was higher among female students' computer laboratories compared to male laboratories. The reasons behind such finding maybe due to that fact that the total number of female students at the university outweighs those of male students; hence, it is possible that the usage of computers at females' computer laboratories is more than that for males' computer laboratories. Another possible explanation is that female students use the computers in the students' laboratories to access e-learning course materials while male students use their personal computers at home. This is in agreement with a previous study carried out in Kuwait, where 64% of university female students agreed that they use university computer laboratories compared to 27% of male students (p<0.001).[19]

In comparison to the SMCL, the THOC had lower levels of contamination. The reason for this may probably be due to the multi-user nature of students' computer laboratories compared to the single user for the THOC PCs. The potential of multi-user computers to harbour a greater number of micro-organisms was recognized by a previous study in which the keyboards of the multiple-user computers in a university laboratory had an average of 20.1 colonies per square centimetres, whereas the single-user keyboards had an average of 4.5 colonies per square centimetres; and the difference was statistically significant.[20]

KUDC had the lowest overall bacterial contamination amongst the three locations. The dental clinic's infection control protocol necessitates that a plastic barrier is placed on keyboards and mice prior to usage and these barriers are changed between patients. Previous investigators recommended the use of a plastic cover on the computer's keyboard, which led to a statistically significant reduction in *Acinetobacter baumannii* contamination in a hospital based study.[13] Likewise, Farias *et al.* indicated that if surface covers are used, pre-cleaning and disinfection at the beginning and end of the day is adequate.[21] Another study reported that no MRSA was detected on the dental operatory surfaces after the introduction of single-use barrier covers on the various surfaces.[22] The same cross infection control protocol at KUDC emphasizes the importance of disinfecting the computers surfaces with the recommended disinfectant before and after each patient appointment. Previously, it has been shown that the use of a disinfectant led to 95% reduction in the tested organisms on PC keyboards and mice.[17] In other studies, daily disinfection was found to reduce both bacterial counts on high-touch surfaces and hand acquisition of pathogens after contact.[2,23,24] No functional or cosmetic damage to the keyboards was observed after 300 disinfection cycles and, therefore, the authors recommended a daily disinfection.[17]

The findings of this study suggest an increase in the overall bacterial contamination in dental non-treatment areas in comparison to treatment areas. This is consistent with an earlier report in which non-treatment surfaces of a paediatric dental clinic were more prone to contamination than treatment areas.[25] However, another study found that *S. aureus* contamination inside and outside patient care areas at a university dental clinic was similar.[26]

In the current work, there was no statistically significant difference in colonization by *S. aureus* and *E. coli* on computers' keyboards and mice in the three areas of interest (p=0.3) since only three samples out of the 178 screened contained *S. aureus* and *E. coli*. At KUDC, *S. aureus* was detected in one sample in the treatment areas. It is possible that some of the dental nurses' adherence with infection control practices was not absolute or that some dental students might have removed the plastic barriers because it posed some difficulties when typing, resulting in the aforementioned finding. This may explain the presence of *S. aureus* despite the strict infection prevention protocol implying that hand washing before and after touching the computer's keyboard and mouse may be an additional asset to the existing protocol in the clinic. This is supported by a previous study which stated that hand washing can effectively reduce the transmission of resistant pathogenic bacteria in high-risk hospital areas.[27] However, a previous literature review stated that compliance with hand hygiene measures is still considerably low in health care settings with an overall median compliance rate of only 40%. [28] This is in agreement with findings from another study in which the percentage of hand washing among the dental staff was 46%.[29] The low compliance rate may be expected due to some dentists' and students' possible perceptions of the inconvenience of washing hands before and after patient contact or when handling nonclinical items.

It should be noted that no MRSA was detected in any of the samples taken in all three locations. These results are similar to a previous study in which MRSA was only found on 1 out of 72 computer keyboards, representing a low contamination rate in a hospital setting.[30] Also, in a previous research conducted in a dental clinic, none of the *S. aureus* isolates was meticillin-resistant.[26] However, this is in disagreement with results from a different investigation, where it was found that over one third of computers keyboards in an intensive care unit were contaminated with MRSA.[18] Regardless of whether computer keyboards and mice harbour pathogenic bacteria or not, it is still strongly recommended to comply with the universal infection control recommendations.[14,17]

Transfer of organisms to and from computer keyboards and mice is mainly by direct skin contact, but in a dental clinic this could also occur via aerosols generated from the oral cavity as hand pieces are being used; hence, hand hygiene should be accompanied by routine chemical disinfection of the dental operatory.[31] It should be noted that previous studies indicated that contamination of hospital computer keyboards and mice was not affected by their proximity to the patient.[1,15] However, proximity to the patient in a dental clinic may play an important role due to possible aerosol contamination and, therefore, needs further investigation.[31,32] Moreover, disinfectant wipes can transfer pathogenic bacteria if reused and, therefore, should not be used for more than one contaminated surface.[33]

This study's contribution to the existing literature stems in its comparative nature as no other study has compared the contamination of two clinical (medical and dental) and one non-clinical (university) educational settings. It is important to note that some limitations have been encountered while conducting this study, such as the fact that percentages of the overall bacterial contamination are expected to be underestimates because MacConkey and mannitol salt media were used and they are selective media i.e. they suppress the growth of certain organisms in order to identify specific organisms in question. Another limitation is that each computer was swabbed only once. Swabbing the same computers at different time intervals can convey more data regarding the survival of bacteria on computer keyboards. Furthermore, pathogenic bacteria that we did not test for may be colonizing computer keyboard and mouse.

In conclusion, computers keyboards and mice in various settings were contaminated with clinically important pathogenic bacteria. Dental, medical, and university students' laboratory settings have different overall bacterial contamination of computers' frequently touched surfaces, but no detectable differences in *S. aureus* and *E. coli* colonization was evident. Hence it is recommended that disinfection protocols be implemented to disinfect computer keyboards and mice on regular basis in health care settings. In addition, students and health care professionals should be aware of the importance of compliance with infection control protocols as computer surfaces may serve as a mode for cross-transmission of bacteria. Hand hygiene in particular is highly recommended before and after the use of computer surfaces in all areas.

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