

Microbial Contamination of Some Office Equipment in a Section of College of Medicine, KFU

Al-hashim A. Mariya,¹ Al-thuwaini Hibah F,¹ Al-motairi Rehab T,¹ Al-masoud Fatimah S,¹ Badger-Emeka* L.,² Al-Sultan AA²

College of Medicine, King Faisal University, Al-Ahsa, Kingdom Saudi Arabia

*Department of Biomedical Sciences, Microbiology Division, College of Medicine, King Faisal University, Al-Ahsa. Kingdom of Saudi Arabia

*Correspondence: marva.alhashim@gmail.com

Abstract

Background: Computers have become a necessity in most 21st century offices, libraries and university settings. Being accessed through the use keyboards and mice, those in the libraries and laboratories are usually shared. This creates an environment with high bacteria presence, some of which could be potential pathogens. This study looks into the types of microbial contamination of shared and single user keyboards and mice, in a section of a university setting.

Methods: A total of 100 samples consisting of 50 keyboard and 50 mice samples were collected and used for the study. Moistened sterile swabs were used for sample collection. All swabs were individually inoculated into nutrient broth, incubated at 38°C overnight. Overnight growth were plated on Blood and MacConkey agar and incubated at 38°C for 24 hours. All isolates were characterized by basic bacteriological and biochemical techniques.

Results: Seventy-two percent (72%) of the investigated samples were found to have microbial contamination. Encountered bacterial isolate were, Staphylococcus species, Bacilli species, Enterococcus faecalis and Streptococcus. Also isolated were yeast cells (40%) while unidentified isolates also constituted of 4% of the isolates. The shared computers showed less microbial contamination than those of the single users. The difference between the contaminated items and the non-contaminated was found to be statically significant with a P-value of 0.000. Statistical analysis showed that there is an association between single and multiple users in terms of bacterial contamination, with the results showing a significant difference between the all the variables compared.

Conclusion: It can therefore be concluded that office keyboards and mice, whether shared or single usage, could be sources of potential pathogenic microbial infection.

Key words: Computer, keyboards, bacteria, contaminants, mouse, users

Introduction

The 21st century has witnessed a rise in the use of computers as they have become an ever needed essential commodity in work places such as universities, [1] inside and outside of hospital settings, [2] laboratories [3] and communal areas.[4] There is an extensive usage of computers in all university settings. A view by Anderson and Palombo[5] was that most universities in order to accommodate this extensive use of computer technology have created computer laboratories accessible to all members of the university community. This therefore creates an environment for both single and multiple users with the shared ones being visited by many different users at any given point in time. Whether used individually or shared by multiple users, keyboards and their computers are subjected to various types of microbial contamination. According to Gabriel [6] and Dougherty,[7] microbiological contamination is defined as “the non-intended or accidental introduction of infectious material like bacteria or their toxins and by-products”. This means that with an increase in population of those using computer facilities at any given university setting, there is the possibility of a transfer of both pathogenic and non-pathogenic microbes among users.[8] It is of the view that the nature of microbial contamination would depend on the user or users and the microbial contaminants that had been brought in by them to the device.[8] Also, it is postulated that the microbial reservoir on both computer keyboard and mouse would vary depending on whether or not it had multiple users.[5] Anderson and Palombo[5] were of the view that keyboards with multiple users will have more average number of microorganisms. It would therefore imply that the sharing of computer keyboards will facilitate an increase in the transmission of

both pathogenic and non-pathogenic microorganisms within a community, a view that had been expressed by Eltablawy and Elhifnawi.[9]

Researchers have reported the nature of microbial contamination of computer keyboards and shared utilities in different parts of the world.[4, 8, 10, 11] All of these studies reported the isolation of non-pathogenic as well as potential pathogenic microorganisms, which had been inclusive of both Gram positive and Gram negative bacteria. For a bacterial infection to occur, it didn't need to have been caused by a high inoculating dose as earlier reports[12] had pointed to the possibility of an infection at low inoculating doses. It has also been reported that these microbial organisms were capable of surviving from hours to weeks such that there will be microbial transference over a period of time. However, the role inanimate objects play in the transmission of pathogens in the hospitals, offices and their surrounding environments is not fully investigated as was noted by Parcholi et al.,[13] and Stepanovic et al.[14] Some researchers [1, 4, 15, 16] have however, reported the presence of viable pathogens on inanimate objects in shared utilities. On the other hand, according to Onochie et al.,[11] “there was no economical way to test all the keyboards and mouse out there” and this might be the reason why there isn't a full investigation on the role of inanimate objects play in the transmission of pathogens in our work places. However, with the rise in the difficulty of treating bacterial infections in the 21st century, the need for continuous surveillance cannot be over emphasized. Al-Ghamdi et al., [4] were of the view that 80% of infections are spread through hand to hand contact, as well as contact with other objects. Numerous studies such those of Ali et al.,[17] and Anderson et al.,[3] indicated that computer keyboards and

mice became contaminated with pathogenic bacteria that could lead to diverse infections among users. Ali et al.,[17] reported that in a university setting, the microbial contamination of office keyboards and mice of which they isolated included 32 Gram positive and 27 Gram negative bacteria. Microbial contamination of office equipment is a neglected but is highly an important public health issue. Literature is silent on bacterial contamination of the keyboards at the region of the present investigation. Also, there are no concise reports on whether or not there is variability in the microbial reservoir between single use computer keyboards and those that are shared by multiple users. The present investigation looked into the nature of microbial contamination of computer keyboards in offices, laboratories and computer laboratories in a university setting. It seeks to highlight any variations in contamination as shown in single and multiple user keyboards.

Materials and Methods

The study area and ethical consideration.

The study was carried out at a section of the College of Medicine King Faisal University Al-Ahsa. The study was carried out on a working day and at the start of the new academic year. For the samples collected from offices, only users who agreed to have their computers keyboard and mouse swapped were included in the study. There was no need for ethical consideration for the computer facilities in the laboratories.

Sample collection and Culturing

Computers were selected randomly from offices, computer laboratory and small group teaching PBL rooms. Sterile moistened cotton swab was used for sample collection. They were swabbed over the surface of the mice, space bar and enter bottom of the keyboards, one sterile cotton swab was used per computer. Collected samples were transported to the laboratory and each was inoculated into nutrient broth and incubated overnight aerobically at a temperature of 37°C.

The overnight growth was then plated out on blood, nutrient and MacConkey agars. All plates were incubated at 37°C for 24 hours. Pure cultures of the isolated organisms were prepared and used for microbial identification. The computers were further grouped as either multi-user or single user.

Identification of Isolates.

Isolates were identified and grouped using their gram stain morphology as well as their biochemical test. Colonies were characterized as either lactose fermenters or non-lactose fermenters. Reaction of isolates to the catalase, oxidase, coagulase and indole tests were used for characterization of the isolated organism according to Cheesbrough[18] method of proper characterization of bacteria isolates.

Statistical Analysis

Statistical analysis was done using Graph Pad Software 2017. T' test was used to compare positive sample between contaminated and non-contaminated key board and mouse. Chi-square test was used to test association between groups and outcomes, while Fisher's exact test was used to test association within the groups and all statistical significance was taken at $P < 0.05$.

Results

A total of 100 samples were collected from the study area consisting of 50 from mice and 50 from keyboards. Of the

collected samples, 72 (72%) were found to have microbial contamination while twenty-eight (28%) of them failed to show any microbial growth. The difference between the contaminated items and the non-contaminated was not statically significant with a P-value of 0.264 and the results are presented in Table 1.

Total number of Samples	Number positive	Number Negative	Total	P Value
100	72	28	100	0.0000
Percentage (%)	72%	28%	100%	

Table 1: Showing the level of positive and negative contaminants from items sampled

Two-tailed probability = 0.0000. Results are statistically significant

Of the single user office computer sampled, only one (2.5%) was found with no contamination. Sixty percent of the multiple user computer keyboards (CKD) and computer mice (CMS) in the computer labs presented with different microbial yields. A chi-square test with p-value < 0.00001 shows the result to be significantly at $p < 0.05$. This therefore implies that there is an association between the variables and that there a significant difference between the all the variables compared. It also shows that there is an association between use and microbial contamination and the results are presented in table 2.

T-test shows a significant between positive and negative samples of single user office computer samples and those of the multiple user computer labs. However although 55% of the sampled CKD and CMS of the PBL rooms had microbial contamination, the difference between positive and negative

was not statistically significant and the results are shown in table 2.

Collection site	Total number of samples	Number Positive	Number Negative	p-value
Single users (offices)	40	39 (97.5%)	1(2.5%)	0.000*†
Multiple users (PBL rooms)	20	9 (45%)	11 (55%)	0.3173
Multiple users (Computer Labs)	40	24 (60%)	16 (40%)	0.0439*

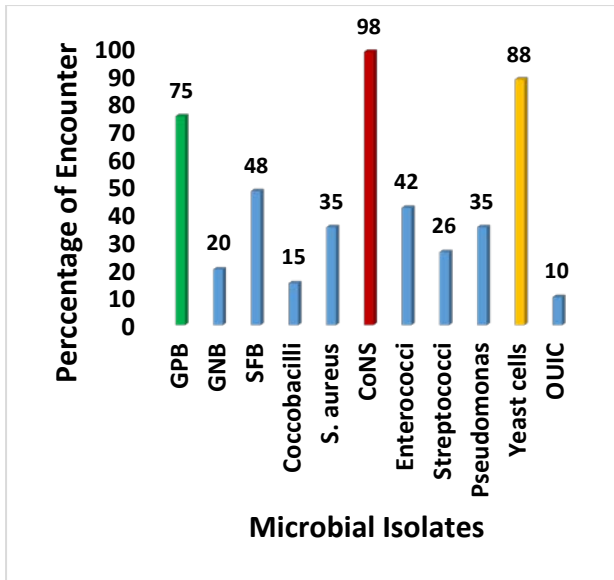
Table 2: Table showing number of positive and negative samples

* = $P < 0.05$

The chi-square statistic is 65.7266. The p-value is < 0.00001. The result is significant at $p < .05$. †= Fisher's exact test p-value 0.0001 between single users and multiple users.

Encountered microbial Isolates

The encountered microbial isolates included the following: Gram positive and negative Bacilli, spore forming Bacilli, Coccobacilli, Staphylococcus aureus, coagulase negative Staphylococci, Streptococci, Pseudomonas aeruginosa, Enterobacter faecalis, yeast cells as well as unidentified organisms. The total number of times these were encountered on the sampled items during the investigation is shown in the figure.



between keyboard and mouse contaminants appeared not to be significant using chi-square statistics test.

Figure: Showing number (%) of times microbial isolates were encountered

GPB = Gram positive Bacilli; GNB = Gram negative Bacilli; SFB = Spore forming Bacilli; CoNS = Coagulase negative Staphylococci

Coagulase negative Staphylococci made up 98% of the total isolated organisms. This was followed by yeast cells and Gram positive Bacilli constituting of 88% and 75% respectively. The least encountered isolates were the unidentified organism (10%), Coccobacilli (15%) and Gram negative rods (20%). The results show that other isolates such as spore forming Bacilli and Enterococcus faecalis made up 48% and 42% of the isolates, respectively while S. aureus and P. aeruginosa had 35% each as shown in the figure. The percentage distribution of the organism between CKB and CMS samples is shown in table 3 while the grouping of the isolated organisms that could serve as potential pathogens is shown in table 4. The keyboard had more S. aureus and P. aeruginosa than Mouse and the results are significant with values at $p < .05$ being 0.0116 and 0.042 respectively. However, for the overall association

Isolation site	Number Sampled	MICROORGANISMS ISOLATED (%)											
		Gram positive Bacilli	Gram Negative Bacilli	Spore forming Bacilli	Cocci bacilli	<i>S. aureus</i>	OCNS	Enterococci	Streptococci	<i>P. aeruginosa</i>	Yeast cells	OID	
KB	50	40 (80)	10 (20)	28 (56)	10 (20)	25 (50)	50 (100)	23 (46)	10 (20)	23 (46)	40 (80)	4 (8)	263
MS	50	35 (70)	10 (20)	20 (40)	5 (10)	10 (20)	48 (96)	19 (38)	16 (32)	12 (24)	48 (96)	6 (12)	229

Table 3: the distribution in the Number (%) of encountered isolated microorganisms between KB and MS
KB = Keyboard; MS = Mouse
S. aureus = Staphylococcus aureus;
OCNS = other coagulase negative Staphylococci; OID = Unidentified organisms

Isolation site	Total Number of Bacteria groups Isolated				
	Bacilli	Staphylococci	Enterococci	Streptococci	<i>P. aeruginosa</i>
Keyboard	88	75	23	10	23
Mouse	70	58	19	16	12

Table 4: Showing the groups of potential pathogenic bacterial isolates were encountered
The chi-square statistic is 4.5898. The p-value is .332031. The result is not significant at $p < 0.05$.

Discussion

This study has shown the level of microbial contamination of computer keyboards and mice in this section of a college in a university setting. Previous studies[11, 15] have also looked into the microbial contamination of computer key boards and mice in university settings. Published results by these studies had varied opinions depending on the region of study. In the present investigation, microbial contamination was encountered in 72% of the total number of CKB and CMS with 28% of the sampled items yielding no growth. This therefore implies that there wasn't a complete 100% contamination rate. The only encountered literature where there was lack of microbial growth was in the control samples of Al-Ghamdi et al.,[4] and they were computers which had not been in use. It therefore implies that once in use, computer keyboards and mice will be exposed to bacterial contaminants from the hand of their users. No specific reason could be attributed to the absence of microbial contamination in the 28% of microbial contaminant free CKBs and CMS as seen in the present investigation. There is the possibility that being in the college of Medicine and used in small group teachings (PBL), they might have been either new at the time of sample collection or had just been recently disinfected just before sample collection. On the other hand, Kumar and Srivastava[19] had observed that it was difficult to completely remove bacteria from keyboards and mice by most sterilizing procedures with Enemour et al.,[1] suggesting cleaning on a regular basis with alcohol and other disinfectants. Thus even prior disinfecting could not have lead to the microbial absence of contaminants as seen in the present case suggesting that the sampled item is a confounder. It is worth noting however, that the bacterial negative sampled CKB and CMS were from the PBL small group tutor rooms and the multiuser computer laboratories. Interestingly, the office single user computers were the most contaminated in the investigation. These findings are contrary to those of earlier researches[1, 4, 5, 15] who reported a greater number of microorganism both pathogenic and non-pathogenic in multiple user computer keyboards and mice. The number of computer visits, type and condition of use might be playing a role in this

case. In an interview with CNN in 2006, Dr. Gerba[20] reported how in his research, it was found that office toilet seats had far less bacterial count than desktops and described computer keyboards and mice as "key germ transfer points." Also, in a 2004 write up by public safety Tufts,[21] the office is described as "home away from home," implying that there will be lots of activities on the office work bench and subsequently a lot of bacteria transference activity such as during eating, coughing, sneezing amongst other activities. The report pointed out the fact that people in offices were not in the habit of disinfecting their desktop before each use. This might therefore explain the more bacteria count found on office CKB and CMS in the present investigation as compared with those of the PBL rooms and computer labs. Results from the present study showed an abundance of a variety of microorganisms some of which are potential pathogens. One of such is *Staphylococcus aureus* isolated from 35% of the sampled items. The bacterium usually colonizes the nasal snares of humans[22] and is a potential pathogen due to its association with MRSA.[22] However, the isolation of *S. aureus* from inanimate objects has also been reported by researchers.[23, 1, 11, 4] Thus their presence on CKB and CMS as seen here simply implies contamination with the normal body flora of the user or users. It was not ascertained whether or not they were any in the form of MRSA but the presence of *S. aureus* was considered in the present study as a potential pathogen.

Various forms of Bacilli were also encountered in the study. Findings of the isolation of Gram Negative Bacilli from CKB and CMS in the present study is similar to those reported by other researchers.[24, 1] It has been explained[24] that Gram Negative Bacilli could be transferred through various means inclusive of handshaking. The presence of *Pseudomonas* amongst the isolates as well as the presence of other Gram Negative Bacilli all point to the possibility of the presence of potential pathogens on our office keyboard and mice. Similar findings had been reported by Kausa and Nabihah[8] and Al-Ghamdi et al.[4]

Representing the highest presence on the isolates in this study, were the coagulase negative *Staphylococci* (CoNS). The results are not unexpected as this group of bacteria form part of the normal body flora and and is expected to be the most encountered microbial contaminant on the sampled items. CoNS were also the most

frequently encountered by Al-Ghamdi et al.[4] While the high incidence of CoNS might not be a source for urgent concern, the presence of high levels contamination with yeast cells cannot be over looked. The isolation of yeast cells and molds from keyboards had been reported by Anderson and Palombo[5] as pointers of the ubiquitous nature of fungi which are airborne. Their high presence as seen in this investigation could either be due to the dryness of the regional environment contributing to airborne of these yeast cell. Other group of microbial contaminants were the Enterobacteriaceae and Streptococci. The presence of Enterococcus faecalis amongst the encountered isolates simply points to fecal contamination, a view that had earlier been expressed by Anderson and Palombo.[5] Generally, Enterococci are known to survive in dry conditions and could be transferred through the handling of commonly used everyday objects.[25] The ability of E. faecalis to cause urinary tract infections (UTIs) means it's presence on computer keyboards or mice could lead to subsequent infections by the user. Also, the Streptococcus group of bacteria range from the α -haemolytic to β -haemolytic bacteria which are known to be the causative agents of Streptococcal infection.

The present investigation therefore shows the degree to which our office computer key boards and mice

could serve as sources of infection on a daily basis and again as Badger-Emeka et al.,[11] pointed out, not all infections are usually traced to their source except when there is a disease outbreak. In the advent of difficult to treat bacteria, it is highly recommended that all keyboards and mice be disinfected regularly.

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Ethical consideration:

Computer keyboards and mice sampled for the investigation, were from users who agreed to participate in the investigation. No names were used in the collection of samples.

Conflict of Interest

The authors declare none.

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