



SHARED COMPUTER KEYBOARDS AND INPUT DEVICES IN CLINICAL AREAS: SOURCE OF NOSOCOMIAL INFECTIONS

Microbiology

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ABSTRACT

Background: In hospital wards computer keyboards, input devices and other electronic devices are shared by doctors and other healthcare workers. These devices get contaminated if strict and proper hand hygiene practice is not followed in clinical areas. Such devices tend to act as potential reservoirs for nosocomial spread of organisms. Significant amount of bacteria are transferred from wet or contaminated gloves and poor hand hygiene in healthcare environments. Bacteria that are often found in healthcare settings are important source of nosocomial infections and death in healthcare arenas.

Objectives: The objectives of the present study were: 1) Determination of bacterial load on the keyboards and mice used by single and multiple users. 2) Evaluation of pathogenic and non-pathogenic bacteria on these surfaces. 3) Determination of efficacy of alcohol wipes for control of microbial contamination of computer input devices. 4) Recommendation of cleaning and disinfection of computer equipment to be included in infection control policy.

Methodology: Samples from input devices operated by single users and multiple users, before and after disinfection were cultured on Nutrient agar, Blood agar, MacConkey agar and Mannitol Salt agar. The total count and identification of microorganisms was done by standard microbiological procedures.

Results: The input devices used by the multiple users showed Bacterial contamination which was higher than those used by the single users although spectrum of pathogenic microorganisms observed on the input devices operated by both was found to be similar. Significant decrease in microbial load was seen after disinfection. (P=0.001) It was also seen that in input devices used by multiple users, there was significant persistence of MRSA and of other bacteria, even after disinfection. None of the input devices operated by single users showed contamination after disinfection (Z=11.513, P<0.001).

Conclusion: Microbial load on shared devices is greater than input devices operated by single users. Disinfection of keyboards and mice has shown significant reduction in the microbial load (P=0.001). Hence this study recommends frequent use of disinfectants for cleaning shared input devices and a strict hand wash protocol before and after handling a patient to prevent probable nosocomial infections.

KEYWORDS

Shared computer devices, microbial contamination, hospital acquired infections.

Introduction:

Computer keyboards, input devices and other electronic devices in hospital wards are shared by doctors and other healthcare workers. These devices get contaminated if strict and proper hand hygiene practice is not followed in clinical areas. Such devices may act as potential reservoirs for nosocomial spread of organisms which can be a leading cause of death in the healthcare arena. Studies have shown that failure to perform appropriate hand hygiene is the leading cause of health care associated infections and their spread of infectious diseases. Proper hand hygiene protocol is followed less than 40% of the times.⁽¹⁻³⁾ In healthcare environments significant amount of bacteria are transferred from wet gloves, contaminated gloves or poor hand hygiene. Bacterial transmission results from tapping on keys and regular usage of device, which may incur contaminants like blood, secretions or various other sticky substances in hospitals.⁽⁴⁾ Studies have shown that 95% of the keyboards tested positive for simple skin flora.⁽⁵⁾ Studies from the US have shown that 25% of keyboards in hospitals carry pathogens at any given time.^(6,7)

Bacteria that are often found in healthcare settings include *Staphylococcus aureus*, *Bacillus* species, *Corynebacterium* spp., *Streptococci*, *Enterococci*, Gram negative bacteria and molds.⁽⁸⁾ Of these bacteria, antibiotic resistant strains of *Staphylococcus aureus* and *Enterococci* are important source of nosocomial infections. The cause of bacterial contamination of keyboards and mice could be poor personal hygiene of the healthcare workers or dust which enables the bacteria to flourish in moisture that is trapped in it.

Hence after seeking a permission from institutional ethics committee, a prospective study was planned.

Objectives:

1. Determination of bacterial load on the keyboards and mice used by single and multiple users.
2. Evaluation of pathogenic and non-pathogenic bacteria on these surfaces.

3. Determination of efficacy of alcohol wipes for control of microbial contamination of computer input devices.
4. Emphasizing the need of Hand wash to be more rigorous in clinical areas.
5. Recommendation of cleaning and disinfection of computer equipment to be included in infection control policy.

Materials and Methods:

This prospective study was carried out in MGM Medical College, Hospital at Kamothe and Central Microbiology Department. Materials and manufacturer's detail: Media, reagents and antibiotic discs from: Himedia, Mumbai.

Sample Size:

The samples were collected from 36 computer keyboards (18 in each group) and 36 computer mice (18 in each group).

They were divided in three groups depending upon the usage of computer device.

The devices covered in this study were from the following departments:

Group I Shared devices by multiple users	Group II Devices with single users	Group III Disinfected devices from group I and II
Respiratory medicine ward Medicine male ward Medicine female ward CVTS ward Pediatrics ward Ophthalmology ward Surgery male ward Surgery female ward Radiology ward Orthopedics ward ICCU	Head nurse office Registration desk PSM department.	Both group I and II areas.

Collection of Sample:

Single sterile swab was used per device. The swab was moistened with sterile saline solution and was moved over surfaces to be tested (keyboard and mice).

Samples from group I and II were collected in the end of the day before disinfection.

Samples from group III were collected approximately 10 minutes after the keyboards and mice were wiped with sterilium (alcohol based disinfectant.)

The efficacy of the disinfectant was determined by calculating the percentage reduction in the microbial count in c.f.u (colony forming units) on Blood agar, MacConkey and Mannitol salt agar.

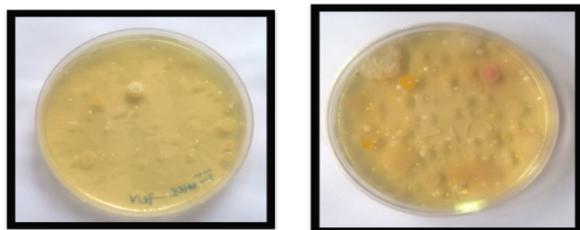
Microbiological Analysis:

After the collection, the swabs were squeezed in 1 ml sterile saline solution. The suspension was spread onto nutrient agar (for total bacterial count); MacConkey agar (for Gram negative bacteria especially Enterobacteriaceae), Blood agar and Mannitol salt agar (for *S.aureus*). All the culture plates were incubated at 37°C for 24-48 hours. Then microbiological counts were taken (colony count, colony morphology). Isolated bacterial organisms were identified using Gram stain and standard biochemical procedures.⁽²¹⁾

All the isolates of *S.aureus* were subjected to Cefotaxin susceptibility test to identify the MRSA. It was done using Cefoxitin discs (30 mcg) on Muller Hinton agar by disc diffusion method. Zones of inhibition were measured after 24 h incubation at 37° C to the nearest millimeter with a slide gauge.

Statistical Analysis:

Data was entered in Microsoft 2007 excel and statistically analyzed using SPSS version 21. Data was expressed in terms of percentage and average. Paired sample t-test and Z-test was used and the significance of P value less than 0.05 was considered as statistically significant. Appropriate statistics were applied with the help of a biostatistician. All the health care workers were explained about the hand wash protocol verbally.

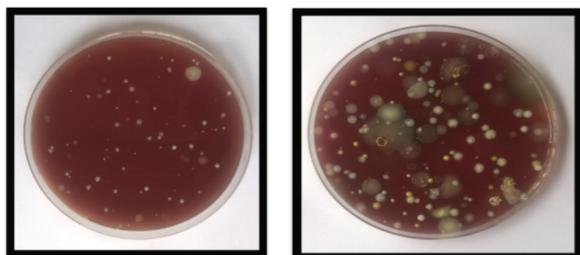


Nutrient Agar:

Microbial Load Seen on Devices Used By Single Users.

Nutrient Agar:

Microbial Load Seen on Devices Used By Multiple Users. Growth of



Blood Agar: Microbial Load Seen on Devices Used By Multiple Users.

Blood Agar: Microbial Load Seen on Devices Used By Multiple Users

Observations and Results:

A total of 36 computer keyboards and 36 mice were tested for microbial contamination.

Table 1: The percentage of contamination in keyboards and mice used

by multiple users and single users is represented in Table 1.

Table 2: This table shows range of total counts it suggests lower microbial load on both keyboards and mice of single users compared to multiple users.

Table 3: This table represents spectrum of microorganisms isolated from keyboard and mice of multiple users.

Table 4: This table represents spectrum of microorganisms isolated from keyboard and mice of single users. It was observed that the spectrum of microorganisms observed by multiple users and single users is more or less same but the microbial load is more in multiple users. No MRSA colonies were seen on the devices operated by single users.

Table 5: This table shows the microbial load on keyboard and mice after disinfection with disinfectant. It was observed that 28% keyboard and mice used by multiple users were contaminated even after disinfection and none of the keyboard and mice used by single user's showed contaminated after disinfection. (Z = 11.513, p < .001)

Table 6: This table shows spectrum of microorganisms isolated from keyboard and mice after disinfection of devices operated by multiple users. Amongst the pathogens, *S.aureus* (MSSA and MRSA) survived even after disinfection with disinfectant.

Table 7: shows that there was no growth after disinfection on devices used by single users.

Table 8: demonstrates that there was 100% reduction in the microbial load from keyboard and mice from all the wards after disinfection except ICU, Radiology and Orthopedics ward, where the reduction was 80 – 99%. However MRSA persisted in the ICU even after disinfection.

Table 9: shows that persistence of MRSA in air-conditioned wards like ICU and CVTS ward which is significant as compared to that in non air-conditioned wards. (P < 0.001)

Table 10: depicts 100% reduction in Gram negative bacteria count after disinfection in keyboards and mice of multiple users.

Table 11: shows 100% reduction in Gram negative bacteria count after disinfection in keyboards and mice of single users.

Table 12: In this table a comparison of the microbial contamination on computer keyboards and mice of both the groups is shown before and after disinfection. This depicts that the contamination after disinfection has decreased. It also shows the difference seen in the contamination of input devices used by single users as compared to multiple users both before and after disinfection.

Table 13: shows the Mean values of bacterial count before disinfection, which is 50.792 (SD=121.901) and after disinfection, the Mean is 1.889 (SD=5.601). These were analyzed using the paired sample t-test (t-stat=3.4, p value = 0.001). This shows that after disinfection of the input devices, there is significant reduction in the total bacterial count.

Table 1: Microbial Contamination of Computer Keyboards and Mice (Before Disinfection)

Group	No. and % of Keyboards Positive for Contamination (18)	No. and % of Mice Positive for Contamination (18)
Multiple users	18 (100%)	15 (83.3%)
Single users	16 (88.9 %)	14 (77.8%)
p-value	Z = 1.3, p = 0.2038	Z = 0.4, p = 0.6768

Table 2: Total Microbial load of Keyboards and Mice (Before Disinfection)

	Average total Count of microorganisms observed in:	
	Keyboard	Mice
Multiple Users	450	22.5
Single Users	150	12.5

Table 3: Spectrum of Microorganisms from Keyboards and Mice of Computers used by Multiple Users (Before Disinfection)

Group	Organisms	Number of input devices contaminated.	
		Keyboards	Mice
Non pathogens	Diphtheriodes	4	3
	Bacillus	8	6
	Micrococcus	2	2
Pathogenic bacteria	S. aureus (MSSA)	14	9
	S.aureus (MRSA)	2	4
	E.coli	1	0
	Pseudomonas	4	1
Molds	Aspergillus	1	0

Table 4: Spectrum of Microorganisms isolated from Keyboards and Mice of Computers used by Single Users (Before Disinfection)

Group	Organisms	Number of input devices contaminated	
		Keyboards	Mice
Non pathogens	Diphtheroides	0	0
	Bacillus	8	8
	Micrococcus	2	2
Pathogenic bacteria	S.aureus (MSSA)	9	4
	S.aureus (MRSA)	0	0
	Pseudomonas	5	0
	Proteus	1	0
Molds	Klebsiella	3	0
	Aspergillus	3	0

Table 5: Microbial load on Computer Keyboards and Mice (After Disinfection)

Group	Number and % of keyboards positive for contamination after disinfection(18)	Number and % of Mice Positive for contamination after Disinfection(18)
Multiple users	5 (28%)	5(28%)
Single users	0 (0%)	0 (0%)
p-value	Z = 11.513, p < .001, Significant	Z = 11.513, p < .001, Significant

Table 6: Spectrum of Micro-Organisms Isolated from Computer Keyboards and Mice of Computer Used by Multiple Users (after disinfection).

	Organisms	Number of input devices showing contamination	
		Keyboards	Mice
Non pathogenic bacteria	Bacillus	0	2
	Diphtheroids	0	0
	Micrococci	1	2
Pathogenic bacteria	Gram negative bacteria	0	0
	S.aureus (MSSA)	4	1
	S.aureus (MRSA)	1	1
Moulds		0	0

Table 7: Spectrum of Micro-organisms Isolated from Computer Keyboards and Mice of Computer Used by Single Users after Disinfection

	Organisms	Number of input devices showing contamination	
		Keyboards	Mice
Non pathogenic bacteria	Bacillus	0	0

	Diphtheroids	0	0
	Micrococci	0	0
Pathogenic bacteria	Gram negative bacteria	0	0
	S.aureus (MSSA)	0	0
	S.aureus (MRSA)	0	0
Moulds		0	0

Table 8:Percentage Reduction of MRSA and MSSA after Disinfection of Input Devices Operated by Multiple users:

Department	Device	Pathogen	Initial count	Count after disinfection	% reduction
Radiology	Keyboards	MSSA	1000	8	99.2%
	Mouse	MSSA	100	0	100%
Orthopedics	Keyboards	MSSA	143	9	93.7%
	Mouse	MSSA	32	3	90.6%
ICCU	Keyboards	MSSA	12	2	83.3%
		MRSA	38	3	92.1%
	Mouse	MSSA	12	1	91.6%
		MRSA	20	4	80%
Surgery female	Mouse	MRSA	1	0	100%
CVTS ward	Keyboards	MSSA	10	0	100%
	Mouse	MRSA	7	0	100%
CVTS doctors duty room	Keyboards	MSSA	15	0	100%
pediatrics	Keyboards	MRSA	4	0	100%
		MSSA	29	0	100%
Ophthalmology	Keyboards	MSSA	8	0	100%
Medicine female	Keyboards	MRSA	5	0	100%
		MSSA	17	0	100%
Medicine male	Keyboards	MSSA	32	0	100%
Respiratory medicine	Keyboards	MSSA	4	0	100%
		Mouse	MSSA	8	0

Table 9:Percentage Reduction in MRSA in Air-conditioned Wards as Compared to Non-air-conditioned wards.

	Initial Count	Count after disinfection	Percentage reduction after disinfection
Air conditioned wards	65	7	89%
Non-air-conditioned wards.	6	0	100%

Persistence of MRSA in AC wards as compared to non-AC wards is Highly Significant (p <0 .001)

Table 10: Reduction in Gram Negative Bacteria after Disinfection in Computer Input Devices Used by Multiple Users.

Department	Device	Pathogen	Count before disinfection	Count after disinfection	% reduction
Respiratory medicine	Keyboards	Pseudomonas	1	0	100%
CVTS	Keyboards	Pseudomonas	4	0	100%
Radiology	Keyboards	E.coli	7	0	100%
	Keyboards	Pseudomonas	1	0	100%
	Mouse	Pseudomonas	7	0	100%

Table 11: Reduction in Gram Negative Bacteria after Disinfection in Computer Input Devices Used by Single Users.

Department	Device	Pathogen	Count before disinfection	Count after disinfection	% reduction
Reception	Keyboards	Pseudomonas	5	0	100%
	Keyboards	Proteus	1	0	100%
	Keyboards	Klebsiella	3	0	100%

Table 12: Number Of Computer Keyboards And Mice Contaminated Before and After Disinfection.

Number of input devices contaminated:	Keyboard	Mice		
		After disinfection	Before disinfection	After disinfection
Multiple users	18	5	15	5
Single users	16	0	14	0

Table 13: Bacterial Count Before and After Disinfection.

Paired Sample Statistics							
	Mean	N	SD	SEM	T-Stat	Df	P-Value
Before Disinfection	50.792	72	121.901	14.366	3.4	71	0.001
After Disinfection	1.889	72	5.601	0.660			

Discussion:

A total of 18 computer keyboards and 18 mice operated by multiple users and 18 computer keyboards and 18 mice used by single users were tested for microbial contamination. It was observed that all the keyboards and 83% of the mice used by multiple users were contaminated in contrast to 88.9% keyboards and 77.8% mice contamination seen in single users. Most of these isolates were normal skin commensals. Among the non pathogens the micro-organisms found on keyboards and mice included *Bacillus* species, *Micrococci* and *Coagulase negative Staphylococci*. These results match with Eltablawy R Elhifnawi. (2009) and Hartmann et al. (2004) who isolated similar skin flora.^(13,17) Rutala et al. (2006) has also reported that *Micrococci* and *Bacillus* species are the most common organisms on keyboards. In this study we observed single colony of *Aspergillus* on keyboard of female medical ward (multiple users) and 3 colonies of *Aspergillus* on reception keyboards (single users).⁽⁸⁾ In a similar study Eltablawy R Elhifnawi et al. (2009) have reported that 30.6% keyboards and 30.3% mice were contaminated with molds; majority of which were *Aspergillus* species followed by *Penicillium* species, *Mucor* species and *Rhizopus* species.⁽¹³⁾ Rutala et al. (2006) have also reported *Aspergillus* species on computer keyboards.⁽⁸⁾

In this study potentially pathogenic organisms were isolated from keyboards and mice of multiple users. They were predominantly *S.aureus* including few MRSA and Gram negative bacteria like *E.coli* and *Pseudomonas* in keyboards and mice of multiple users. On the keyboards and mice of single users no MRSA was isolated but Gram negative bacteria like *Klebsiella*, *Proteus* and *Pseudomonas* species were isolated. However the count of pathogenic and non-pathogenic bacteria was less on the keyboards and mice of single users as compared to multiple users. This underlines the need for frequent disinfection of shared computer input devices used by multiple users.

Also we observed that computer keyboards and mice in air-conditioned environment showed a larger bacterial load. The numbers of MRSA isolated were more in the CVTS ward and ICCU (all of which have air conditioning). This could be attributed to the favorable environment, reduced ventilation and busy schedule of ICCU's. S. A. Udumanet al (2002) had found air conditioning to be a source of a *Serratia marcescens* infection in NICU which is a hospital acquired pathogen like MRSA.⁽²²⁾ In view of this frequent cleaning and disinfection in these wards is needed.

Computer equipments may act as a reservoir for the transmission of potentially pathogenic organisms.⁽⁷⁾ Their role in hospital environment is documented by various researchers.^(6, 24) Periodic surveillance and monitoring the bacterial contamination in ICCU devices is hence necessary in the view of probable Hospital Acquired infections in such areas.

Cleaning the keyboards and mice regularly with appropriate disinfectant could be very useful in order to curb the spread of infections through these devices. Disinfectants like alcoholic and/or non-alcoholic wipes can be used for cleaning these devices. The most effective disinfectant could be the one which remains on the surface for at least 10 minutes before it is wiped out.

Alcohol wipes have been found out to be highly effective at removing or inactivating pathogens.⁽¹⁹⁾ In this study we also evaluated the efficacy of alcohol based disinfectant for cleaning of computer devices. It was observed that there was 100% reduction in Gram negative bacteria and 90-100% reduction in MRSA. Percentage reduction of MRSA was observed to be 92.1% on Keyboards and 80% on the mice of ICCU. In this study, we observed that alcohol wipes can significantly ($P=0.001$) reduce the bacterial load from the computer keyboards and mice and can be used routinely for disinfection. In another study it was reported that the disinfectant containing 30% ethyl alcohol decreased the colony forming units to zero in most of the cases.⁽¹⁶⁾

In this study, the hand wash protocol was discussed with the health care workers. It was observed that the protocol is meticulously followed by most of the health care workers. However there could be lapses in the same when there is change of duties and for newly recruited staff.

Hence we recommend educating the healthcare workers regarding disinfection of these devices as neglecting the disinfection of these devices will allow long survival of some bacteria which have important role in hospital acquired infections. Proper disinfection of shared devices along with the stringent hand wash protocol can greatly reduce the risk of spread of Hospital Acquired Infections.

Conclusion:

In this study it was observed that there is a high degree of contamination of computer devices like keyboards and mice, used by multiple users as compared to single users.

The spectrum of pathogens was similar in multiple users and single users. Contamination of keyboards and mice by *S.aureus* and MRSA which are potential nosocomial pathogens was noted.

Our results highlight the importance of proper disinfection of computer user interfaces like keyboards and mice which greatly reduces microbial load on the surfaces in clinical areas. ($P=0.001$)

Hence this study stresses that disinfection of computer devices should be made mandatory in hospital setups as there could be difference in hygiene practices of different health care workers.

The authors suggest further evaluation of appropriate method to determine frequency and duration of disinfection so as to minimize the spread of nosocomial infections through computer input devices. This could help in recommending a proper protocol for disinfection of the computer input devices which along with hand hygiene protocol could reduce the rate of hospital acquired infection.

Conflict of interest : None declared.

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