Keywords

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Microbial contamination of computer user interfaces (keyboard, mouse) in a tertiary care centre under conditions of practice

Summary

Background: The role of hands in the transmission of nosocomial infections is well established. Our study aimed to assess the level of microbial contamination of computer user interfaces in a large tertiary care centre under conditions of practice.
Methods: A total of 300 samples were collected from 100 workstations by direct contact using Columbia blood agar Rodac plates.
Results: In total 32 % of workstations proved positive for growth of potentially pathogenic microorganisms (*Staphylococcus aureus*, 12 %; viridans streptococci, 11 %; enterococci, 8 %; Gram-negative microorganisms, 14 %). The highest contamination rates were found when samples were collected immediately after the computer workstation had been touched by users (47 % vs. 25 %; p =0.028). Stratification for other variables (type of patient care, type of room, number of persons using the workstation) yielded no significant differences. Regarding the fungal contamination 25 % of workstations proved positive, however, with low absolute concentrations (range, 1 to 2 cfu/25 cm2). On general wards fungi were detected significantly more often than in ICUs (44 % vs. 7 %, p<0.0001).
Conclusion: We conclude that in patient care areas routine disinfection of hand contact surfaces also should apply to computer user interfaces and that these surfaces should be specifically designed for this purpose.
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Introduction

There is ample evidence to document the role of hands in transmission of nosocomial (hospital-acquired) infections [1,2]. It is also well known that those surfaces coming into contact with hands are often contaminated with nosocomial pathogens and can serve as vehicles for infection transmission [3,4,5]. In addition to various other types of surfaces, some authors have also suggested that computer user interfaces were also implicated here, albeit using very different methods and with very different results [6,7,8,9,10]. The aim of our study was therefore to investigate the extent of microbial contamination found on computer user interfaces (keyboard, mouse) under everyday use conditions in a university hospital and, as far as possible, to identify predictors of elevated contamination rates.

Materials and Methods

Setting

The study was carried out at Bonn University Hospital. This hospital has 1,224 beds, of which 93 are intensive care beds in eight intensive care units (ICUs) (3 surgery / anaesthesiology, 2 medicine, neonatology / paediatrics, 1 neurosurgery). Since June 2004 a computerised system, with some 700 workstations, has been in use to process patient data and medical reports. Overall, during the study period the university hospital disposed of around 7,000 PC workstations. Between May 2005 and October 2006 a total of 300 samples were taken from 100 PC terminals (Enter key, space bar, mouse). These belonged to 23 non-clinical (13 offices, 10 laboratories) and 77 clinical areas (11 doctors' rooms, 30 nurses' stations, 36 patient rooms). Of the 77 clinical workstations (41 neurology /neurosurgery, 11 sur-

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gery, 9 internal medicine, 6 gynaecology, 6 ophthalmology, 4 paediatrics /neonatology), 32 belonged to general wards and 45 to ICUs. The computer user interfaces were conventional office equipment that did not feature any specific properties in terms of amenability to wipe disinfection or disinfection tolerance.

Microbiological methods

Samples were collected by direct contact using Rodac plates (Columbia blood agar) during normal routine activities in the respective areas. In each case, a sample was taken from the Enter key, space bar and mouse using a method in which each investigator had received training in advance. The plates were incubated for 48 h at 37 °C and the colonies were differentiated on the basis of the usual microbiological methods (colony morphology and colour, Gram staining, haemolysis patterns, coagulase test [staphylococci], bile-aesculin selective medium [enterococci], O-F test and oxidase test [Gram-negative bacteria], microscopic differentiation [moulds] as per the pertinent literature). As necessary, further differentiation was done using the API 20 E/NE system (BioMerieux, Nürtingen, Germany). Antibiotic resistance tests were not performed.

Table 1: Incidence of detection (absolute, percentage-based) of bacteria and moulds in 300 samples taken at 100 PC workstations (in each case, space bar, Enter key, mouse) in a university hospital and mean (median) number of colony forming units (cfu)/plate (25 cm²).

Microorganisms	Positive Samples		Cfu / 25 cm2		Positive workstations
	n	%	Mittel	Median	n (=%)
Staphyloccocus aureus	19	6	26	12	12
Coagulase-negative staphylococci	273	91	16	12	96
Micrococcus spp.	219	73	8	4	96
Viridans streptococci	15	5	4	1	11
Enterococci	8	3	5	3	8
Bacillus spp.	220	73	6	3	96
Gram-negative bacteria	19	6	2	1	14
*Acinetobacter**	12	4			8
Other non-fermenters**	4	1			4
Enterobacteriaceae	3	1			3
Moulds ***	34	11	1	1	25

* *Acinetobacter species*, 4; *A. baumannii*, 5; *A. lwoffii*, 2; *A. junii/johnsonii*, 1
** *Chryseomonas luteola*, 2; *Pseudomonas stutzeri*, 2
*** *Aspergillus fumigatus*, 25; *Aspergillus niger*, 9; *Paecilomyces variotii*, 1; *Geomyces pannorum*, 1

The sampling protocol featured the following variables: type of patient care (general ward, ICU), room type, room utilisation, number of users per PC terminal, interval between last episode of PC use and sampling. For statistical processing, the chi square test or Fisher´s exact test (original 506 Hyg Med 2008; 33) [12] (Version 6; Epi Info, CDC, Atlanta, GA) was performed, and the significance level chosen was p<0.05.

Table 2: Incidence of detection (absolute, percentage-based) of bacteria and moulds at 100 PC workstations in a university hospital, broken down in accordance with different variables (room type/utilisation, number of users, tile PC last used before sampling).

		S. aureus (a)		Viridans strepto-cocci (b)		Entero-cocci (c)		Gram-neg. bacteria (d)		Bacteria (any from a to d)		Moulds		
	n	n	%	n	%	n	%	n	%	n	%	n	%	
Room type/utilisation														
Laboratory (L)	10	0	-	1	10	0	-	0	-	1	10	3	30	<.001 (fungi; l/s)
Office (B)	13	2	15	2	15	1	8	1	8	5	38	5	38	<.001 (fungi; b/s)
Doctors' room (A)	11	3	2	3	27	1	9	0	-	5	45	2	18	<.01 (fungi; p/s)
Nurses' station (P)	30	3	10	3	10	3	10	7	23	12	40	15	50	<.00001 (fungi; n/s)
Patient room (K)	36	4	11	2	6	3	8	6	17	9	25	0	-	
Type of patient care														
General ward	32	6	19	4	13	1	3	6	19	12	38	14	44	< .0001(fungi)
ICU	45	4	9	4	9	6	13	7	16	14	31	3	7	
Number of users of PC terminal														
1 person	13	2	15	2	15	1	8	0	-	4	31	2	15	
> 1 person	87	10	11	9	10	7	8	14	16	28	32	23	26	n.s. (all)
Time PC last used before sampling														
Immediately before	32	6	19	5	16	4	13	5	16	15	47	7	22	
Unknown	68	6	9	6	9	4	6	9	13	17	25	18	26	.028 (bacteria)

Table 3: Persistence of clinically relevant bacteria on dry inanimate surfaces (modified as per Kramer et al.[5]).

Type of bacterium	Duration of persistence (range)
Acinetobacter spp.	3 days to 5 months
Clostridium difficile (spores)	5 months
Enterococcus spp.	5 days to 4 months
Escherichia coli	1.5 hours to 16 months
Klebsiella spp.	2 hours to >30 months
Pseudomonas aeruginosa	5 weeks
Staphylococcus aureus	7 days to 7 months

Results

Of a total of 300 tests, 296 (98.7 %) showed growth of one or several microorganisms (Table 1). Overall, growth of facultative or opportunistic pathogenic microorganisms was detected in at least one sample from 32% of the workstations (Staphylococcus aureus 12 %; viridans streptococci11 %; enterococci 8 %; Gram-negative bacteria 14 %).

The highest contamination rates were found in the samples taken immediately after using the terminal (47 % vs. 25 %; p=0.028) (Table 2). No significant differences were seen as regards the other variables (ICU versus general ward, room type, room use, number of PC users). Moulds were detected at 25 % of PC workstations, albeit in lower densities (range 1 to 2 cfu /25 cm2); these were found significantly more often in general wards than in ICUs (44% vs. 7 %, p<0.0001) which disposed of room ventilation systems.

Discussion

The study shows that a proportion of around one-third of all PC workstations, and of almost half of those sampled immediately after use, were contaminated with microorganisms, a finding that could have implications for nosocomial infections. Of course, detection of contamination is not to be equated with proof of a causal role in the pathogenesis of nosocomial infections [5,11]. But if one considers the high tenacity and persistence (in some cases even over a period of several months) of many microorganisms on dry inanimate surfaces [5] (Table 3), the long time the hands of personnel are in contact with PC user interfaces and the low compliance rate with hand hygiene regimens among doctors and nurses (scarcely more than 50 %) [12], then one must view it as very probable that such surfaces act as additional reservoirs for transmission of nosocomial infections. That fundamental belief is also shared by other authors, even if the contamination rates found varied between the different studies in accordance with locally prevailing conditions [6,7,8,9]. Noteworthy is that under experimental conditions the highest bacterial transfer rates from surfaces to the hands were observed for hard, non-porous surfaces (e.g. water taps, telephone receivers) [13]. Based on studies conducted in a surgical ICU, Hartmann et al. [7] noted that contamination rates with potentially pathogenic microorganisms on computer keyboards or mouse devices were higher than on other (non-porous) surfaces.

Comparison of the contamination rates at workstations in different types of rooms (office, laboratory, doctors' room, nurses' station, patient room), type of patient care (general ward, ICU) or with varying numbers of users did not show any significant differences. It is therefore not possible to predict the extent of probable contamination for a particular type of workstation. As in our case, Bures et al. [16] reported a relatively uniform contamination rate across an internal medicine ICU, regardless of proximity to patients or the geographic location within the ward. Likewise, studies comparing the hand flora of medical with those of non-medical staff within [14] or outside the hospital [15] demonstrated that all these groups could serve as reservoirs for nosocomial pathogens, even if the pattern of antimicrobial resistance differed. As regards contamination with moulds, the incidence of positive results was considerably lower in ICUs compared with general wards; similar differences in patient rooms compared with all other room types were not significant when taking account of that variable (ICU versus general ward): 78% of patient rooms belonged to ICUs compared with only 40% of nurse stations and 45 % of doctors' rooms. These findings apparently reflect lower aerogenic introduction of moulds in view of the fact that all the ICUs investigated during the study were equipped with room ventilation systems and terminal particulate filters (filter class H13). There are ample data attesting to the effectiveness of these high-performance particulate filtration systems for prevention of Aspergillus ambient contamination, for example in studies into renovation works in the hospital setting [16].

Unfortunately, there is a paucity of information on the efficacy of various disinfectants and their cosmetic and functional effects on computer keyboards. Rutala et al [9] investigated six disinfectants used in hospitals (phenol-based wipes with alkaline detergents, 70 % isopropyl alcohol, chlorine-based agents as well as three different products based on quaternary ammonium compounds) and showed that all were endowed with good efficacy profiles in respect of elimination and inactivation of pathogenic microorganisms after 5-second application with a wipe. As opposed to alcohol-based disinfectants, sustained efficacy was noted for all three disinfectants based on quaternary ammonium compounds for up to 48 hours after application [9]. However, the quaternary ammonium compounds do not have a broad spectrum of viricudal activity, at least not where non-enveloped viruses are concerned. Therefore further studies are needed to find better solutions.

Conclusion

In patient treatment areas disinfection of the surfaces coming into contact with hands should also include computer user interfaces (keyboard, mouse), which should be specifically designed for that purpose (suitable for wipe disinfection and disinfection tolerance [6, 8- 10,17]. Such user interfaces are already available on the market. When choosing a suitable disinfectant, clinical requirements as well as material compatibility aspects should be borne in mind. That insight should also be imparted in staff-training and motivational programmes.

Conflict of Interest

The authors declare that there is no conflict of interest as understood by the International Committee of Medical Journal Editors.

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