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).

**Conclusion:** We conclude that in patient care areas routine disinfection of hand contact surfaces should also apply to computer user interfaces and that these surfaces should be specifically designed for this purpose.

**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-
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-esculin 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 20E/NE system (BioMerieux, Nürtingen, Germany). Antibiotic resistance tests were not performed.

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 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).

<table>
<thead>
<tr>
<th>Microorganisms</th>
<th>Positive Samples</th>
<th>Clu./25 cm²</th>
<th>Positive workstations</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>%</td>
<td>Mittel</td>
</tr>
<tr>
<td>Staphylococcus aureus</td>
<td>19</td>
<td>6</td>
<td>26</td>
</tr>
<tr>
<td>Coagulase-negative staphylococci</td>
<td>273</td>
<td>91</td>
<td>16</td>
</tr>
<tr>
<td>Micrococcus spp.</td>
<td>219</td>
<td>73</td>
<td>8</td>
</tr>
<tr>
<td>Viridans streptococci</td>
<td>15</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>Enterococci</td>
<td>8</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>Bacillus spp.</td>
<td>220</td>
<td>73</td>
<td>6</td>
</tr>
<tr>
<td>Gram-negative bacteria</td>
<td>19</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>Acinetobacter*</td>
<td>12</td>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td>Other non-fermenters**</td>
<td>4</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Enterobacteriaceae</td>
<td>3</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Moulds***</td>
<td>34</td>
<td>11</td>
<td>1</td>
</tr>
</tbody>
</table>

* 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

**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).

<table>
<thead>
<tr>
<th></th>
<th>S. aureus (a)</th>
<th>Viridans streptococci (b)</th>
<th>Enterococci (c)</th>
<th>Gram-neg. bacteria (d)</th>
<th>Bacteria (any from a to d)</th>
<th>Moulds</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>%</td>
<td>n</td>
<td>%</td>
<td>n</td>
<td>%</td>
</tr>
<tr>
<td>Room type/utilisation</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Laboratory (L)</td>
<td>10</td>
<td>0</td>
<td>1</td>
<td>10</td>
<td>0</td>
<td>-</td>
</tr>
<tr>
<td>Office (B)</td>
<td>13</td>
<td>2</td>
<td>15</td>
<td>2</td>
<td>15</td>
<td>1</td>
</tr>
<tr>
<td>Doctors’ room (A)</td>
<td>11</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>27</td>
<td>1</td>
</tr>
<tr>
<td>Nurses’ station (P)</td>
<td>30</td>
<td>3</td>
<td>10</td>
<td>3</td>
<td>10</td>
<td>3</td>
</tr>
<tr>
<td>Patient room (K)</td>
<td>36</td>
<td>4</td>
<td>11</td>
<td>2</td>
<td>6</td>
<td>3</td>
</tr>
<tr>
<td>Type of patient care</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>General ward</td>
<td>32</td>
<td>6</td>
<td>19</td>
<td>4</td>
<td>13</td>
<td>1</td>
</tr>
<tr>
<td>ICU</td>
<td>45</td>
<td>4</td>
<td>9</td>
<td>4</td>
<td>9</td>
<td>6</td>
</tr>
<tr>
<td>Number of users of PC terminal</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 person</td>
<td>13</td>
<td>2</td>
<td>15</td>
<td>2</td>
<td>15</td>
<td>1</td>
</tr>
<tr>
<td>&gt; 1 person</td>
<td>87</td>
<td>10</td>
<td>11</td>
<td>9</td>
<td>10</td>
<td>7</td>
</tr>
<tr>
<td>Time PC last used before sampling</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Immediately before</td>
<td>32</td>
<td>6</td>
<td>19</td>
<td>5</td>
<td>16</td>
<td>4</td>
</tr>
<tr>
<td>Unknown</td>
<td>68</td>
<td>6</td>
<td>9</td>
<td>6</td>
<td>9</td>
<td>4</td>
</tr>
</tbody>
</table>
one-third of all PC workstations, and of all
The study shows that a proportion of around
rate with hand hygiene regimens among
animate surfaces [5] (Table 3), the long time
(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 differ-
cences were seen as regards the other vari-
ables (ICU versus general ward, room type, room use, number of PC users). Moulds
were detected at 25 % of PC workstations,
although 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 al-
most half of those sampled immediately after
use, were contaminated with microorgan-
isms, a finding that could have implications
for nosocomial infections. Of course, detec-
tion of contamination is not to be equated with
proof of a causal role in the pathogene-
sis 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 in-
animate 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 con-
tamination 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 num-
bers of users did not show any significant
differences. It is therefore not possible to
predict the extent of probable contamina-
tion 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, stud-
ies 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 reser-
voirs for nosocomial pathogens, even if the
pattern of antimicrobial resistance diﬀered.
As regards contamination with moulds,
the incidence of positive results was con-
siderably lower in ICUs compared with
general wards; similar differences in pa-
tient rooms compared with all other room
types were not significant when taking ac-
count 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 effective-
ness of these high-performance particu-
late 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 in-
formation on the eﬃcacy of various disin-
fectants and their cosmetic and functional
effects on computer keyboards. Rutala et
al [9] investigated six disinfectants used
in hospitals (phenol-based wipers with al-
kaline detergents, 70 % isopropyl alcohol,
chlorine-based agents as well as three dif-
ferent products based on quaternary am-
onium compounds) and showed that all
were endowed with good eﬃcacy proﬁles
in respect of elimination and inactivation
of pathogenic microorganisms after 5-sec-
ond application with a wipe. As opposed
to alcohol-based disinfectants, sustained
eﬃcacy was noted for all three disinfect-
ants based on quaternary ammonium
compounds for up to 48 hours after ap-
lication [9]. However, the quaternary
ammonium compounds do not have a
broad spectrum of viricidal 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
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 motiva-
tional programmes.

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

<table>
<thead>
<tr>
<th>Type of bacterium</th>
<th>Duration of persistence (range)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acinetobacter spp.</td>
<td>3 days to 5 months</td>
</tr>
<tr>
<td>Clostridium difficile(spores)</td>
<td>5 months</td>
</tr>
<tr>
<td>Enterococcus spp.</td>
<td>5 days to 4 months</td>
</tr>
<tr>
<td>Escherichia coli</td>
<td>1.5 hours to 16 months</td>
</tr>
<tr>
<td>Klebsiella spp.</td>
<td>2 hours to &gt;30 months</td>
</tr>
<tr>
<td>Pseudomonas aeruginosa</td>
<td>5 weeks</td>
</tr>
<tr>
<td>Staphylococcus aureus</td>
<td>7 days to 7 months</td>
</tr>
</tbody>
</table>
The authors declare that there is no conflict of interest as understood by the International Committee of Medical Journal Editors.

References