Staphylococcus aureus on computer mice and keyboards in intensive care units of the Universitas Academic Hospital, Bloemfontein, and ICU staff's knowledge of its hazards and cleaning practices

P Anastasiades, TL Pratt, LH Rousseau, WH Steinberg, G Joubert

Introduction
Apart from posing serious implications to patients’ health, nosocomial infections have a considerable financial impact not only for the individual, but also for the health system. In Brazil, nosocomial infections cause an estimated 45,000 deaths per year at an indirect cost of $4.8 billion.1 More than two million patients acquire nosocomial infections in the United States each year, at a cost exceeding $4.5 billion and resulting in 90,000 deaths.2 In South Africa, approximately one in seven patients admitted to hospital are at risk of developing a nosocomial infection.3 It is estimated that the worldwide prevalence of nosocomial infections is about 10%, with an incidence of about 5% of all hospital admissions.4

Healthcare workers are a potential source of hospital-acquired infections. Pathogens are transmitted by carriage on hands from inanimate objects present in the hospital setting, including computer keyboards and mice.5 Staphylococcus aureus causes the majority of all hospital-acquired infections. It is the most common cause of surgical wound infections and pneumonia, and the second most common cause of bacteraemia. Other infections caused by this pathogen include endocarditis, septicaemia, osteomyelitis, meningitis, various types of skin infections, gastroenteritis, and toxic shock syndrome.5,6 S. aureus is carried by 20-40% of healthy individuals at any given time. Carriage occurs mostly on the skin and the organism is found in large quantities on the mucous membranes of the anterior nares and vagina. Carriers serve as a source of infection to themselves and others via direct contact or contamination of fomites.6 Multidrug-resistant strains of S. aureus, particularly methicillin-resistant S. aureus (MRSA), pose a major clinical and epidemiological problem in hospitals, as they are easily transferred among hospital staff and patients, especially in intensive care units (ICUs).7 In a study conducted in ICUs in the United Kingdom, Hails et al8 found that at least 16% of patients were colonised with MRSA. A significant factor contributing to the transmission of microorganisms is their ability to survive on environmental surfaces. Although microbial contamination of environmental surfaces in the hospital setting is not unique to computer equipment, computer keyboards and mice represent a high contact area for hospital staff, and may contribute to the spread of potential pathogens without direct patient contact.

Coagulase-negative staphylococci were cultured from all keyboards investigated in different studies conducted in the USA.9,10 In another study which focused on the isolation of MRSA, 65% of nurses who had contact with MRSA-infected patients, contaminated their uniforms as well as the keyboards and mice in the wards in which they worked. These results confirmed that inanimate objects could serve as reservoirs for bacteria.11 Hartmann et al12 also found that keyboards and mice might serve as a source for the transmission of microorganisms. Qualitative bacteriological sampling was used to show that the colonisation rate for keyboards and mice with potentially pathogenic bacteria was greater than that of other surfaces in the ICU.5

South Afr J Epidemiol Infect 2009;24(2):22-26
In a study investigating the presence of both Gram-positive and Gram-negative bacteria on computer keyboards, coagulase-negative staphylococci and \textit{S. aureus} were isolated from 100% and 4% of keyboards, respectively. It was suggested that plastic keyboard covers with regular cleaning policies could reduce contamination. It was found, however, that covers did not provide secure protection against bacterial transmission due to frequent use. It was then recommended that the same infection prevention measures employed during direct contact with patients (i.e. hand washing and use of gloves), should be enforced when handling computer hardware.

Universitas Academic Hospital in Bloemfontein does not have a cleaning protocol for computer keyboards and mice.\textsuperscript{12} Cleaning companies usually do not accept responsibility for the cleaning of technological equipment due to the possible damage and consequent replacement costs. Cleaning protocols for computer keyboards and mice were not found in the housekeeping services’ contract.

In view of these circumstances, the aim of this study was to detect \textit{S. aureus} on keyboards and mice in the ICUs of Universitas Academic Hospital. The knowledge of ICU staff with regard to cleaning of keyboards and mice and the potential hazard posed by these fomites as reservoirs for pathogenic microorganisms, was also investigated.

**Methods**

A descriptive study was conducted. Firstly, the presence of \textit{S. aureus} on the keyboards and mice in the ICUs was investigated. Secondly, the knowledge and awareness of ICU staff members regarding keyboard and mouse contamination, its potential hazard in the hospital setting, and cleaning policies were determined by means of a questionnaire.

The study was divided into two categories, namely computer keyboards and mice in the eight ICUs in Universitas Academic Hospital. The multi-disciplinary, surgical, neurosurgical, neonatal, coronary and cardiothoracic ICUs each had two computers, while the paediatric cardiology and paediatric ICUs each had one, giving a total of 14 keyboards and 14 computer mice included in the investigation. Personal and secretarial computers were excluded.

Computer keyboards and mice were swabbed with sterile swabs moistened in an isotonic saline solution. Swabbing was performed as shown in Figure 1. Due to the fact that the initial investigation yielded an unexpectedly low isolation rate of \textit{S. aureus}, a second round of the investigation was performed six months later. The student researchers were trained in the technique of swabbing. Two researchers were allocated to swab the computer mice and keyboards, respectively, which was performed by the same individuals in both rounds of the investigation.

All swabs were streaked out onto mannitol salt agar (MSA) plates and incubated for 72 hours at 37°C.\textsuperscript{6,13,14} The student researchers were trained by an experienced medical technologist to identify microbial colonies on basic morphological characteristics. Consequently, estimated colony counts could be obtained for coagulase-negative staphylococci, Gram-positive bacilli, micrococci, fungi and \textit{S. aureus}.

The student researchers’ findings were double-checked by the medical technologist. This technique could, however, be regarded as a limitation of the study, as a standardised method was not employed to obtain exact colony counts of each type of organism isolated from computer mice and keyboards.

In order to isolate and identify \textit{S. aureus}, Gram stains as well as catalase and coagulase tests were performed on all colonies turning MSA plates from pink to yellow. These tests are routinely used in the local diagnostic microbiology laboratories, and therefore no additional biochemical investigations were performed to confirm the identification of \textit{S. aureus}.

A self-administered questionnaire was used to determine the level of awareness amongst ICU staff members about keyboards and mice as reservoirs for potential pathogenic bacteria. Questionnaires were distributed among staff members (n=160) who were present at the time of the study. Cleaning staff, nurses, doctors and any other persons who regularly used the computers in the ICUs were included. Questionnaires were personally handed out by the researchers and collected again within two days, ensuring a good response rate. Participation was voluntary and anonymous, and consent was obtained from all respondents. In addition to an information leaflet, the questionnaire was accompanied by pictures of computer mice and keyboards to clarify any potential misinterpretation by respondents.

Afrikaans and English questionnaires were distributed, which could be regarded as a limitation of the study as it was not available in any of the other nine official languages. However, since the questionnaires were handed out in person, assistance could be offered should any problems have occurred.

Approval to perform the investigation was granted by the Ethics Committee of the Faculty of Health Sciences, University of the Free State. Permission was also obtained from the Head: Clinical Services, of the Universitas Academic Hospital, as well as the head of Department of Medical Microbiology. After a pilot study, conducted in the Universitas Referrals Department and exactly modeling the main study, minor changes were made to the questionnaire to ensure language and technical clarity.

**Results**

**Microbiology results**

A contaminated ICU was defined as an ICU with either the computer mouse or keyboard yielding the isolation of \textit{S. aureus}. Out of the
eight ICUs, only one (12.5%) was contaminated in the first round of investigation, and five (62.5%) in the second round.

*S. aureus* was isolated from only one computer mouse and no keyboards in the first round of investigation. In the second round, two keyboards (14.3%) and five mice (35.7%) were contaminated. *S. aureus* was found on both the computer mouse and keyboard in only one ICU. The estimated number of colonies grown from the second round of investigation was less per item than in the first round.

Table 1 summarises the estimated colony counts of the different types of microorganisms isolated from all the computer mice and keyboards examined during the first and second rounds of investigation. From 28 swabs (taken from 14 computer mice and 14 keyboards) obtained in each of these rounds, a total of 806 microbial colonies were isolated in round one, of which 17 (2.1%) were identified as *S. aureus*. In the second round of swabbing, however, 31 (6.6%) *S. aureus* colonies were isolated.

Coagulase-negative staphylococci (CNS) substantiated the bulk of the colony count in both rounds of investigation (first round: n=559, 69.4%; second round: n=281, 59.8%) and were isolated from all the computer mice and keyboards. In round two of the investigation, performed six months later, 92.8% (n=13) of the keyboards and 78.5% (n=11) of the computer mice were contaminated with CNS.

The Gram-positive bacilli, micrococci and fungi that were isolated were not identified to species level due to time constraints, and also because these organisms are commonly regarded as contaminants of environmental origin. As a result, potential pathogenic species belonging to each of these groups were not identified, which was beyond the scope of this investigation. Fungi were only found on the keyboards and not on the computer mice in both rounds of swabbing.

When comparing the estimated colony counts obtained during the first and second rounds of the investigation, results from the second round showed a lesser degree of contamination (Table 1). With regard to *S. aureus*, however, the number of colonies isolated increased from 17 in the first round to 31 in the second round of investigation. All 17 colonies of *S. aureus* cultured during the first round were obtained from computer mice, while nine colonies of *S. aureus* were isolated from keyboards and 22 colonies from computer mice in the second round of swabbing.

Table 1: Comparison of estimated colony counts obtained with first and second round swabbing of computer mice and keyboards.

<table>
<thead>
<tr>
<th>Type of organisms isolated</th>
<th>Estimated colony counts</th>
<th>First round</th>
<th>Second round</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Keyboards</td>
<td>Mice</td>
<td>Total</td>
</tr>
<tr>
<td>Coagulase-negative staphylococci</td>
<td>345</td>
<td>214</td>
<td>559</td>
</tr>
<tr>
<td>Gram-positive bacilli</td>
<td>193</td>
<td>28</td>
<td>221</td>
</tr>
<tr>
<td>Micrococcus</td>
<td>2</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>Fungi</td>
<td>14</td>
<td>0</td>
<td>14</td>
</tr>
<tr>
<td>Staphylococcus aureus</td>
<td>0</td>
<td>17</td>
<td>17</td>
</tr>
<tr>
<td>Total</td>
<td>554</td>
<td>262</td>
<td>816</td>
</tr>
</tbody>
</table>

Questionnaire results

From a total of 160 questionnaires distributed to ICU staff members, 137 (85.6%) were returned. The majority of respondents (n=85; 62%) were nurses, while 31 (22.6%) were doctors and 20 (14.6%) were cleaning staff. One respondent (0.7%) was a medical technologist. In the case of cleaning staff, respondents were instructed not to complete two questionnaire items pertaining to direct contact with patients, and these specific items from their questionnaires were excluded from the analysis.

According to questionnaire results as shown in Figure 2, 59% of doctors indicated that they washed their hands both before and after contact with a patient, as opposed to 75% of nurses who applied this practice. Thirty-five percent of doctors and 12% of nurses indicated that they washed their hands only after contact with a patient.

![Figure 2: Participants’ response to the questionnaire item pertaining to the washing of hands and patient contact](image)

Figure 3 shows participants’ responses with regard to the washing of hands in relation to the use of computer mice and keyboards. Sixty-two percent of doctors and 40.3% of nurses indicated that they did not wash their hands at all (i.e. neither before nor after) when using computers. The feedback also showed that only 3% of doctors and 16.9% of nurses practiced washing of hands both before and after the use of computer mice and keyboards.

In response to the questionnaire item investigating participants’ perception regarding the frequency of cleaning of computer mice and keyboards, contrasting results were obtained. Responses varied from ‘once a day’ to ‘never’, selected by 37% and 28% of respondents, respectively. Two percent of respondents believed...
computer mice and keyboards were cleaned once a year, 4% once a month and 5% once a week.

When respondents were asked to indicate who they thought was assigned the responsibility of cleaning computer mice and keyboards, 12% indicated a member of the nursing staff, while 39% said it was done by the cleaning staff and 40% said that no-one was doing it.

The most commonly suggested cleaning method as perceived by the participants, was using a wet or damp cloth to wipe the computer mice and keyboards, with 22% and 23% of respondents suggesting this method for mice and keyboards, respectively. Other agents suggested for cleaning of mice and keyboards included Biocide D solution (14%), Hibitane solution (11%) and alcohol, which was suggested by only 9% of respondents as a cleaning agent for computer mice.

In response to the questionnaire item indicating that computer mice and keyboards played an important role in the transmission of nosocomial infections, 71% of respondents said yes, 5% said no, and 24% were not sure. The feedback from different occupational groups with regard to computer equipment as a potential source of contamination had improved.

S. aureus had increased, or the level of environmental cleaning and disinfection had improved. A possible explanation for this finding might be that an individual’s hand is in direct contact with the upper surface of the computer mouse. In addition, one’s palm is usually moist to a varying degree due to perspiration, which contains sodium chloride that will sustain the growth of halophilic bacteria such as S. aureus.

Although CNS are found in large numbers in the environment and are present on the human body as a member of the commensal flora, these organisms can cause serious opportunistic infections in an immunocompromised individual, ranging from urinary tract infections to osteomyelitis and valvular endocarditis. Therefore, the high isolation rate of CNS from computer mice and keyboards in the ICUs was a cause of concern.

Aerobic Gram-positive bacilli are frequently isolated from a wide variety of environmental sources and are usually not of medical importance. Micrococci are also found in the environment and are members of the normal flora in humans. Micrococcus luteus, however, can cause endocarditis and pneumonia in immunocompromised patients.

Fungi are very common and widely distributed environmental organisms. It should be noted, however, that even non-pathogenic fungi can cause serious morbidity and mortality in immunocompromised persons such as HIV/AIDS patients, patients undergoing treatment for various malignancies, and those suffering from diabetes mellitus.

The antibiotic susceptibility profiles of the S. aureus strains isolated from computer mice and keyboards in the ICUs were not determined in this study, and therefore warrant further investigation.

The response rate of 85.6% to the questionnaire was sufficient to regard it as representative of the total ICU medical, nursing and cleaning staff of Universitas Academic Hospital. The questionnaire provided information regarding important issues, such as washing of hands in relation to contact with patients and computer mice and keyboard use, and the awareness of cleaning policies and procedures.

Despite the fact that 60% of doctors and 81% of nurses believed that computer mice and keyboards played an important role in the transmission of nosocomial infections, 62% of doctors and 40.3% of nurses indicated that they never washed their hands when using computers. This discrepant finding gave the impression that although an awareness existed among medical and nursing staff regarding the potential health hazard of computer mice and keyboards, the majority of them did not consider washing of hands as a preventive measure to break the potential cycle of microbial transmission between computer equipment, staff and patients. The importance of applying hand hygiene, not only when contact with patients is involved, needs to be addressed. It is furthermore essential that emphasis is focused on the actual implementation of and compliance to these protocols, rather than merely increasing awareness.

The cleaners were generally perceived to be responsible for cleaning the keyboards and mice. However, the external cleaning company hired by Universitas Academic Hospital has no such contractual obligation. The absence of an official cleaning protocol for computer mice and keyboards was highlighted by the perception of 37% of respondents that computers were cleaned once a day, and 28% of respondents who believed that it was not done at all. This conflicting feedback was supported by the fact that the vast majority of ICU staff

Discussion

The rate of contaminated ICUs (12.5% in the first round and 62.5% in the second round of the investigation) was consistent with results reported in the literature, ranging from zero to 38%.

Although the total microbiological burden on computer mice and keyboards was higher in the first round of the investigation, S. aureus was isolated in greater numbers during the second round. However, no valid scientific explanation could be put forward for this observation. It would be purely speculative to propose that either the level of contamination had been diminished, colonisation with S. aureus had increased, or the level of environmental cleaning and disinfection had improved.

More computer mice were contaminated with S. aureus as compared to keyboards. A possible explanation for this finding might be that an
members (≥88%) were not aware of any cleaning policy regarding computer mice and keyboards.

Only 9% of respondents were of the opinion that alcohol was a suitable cleaning agent for computer mice, which is in actual fact the most appropriate disinfectant to use on the type of material computer mice and keyboards are made of. The frequency of cleaning of computer mice and keyboards, and proper training of the person appointed to take responsibility for this matter, should be elucidated with the Infection Control Division of the hospital, the person in charge of each ICU, and the manager of the cleaning staff.

According to guidelines proposed by the Centers for Disease Control and Prevention (CDC) in the USA, difficult-to-clean hospital equipment (eg, computer keyboards) should be protected from potential contamination by means of special protective covers.19,20 However, despite the use of keyboard covers on bedside computers, Neely et al9 reported an increase in Acinetobacter baumannii colonisation of patients in a paediatric burn unit. The keyboard covers were identified as the primary source of this organism, which was transferred from the covers to staff’s hands and subsequently to patients. The problem could only be reversed after daily cleaning and disinfection of the covers were instated as a supplementary control measure,21 thus emphasising regular cleaning and disinfection procedures as the key solution to keyboard contamination in hospitals.

Neely et al9 further recommended the use of immersible computer keyboards in high-risk areas in hospitals, such as patients’ rooms. The use of washable computer equipment, especially keyboards and mice, have been found to reduce the spread of pathogenic microorganisms considerably.22 The UK-based inventor and manufacturer of washable computer equipment, Unotron Ltd, predicted in 2006 that their fully-immersible computer mouse manufacturer of washable computer equipment, Unotron Ltd, of the covers were instated as a supplementary control measure, 21 problem could only be reversed after daily cleaning and disinfection and keyboards in intensive care units. The person(s) responsible for this task should be identified, and also the frequency and method of cleaning, with ethanol being proposed as the most effective in terms of reducing microorganisms as well as cost. Furthermore, a specific protocol on the washing of hands before and after using computer mice and keyboards is strongly advocated.

**Acknowledgements**

The authors thank the ICU staff members of the Universitas Academic Hospital who participated in the study; Dr Nic van Zyl, Head: Clinical Services of Universitas Academic Hospital who granted permission for this investigation to be undertaken and published; Department of Medical Microbiology, Faculty of Health Sciences, University of the Free State, for permission to use laboratory facilities and equipment, and Elzette Sonnekus and Mthethelei Kesa, for assistance with the isolation and identification of microorganisms; Daleen Struwig, medical writer, Faculty of Health Sciences, for technical and editorial preparation of the manuscript for publication.

**References**