Microbial contamination of computer keyboards in a university setting

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The keyboards of multiple-user (student) and single-user (staff) computers located on a university campus were sampled to assess microbial contamination. The average number of microorganisms present on multiple-user computer keyboards was significantly greater than on single-user keyboards, and the number of keyboards harboring potential pathogens was also greater for multiple-user computers. It is recommended that regular cleaning and disinfection of computers be used to reduce the microbial load, especially for multiple-user workstations.

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Computers continue to have an increased presence in almost every aspect of our occupational, recreational, and residential environments. In the university environment, students have indicated that 100% have access to computers, 92.1% regularly use the Internet, and 73.3% regularly use e-mail.[1] To accommodate the extensive use of computer technology, universities have developed multiple-user ''computer laboratories'' on campus for general student access. As the popularity of such facilities increases, there is a need to recognize that computer equipment may act as a reservoir for the transmission of potentially hazardous or pathogenic microorganisms. The ability for computers to act as fomites has been previously documented in hospital[2-8] and health care[9-11] environments. In the workplace, contamination of the office environment (including the computer keyboard) with bacteria is also recognized.[12] The computers in the environments mentioned above are likely to be operated by a few regular users. However, the increased availability of multiple-user computers in the university setting means that these items of equipment are handled by numerous users on a daily basis. Given that computers are not routinely disinfected, the opportunity for the transmission of contaminating microorganisms is potentially great.

In this study, we investigated the number and nature of contaminating microorganisms on the keyboards of personal computers located in 3 large, multiple-user facilities located on a university campus. These were compared with the computers located in staff offices that were generally handled by 1 individual.

METHODS

Computer terminals were located in 3 separate multiple-user student computer laboratories located on the Hawthorn campus of Swinburne University of Technology in Melbourne, Australia. Ten keyboards were sampled at random from each laboratory at least 12 hours after the laboratories were last occupied by students. Five single-user computer keyboards (located in staff offices) were also sampled. All computers had been in use for a period of 1 to 3 years. To obtain an estimate of the total level of microbial contamination, a contact agar plate containing 4 cm^2 of Plate Count Agar (PCA; Oxoid, Basingstoke, UK) was directly contacted with an area of the keyboard that included the space bar. These plates were incubated at 30°C for 48 hours. To determine the types of microorganisms present, the remainder of the keyboard was sampled with a moistened sterile cotton swab, which was then placed into 4 mL of Tryptic Soya Broth (Oxoid) and incubated at 30°C for 48 hours.

A variety of selective and differential microbiologic media was used for presumptive identification of contaminating microorganisms (Table 1). Gram's staining, microscopic examination, and confirmatory biochemical tests were performed to further identify bacteria, prior to confirmation by miniaturized identification systems: BBL Crystal Identification System (BD, Franklin Lakes, NJ) for gram-positive bacteria and Microbact Identification System (Oxoid) for gram-negative bacteria.

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Table 1. Microbiologic media*

Media	Microorganism(s) to be identified
Baird-Parker agar and Mannitol salt agar	*Staphylococcus aureus*
Bacillus cereus agar	*Bacillus cereus*
MacConkey agar	*Enterobacteriaceae*
Malt extract agar	Yeasts and molds
Tryptic phosphate agar plus sodium azide	*Enterococcus faecalis*

*All media purchased from Oxoid, Basingstoke, UK.

RESULTS

Overall, a greater number of microorganisms was detected on the keyboards of the multiple-user computers, with an average of 20.1 colonies per square centimeters, whereas the single-user keyboards had an average of 4.5 colonies per square centimeters. Although this difference was found to be statistically significant ($P < .05$), a larger sample of single-user computers may be required to confirm this finding. The number and types of potentially pathogenic bacteria were also greater on the multiple-user keyboards (Table 2). Forty-seven percent of multiple-user keyboards were found to harbor *Staphylococcus aureus*, compared with only 20% of the single-user keyboards. In one of the multiple-user laboratories, 60% of keyboards contained *S aureus*. Whereas this microorganism is part of the normal microbiota of human skin and nasal passages, it is known to be associated with numerous disease conditions. Other potentially pathogenic bacteria were also isolated from the multiple-user keyboards, which were not detected on the single-user workstations. Of particular interest was the isolation of bacteria belonging to of the *Enterobactericeae* family, including *Escherichia coli* from one keyboard, as well as *Enterococcus faecalis,* which is indicative of fecal contamination. The isolation of *Bacillus cereus*, a common soil bacterium, is evidence of environmental contamination. Similarly, the identification of yeasts and molds on all keyboards (multiple user and single user) is indicative of the ubiquitous nature of these fungi in the airborne environment.

DISCUSSION

Numerous studies have indicated that computer keyboards (and mice) can become contaminated with pathogenic bacteria. In health care settings, it is perhaps not unexpected that such microorganisms would contaminate these common work surfaces. However, the present study showed that microbial contamination also occurs on computer equipment located in a large university environment. A particularly interesting finding was that multiple-user computer workstations had significantly more numbers of microorganisms, as well as greater numbers of potentially pathogenic species, compared with workstations used by predominately 1 person. However, this may simply reflect the multiple-user environment where the likelihood of contamination by individuals who are carriers of bacteria such as *S aureus* is greater. Because the sampling of the keyboards was performed a number of hours after they were last used, the isolation of viable microorganisms suggested that the species present are able to persist for a period of time.

As with health care settings, computer keyboards in educational institutions may act a mechanism for the transmission of pathogenic bacteria. Previous studies have demonstrated that other shared communication equipment, such as telephones, can also become contaminated by potentially pathogenic microorganisms, often members of the human microbiota.[13-15]

Because handwashing before and after use of computers may be impractical and compliance by students may be imperfect, it might be desirable instead to clean keyboards (and other hand contact areas such as mouse) with alcohol or other disinfectants on a regular basis. Similar recommendations have been made by previous researchers[8,16] and may be pertinent to other settings, such as the one investigated in this study.

In summary, this study has demonstrated that microbial contamination of multiple-user computer keyboards may be a common mechanism of transfer of potentially pathogenic bacteria among users.

Table 2. Microorganisms identified on computer keyboards

Location of keyboards sampled*	Number of keyboards sampled	Microorganisms detected (% of keyboards tested)				
		Staphylococcus aureus	*Enterobacteriaceae*	*Enterococcus faecalis*	*Bacillus cereus*	Yeasts and molds
M1	10	40	10	0	10	100
M2	10	40	0	10	0	100
M3	10	60	20*	0	0	100
S	5	20	0	0	0	100

M, multiple-user laboratory, *S*, single-user office.
*Includes 1 keyboard with *Escherichia coli* identified.

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