

Computer Keyboard and Mouse: Etiologic Agents for Microbial Infections

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Abstract: Surface bio-contamination is a problem that contributes to outbreaks of community-acquired and nosocomial/environmental infections through episodic fomite transmission of disease and persistent fomite reservoirs. Public user interfaces like computer keyboard and mouse have been shown to be reservoirs and transmitters of microorganisms. The purpose of this study therefore was to examine computer keyboards and mouse in National Veterinary Research Institute's cyber café in Vom, Plateau State, Nigeria for contamination by microorganisms. Bacteria isolated include: *Bacillus species*, *Escherichia coli*, *Staphylococcus aureus*, *S. albus*, *Streptococcus epidermidis* and *Diphtheroids*. *Trychophyton species*, *Aspergillus species* and *Candida albicans* were the fungi/mould isolated. *Bacillus species* (84%) was the most isolated bacteria. All fungi were isolated in equal percentages (45.0%). Most of these isolates were traditional skin flora and probably dust associated. It is suggested that routine cleaning of keyboards and mice or the use of transparent plastic covers alongside hand hygiene may aid the fight against infection transmission via fomites.

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1. Introduction

Surface bio-contamination is a problem that has been shown to aid outbreaks of community-acquired and nosocomial infections through episodic fomite transmission of disease and persistent fomite reservoirs. The extent to which fomite reservoirs contribute to the overall extent of nosocomial or environmental infections is unknown, but fomites are known to play some role in the transmission of many diseases (Feied, 2004).

Fomites consist of both porous and nonporous surfaces or objects that can become contaminated with pathogenic microorganisms and serve as vehicles of transmission of these disease agents (England, 1982). Fomites become contaminated with organisms by direct contact with body secretions or fluids, contact with soiled hands, contact with aerosolized virus (large droplet spread) generated via talking, sneezing, coughing, vomiting or with airborne organisms that settles after disturbance of a contaminated material (i.e. shaking a contaminated material close to it) (Goldmann, 2000 & Reynolds et al., 2005).

Diseases that commonly spread by means of fomites include the common colds, cold sores, conjunctivitis, coxsackievirus (hand-foot-mouth disease), croup, *E. coli* and Staphylococcal infections, fifth disease ("slap cheek"), *Giardia* infection, impetigo, influenza, lice, meningitis,

pinworms, rotavirus diarrhea, and Respiratory Syncytia Virus to mention but a few. Once a fomite is contaminated, the transfer of infectious organisms may readily occur between inanimate and animate objects, or vice versa, and between two separate fomites (if brought together) (Sattar, 2001). In the chain of infection, fomites can serve as the reservoir, with pathogens being spread from the inanimate environment to an animate environment via the hands.

The role of surface contamination of public user interface systems in the spread of disease raises a lot of questions though research findings have shown a lot of evidence in support of their active role in this regard. Public user interfaces like computer keyboard and mouse (being fomites in close and regular contact with hands), may serve as reservoirs for the transmission of microorganisms (Kassem, 2007). Pathogens may be transferred via the hands of a user to subsequent users of the same computer leading to infection(s). A contaminated personal computer has been implicated in transmission of methicillin-resistant *Staphylococcus aureus* to a nurse. Computer keyboards have been contaminated with staphylococci and *Pseudomonas* spp. (Isaacs et al., 1998). Keyboards also have been implicated in nosocomial *A. baumannii* infection in burn units and ICUs (Neely et al., 1999) and have been contaminated with enterococci and *Enterobacter* spp.

with a genetically identical methicillin-resistant *S. aureus* strain (Bures et al., 2000).

For public centres like cyber café's, computer components that attract a wide user interface cannot be ruled out as a potential etiologic agent for some of these organisms going by the unhygienic practises of users viz-a-viz sneezing, nose picking, unhygienic use of rest rooms, eating habits, etc as elucidated by Goldmann (2000). Of increasing concern, is the role of keyboards and mice as pathogen reservoirs because of frequent dermal contact by numerous users. Computer keyboards have been shown to harbour methicillin resistant *Staphylococcus aureus* (MRSA) (Bures et al., 2000 & Wilson et al., 2006).

According to the work of Weber (2005) "the acquisition of pathogens depends on a complex interplay of the host, pathogen and environment." Breaches in the host's skin integrity allows microbes to invade, while microorganisms must be present in a minimum inoculating dose sufficient to trigger infection, virulence, infectivity and the ability to produce a latent infection. Nosocomial and environmental infections can result from endogenous or exogenous floras, with the latter often present on an environmental reservoir or fomite like a computer keyboard or mouse.

The prevalence of bacterial infections in humans is increasing (Weber, 2005 & Eguia and Chambers, 2003). Because the asymptomatic carriage of some bacteria like MRSA in humans is increasing alongside other pathogenic organisms (Creech et al., 2005 & Hidron et al., 2005) along with the occurrence of community-associated infections (Purcell and Fergie, 2005), it follows that the ubiquitous sharing of public computers by a broad user base might facilitate increased transmission and prevalence of these pathogens throughout the community (Kassem et al., 2007). Their preponderance as etiologic agents for some aforementioned infections in the study area, cannot be ruled out.

The purpose of this study therefore is to examine the microbial colonization of computer keyboard and mouse; components of computers which serve as public user interfaces in a cyber café.

2. Materials/Methods:

Study area/location

National Veterinary Research Institute's Cyber Café located in Vom, Plateau State.

Samples

Samples consist of 50 swabs taken from keyboard and mouse in active use in the café. 22 keyboards and 22 mice were sampled from multiple

user computers. 3 keyboards and 3 mice were sampled from the Café Manager's room as single user computers.

Sample collection and processing

A single sterile swab per component (keyboard or mouse) moistened by dipping it in sterile Tryptic Soy Broth (BD™ Tryptic Soy Broth: BA-257107.03, TSB), was rolled over the entire component surface. The swabs were placed back in their holders and taken to the Microbiology laboratory of Federal College of Veterinary and Medical Laboratory Technology, Vom (which was within 3 minutes walking distance from the café). All swabbed keyboards and mice were disinfected with 70% alcohol.

Culture and isolation

In the laboratory, each swab head was aseptically cut off and dropped into a separate sample bottle containing 5 ml of TSB. These were incubated at 37°C. After 24 hours, each sample in TSB was aseptically sub-cultured on blood agar (BA), McConkey agar (MCA). After 48 hours, they were subcultured onto sabouraud dextrose agar (SDA) slope. The cultures on BA and MCA were incubated at 37°C for 24 hours while those on SDA were incubated for 21 days at 25 °C. Cultures that yielded bacterial growth were sub-cultured for purification on another set of BA and MCA plates. Same was done for fungal growths.

Identification of isolates

Bacteria: Isolates were identified on the basis of cultural characteristics on growth media (which include: colony size, colour, opacity, consistency, hemolysis on blood agar, colony pigmentation, elevation, swarming and odour). Identification materials, reagents and protocols according to Cowan and Steel (Hartmann et al., 2004) were used to identify discrete colonies from purity plates of subcultured isolates. The identification methods include Gram staining, followed by other tests: catalase and coagulase test, biochemical tests (indole and methylred production, Voges-proskauer reaction, citrate and urease activity and sugar fermentation tests for all isolates, including Triple sugar ion agar (TSIA) tests.

Fungi: Identification protocols according to Larone (Cowan and Steel, 1995) were used to identify fungal isolates.

3. Results

The following bacteria were isolated: *Bacillus species*, *Escherichia coli*, *Coagulase positive*

Staphylococcus, *Coagulase negative Staphylococcus*, *Streptococcus species* and *Diphtheroids*. The following fungi/moulds were isolated: *Trichophyton species*, *Aspergillus species* and *Candida albicans* as reported in table 1.

Bacillus species (84%) were the most isolated bacteria in both keyboards and mice as presented in table 1. Only two bacterial species

(*Bacillus species* and *Staphylococcus aureus*) were isolated from the single user computers (as presented in table 3) as against six isolated from multiple user computers as presented in table 2. All fungi mentioned above were isolated in equal percentages from public user computers. *Trichophyton species* was isolated from all single user keyboards and mice.

Table 1: Microbial contamination in all keyboards and mouse sampled.

Organisms	No. (%) of keyboards positive for contamination (n=25)	No. (%) of mouse positive for contamination (n=25)
Bacteria		
<i>Bacillus species</i>	21 (84.0)	19 (76.0)
<i>Escherichia coli</i>	5 (20.0)	4 (16.0)
<i>Coagulase positive Staphylococcus</i>	7 (28.0)	10 (40.0)
<i>Coagulase negative Staphylococcus</i>	1 (4.0)	2 (8.0)
<i>Streptococcus species</i>	2 (8.0)	4 (16.0)
<i>Diphtheroids</i>	3 (12.0)	3 (12.0)
Fungi/Mould		
<i>Trichophyton species</i>	2 (8.0)	0 (0.0)
<i>Aspergillus species</i>	0 (0.0)	1 (4.0)
<i>Candida albicans</i>	1 (4.0)	0 (0.0)

Table 2: Microbial contamination in multiple user keyboards and mouse.

Organisms	No. (%) of keyboards positive for contamination (n=22)	No. (%) of mouse positive for contamination (n=22)
Bacteria		
<i>Bacillus species</i>	18 (81.8)	16 (72.7)
<i>Escherichia coli</i>	5 (22.7)	5 (22.7)
<i>Coagulase positive Staphylococcus</i>	5 (22.7)	9 (40.9)
<i>Coagulase negative Staphylococcus</i>	1 (4.5)	2 (4.5)
<i>Streptococcus species</i>	2 (9.1)	4 (18.2)
<i>Diphtheroids</i>	0 (0.0)	0 (0.0)
Fungi		
<i>Trichophyton species</i>	1 (4.5)	0 (0.0)
<i>Aspergillus species</i>	0 (0.0)	1 (4.5)
<i>Candida albicans</i>	1 (4.5)	0 (0.0)

Table 3: Microbial contamination in single user keyboards and mouse.

Organisms	No. (%) of keyboards positive for contamination (n=3)	No. (%) of mouse positive for contamination (n=3)
Bacteria		
<i>Bacillus species</i>	3 (100.0)	3 (100.0)
<i>Coagulase positive Staphylococcus</i>	1 (33.3)	1 (33.3)
Fungi		
<i>Trichophyton species</i>	1 (33.3)	0 (0.0)

4. Discussion

We found out that all computer keyboards and mice were positive for microbial colonization (100% colonization respectively). Most of these isolates were traditional skin flora and probably dust associated organisms especially those isolated from

keyboards. In addition, other organisms such as gram positive rods, cocci and mould, revealed a general level of colonization of these widely used equipments. *Coagulase negative Staphylococcus* has been shown to comprise a significant proportion of bacteria associated with humans (Larone, 2002). The

isolation of these from keyboards was not surprising. However, increased virulence of *Coagulase negative Staphylococcus* resulting from the acquisition of methicillin resistance has been recognized in isolates from keyboards (Ben-Saida et al., 2006). This reinforces our assertion of the role of keyboards as etiologic agents for infectious pathogens.

Our findings are similar with those of Hartmann et al. (Blum and Rodvold, 1987) who isolated *Staphylococcus epidermidis* from keyboards in intensive care units on multiple user computers. They also revealed that the highest rate of colonization in patient's rooms in a screened hospital was found on computer keyboards (with 5.9% occurrence of *Staphylococcus aureus*). As is reported *Coagulase positive Staphylococcus* gave a percentage colonization of 22.7% in multiple user computer keyboards. This raises an alarm as *Coagulase positive Staphylococcus* is a potential pathogen when given the right environment. In this study, the source(s) of the colonizing microbes on the keyboards and mouse are unknown. However, the widespread nasal carriage of staphylococci by humans (Graham et al., 2006) likely facilitated the colonization via (i) hand-to-mouth or hand-to-nose contact while using the keyboard or mouse, and/or (ii) poor hand-washing habits (ASM, 2005). Rutala et al. (2006) showed that on testing 25 computer keyboards, they contained 64% of *Bacillus* species. This does not differ so much from the 72% recorded for *Bacillus* sp on multiple user computers in this work. The isolation of *Streptococcus species* indicates the possibility of mouth contamination.

As reported, the wide gap in the number of colonizing isolates and their rates of isolation from multiple user keyboards and mice as compared to the single user ones shows a higher degree of colonization for multiple user computers. It therefore means that any user of a multiple user appliance should be more hygiene conscious to prevent self or cross infection via its use. We recorded a higher percentage (100%) of *Bacillus* species from single use computers. This does not mean that they were more exposed to contamination. Rather, it may be because the single user computer is not cleaned regularly as the ones in the main café so dust accumulation may have been responsible for the higher isolation rate.

Aspergillus species are ubiquitous in the environment in most countries of the world. The fungus grows well on a variety of substrates, including stored hay or grain, decaying vegetation, soil and dung. *Aspergillus* is usually nonpathogenic, but can act as opportunistic pathogen in populations with compromised immune system (Fridkin and Jarvis, 1996). It is thought that the transmission of

aspergillosis is airborne: the *Aspergillus* enters the patients by airborne conidia that are small enough (2.5-3.5 µm) to reach the alveoli upon inhalation and hardy enough to survive for prolonged periods on fomites. In this research, the finding of *Aspergillus* species on a mouse may be due to soil deposits on the mice and hand to mouth contact after its use may lead to aspergillosis.

In like manner, the isolation of *Trichophyton* species may be a pointer towards the transmission of Tinea infections especially to children/pupils who use these computers regularly. Though the diseases are more common in low socioeconomic groups, transmission is primarily due to fomites; computer keyboards and mice not being exceptions.

Conclusion:

In this study, we found that there was a high colonization rate of computer user interfaces like keyboard and mouse. The colonization rates of non pathogenic bacteria and moulds were higher than pathogenic organisms. On the basis of these findings, it is suggested that routine cleaning of keyboards and mice or transparent plastic covers may aid the fight against infection. Also, hand washing before and after contact with keyboards and mice should be practised to significantly reduce the risk of infection and cross transmission. Were affordable, washable keyboards and mice should be used in cafés so that periodic washing and proper disinfection can be undertaken.

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