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Full Length Research Paper

Bacterial contamination of computer keyboards and mice, elevator buttons and shopping carts

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This study aims at investigating the status of bacterial contamination of four daily used objects, computer keyboards, computer mice, elevator buttons and shopping carts handles. A total of 400 samples were collected from 4 different objects; 100 from each. Samples were collected from different places (offices, internet cafes, homes, buildings and supermarkets) in the city of Jeddah, Saudi Arabia. 95.5% of the total samples collected were contaminated with mixed bacterial growth. Coagulase-negative staphylococci dominated the isolates. The second most common bacterial growth in all specimens was Gram-positive bacilli. Potential pathogens isolated from all specimens were: *Staphylococcus aureus, Pseudomonas* spp. and Gram negative bacilli. Results indicate that internet café computer keyboards and mice showed 100% contamination in comparison with other objects. The presence of pathogenic and commensal bacteria on the four objects indicates that they might act as environmental vehicles for the transmission of potentially pathogenic bacteria.

Key words: Bacterial contamination, computers, public surfaces.

INTRODUCTION

Most people do not realize that microbes are found on many common objects outdoors, in their offices, and even in their homes. Such objects include; playground equipments, ATM keyboards, kitchen sinks, office desks, computer keyboards, escalator handrails, elevator buttons and with the spread of supermarkets and hypermarkets the shopping carts handles. All of the latter objects are places that are most touched by the bare hands of people who are in various hygienic conditions. People believe that microbes are only present in research labs or in hospitals and clinics and thus they have a misleading feeling of security in other places. Lack of knowledge about where germs prowl could be the cause of health problems. In fact 80% of infections are spread through hand contact with hands or other objects (Reynolds et al., 2005). Reynolds et al. (2005) used an invisible fluorescent tracer for artificial contamination of public surfaces, they found that contamination from outside surfaces was transferred to 86% of exposed individual's hands and 82% tracked the tracer to their home or personal belongings hours later (Reynolds et al., 2005). The viability of Gram-positive and some Gram-negative organisms under various environmental condi-tions have been described (Noskin et al., 1995). Some microbes are infectious at very low doses and can survive for hours to weeks on nonporous surfaces, such as countertops and telephone hand pieces (Reynolds et al., 2005).

Enterococci have been found to survive in dry conditions and on various fabrics utilized in the health care environment. Infectious doses of pathogens may be transferred to the mouth after handling an everyday contaminated household object (Rusin et al., 2002).

Recently Ulger et al. (2009) have demonstrated that health care workers' hands and mobile phones were contaminated with various types of microorganisms and

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Abbreviations: CK, Computer keyboards; **CM,** computer mice; **Shc,** shopping carts; **EB,** elevator buttons.

Table 1. Sites sampled for the presence of bacteria and percentage contamination.

Site	No. of samples	Percentage contamination	Total percentage contamination
Computer key boards			
Homes	25	88	**93**
Offices	25	92	
Internet café	50	100	
Computer mice			
Homes	25	91	95
Offices	25	91	
Internet Café'	50	100	
Shopping carts handles			
Supermartket 1	25	89	
Supermartket 2	25	95	93
Supermartket 3	25	95	
Supermartket 4	25	92	
Elevator buttons			
Shopping Malls	50	96	97
Residential Buildings	50	98	

concluded that mobile phones used in daily practice may be a source of nosocomial infections in hospitals. Scientific information about the occurrence of bacteria on various objects outside the health care facilities is very little and needs to be enriched in order to educate people on the necessity of improving the habit of hand washing to reduce microbial transmission. The aim of this study was is to investigate the presence of bacteria on 4 different objects (computer keyboards and computer mice, elevator buttons and shopping carts handles) that are frequently used by people in the city of Jeddah, Saudi Arabia.

MATERIALS AND METHODS

A total of 400 samples (100 computer keyboards (CK), 100 computer mice (CM), 100 shopping carts (Shc) and 100 elevator buttons (EB) were collected from different places of Jeddah, Saudi Arabia (Table 1) using sterile swabs. 30 control samples from brand new untouched computer keyboards and computer mice were also included.

Isolation of various bacterial contaminants from the four different objects (CK, CM, Shc and EB) was performed through standard techniques described by Cheesbrough (2006). Briefly, sterile water-moistened swabs were wiped firmly over the entire surface of the specific object. Each swab was placed in 2 ml of brain heart infusion broth in a sterile container, and vortexed for one minute. Total amount of 100 µl was plated out on each of blood agar and MacConkey agar. All samples were plated within three hours of collection. The pairs of inoculated media were incubated aerobically at 37°C for 24 h. Pure colonies of isolates were identified and characterized using standard microbiological techniques (Cheesbrough, 2006).

Statistical analysis

One-way ANOVA test was used to compare the means of all bacteria found on computers (mouse and keyboard) at different places (Internet Cafe, Office and Home). An alpha level of .05 was used for all statistical tests.

RESULTS AND DISCUSSION

The 30 control samples showed no bacterial growth. The average rate of bacterial contamination of the four objects was 95.5% with the elevator buttons showing the highest percentage (97%) and computer keyboards from homes showing the least (88%) (Table 1). Qualitative analysis of bacterial isolates revealed the abundance of normal flora isolates belonging to Coagulase negative Staphylococci (ConS) and Gram positive bacilli in all four objects. Potential pathogens such as *Staphylococcus aureus*, *Pseudomonas* spp. and Gram negative bacilli were also isolated but in lower frequencies (Table 2). Distribution of isolates between the four different objects was almost identical (Figure 1). However percentage of different isolates recorded from computer keyboards and mice of internet cafes was significantly higher ($p<0.000$) than those from houses and offices (Figures 2 and 3).

The bacterial occurrence on four commonly used public surfaces was investigated in this study. Surfaces varied

Table 2. Percentages of bacterial isolates on each object.

Isolated bacteria	CK (%)	CM (%)	Shc (%)	EB (%)
Coagulase-negative staphylococci	85	88	87	84
Gram-positive bacilli	58	60	55	60
Staphylococcus aureus	20	19	14	11
Pseudomonas spp.	11	10	10	10
Gram-negative bacilli	14	11	8	7

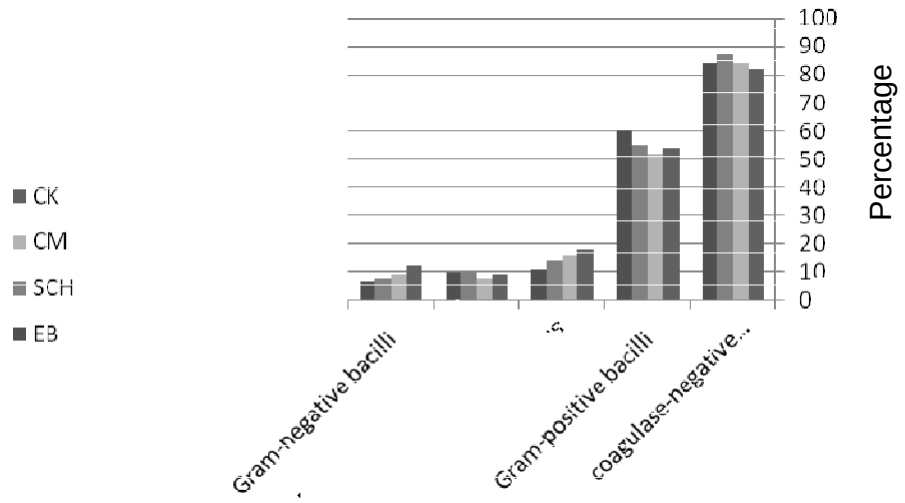

Figure 1. Distribution of bacterial isolates in the four objects computer key boards (CK), computer mice (CM), shopping cart handles (SCH) and elevator buttons (EB).

between computer keyboards, mice, shopping cart handles and elevator buttons. All tested surfaces were found to be contaminated with mixed growth. Gram +ve and G-ve pathogenic and non-pathogenic bacteria were isolated. The distribution of isolates on different surfaces was similar (Figure 1). Qualitative bacterial analysis of the isolates on the four different objects revealed that CoN-Staphylococci followed by Gram +ve bacilli were the most common isolates (Table 2). The previous results are expected due to the common vehicle of microbial transmission which is the human hands and fingers. Scott and Bloomfield (2008) suggested that, where contaminated surfaces come into even relatively brief contact with the fingers or an inanimate surface, a significant number of organisms can be transferred which can be recoverable onto an agar surface. In our study Gram +ve bacteria were more frequently isolated from all surfaces compared to Gram -ve (Figure 1). This could be in part due to the fact that survival of Gram +ve species on laminate surfaces is greater than that of Gram negative organisms (Scott and Bloomfield, 2008). However, both Gram +ve and Gram -ve bacteria have been shown to have similar transfer rates from laminate surfaces to fingertips (Scott and Bloomfield, 2008). Normal skin is inhabited with two categories of bacteria: transient and resident. Resident flora, which are attached to deeper layers of the skin, are more resistant to removal by routine washing. Coagulase-negative staphylococci and Gram +ve diphtheroids are members of this group (Boyce and Pittet, 2002). On the other hand, transient flora colonizes the superficial layers of the skin, and is more amenable to removal by routine hand washing (Boyce and Pittet, 2002). Domestic and public computer key boards and mice were swabbed and cultured. The swabbed areas were the keys mostly pressed like the space bar, the Enter and Backspace buttons. 100% of Internet café's computers were found to be contaminated (Table 1). Comparing these results to the home computer keyboards and mice there is a reduction in the percentage of contamination to 88 and 91% respectively. This reduction is expected due to the limited number of users and assumed continuous cleaning in houses. Nevertheless a percentage of 88 or 91% is still considered high. Percentage of contamination of offices' computer keyboards and mice came in between; this could be attributed to the higher number of heterogeneous users, periodic cleaning and dusting of the office furniture and computers. Most common

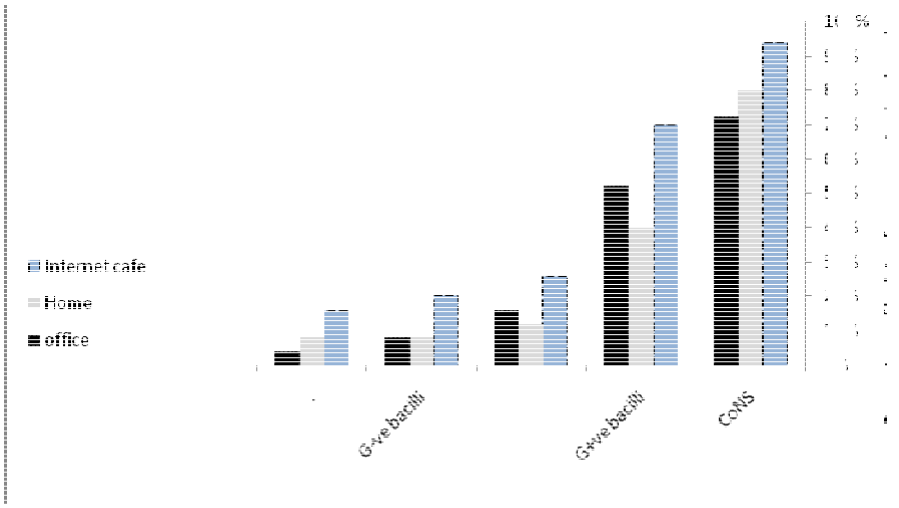

Figure 2. Comparison between isolates from computer keyboards from homes, offices and Internet cafes.

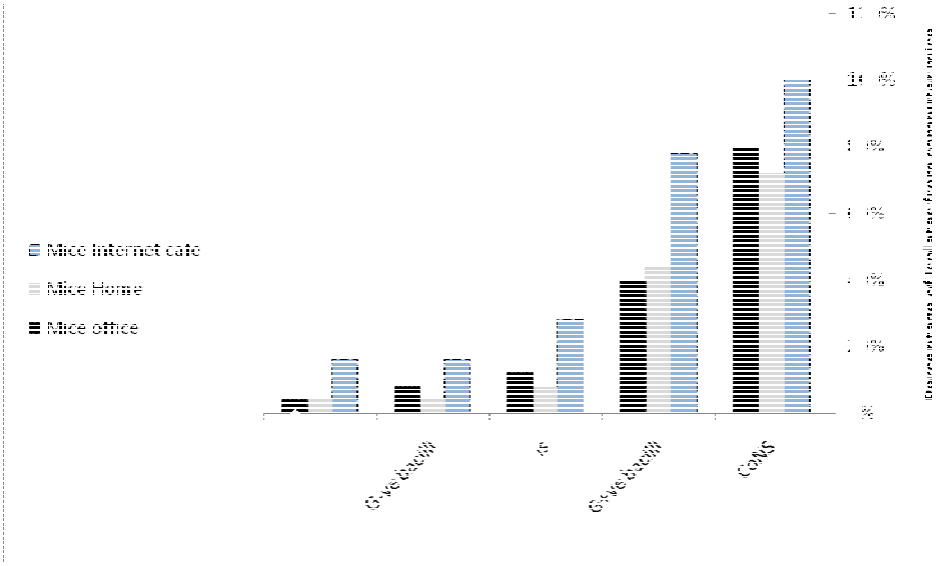

Figure 3. Comparison between percentage isolates from computer mice from homes, offices and internet cafes.

contaminating microbes for computer keyboards and mice were commensal skin organisms followed by some pathogenic microbes (Figures 2 and 3) however, key boards and mouse of internet café exhibited the highest percentage of pathogenic organisms (Figures 2 and 3). Computer keyboards are one of the most commonly-touched and shared surfaces today. By inference, anytime a keyboard is shared among two or more people, it becomes a risk for the spread of infection (Marsden, 2009). Thus, keyboards have become reservoirs for pathogens especially in hospitals and schools (Diggs et al., 2008). One should also note here that a reason for the increased percentage of contamination of computers is the difficulty of cleaning and disinfection (Marsden, 2009), as well as the misconception that cleaning keyboards could possibly damage therm. A possible solution to the spread of infectious diseases through keyboard sharing could be by making both cleaning and disinfection effective and easy (Marsden, 2009).

The occurrence of bacteria on the handles of shopping carts was detected in four different locations that were geographically far apart. The percentage of contaminated

cart handles was almost the same for all locations except for location 1, yet the observed difference was not significant (Table 1). People who push the shopping carts vary in their hygienic status; moreover the items that shoppers hold in their hands vary in the degree of cleanliness. The in-shop handling of different items is another factor that determines hand hygiene. Fluctuation between items such as fresh vegetables, fruits and then fresh dripping chicken, fish or frozen items would subject the hands to dampness and make them apt for picking up microbes. Those samples obtained from elevator buttons of shopping malls and of residential areas revealed nearly the same percent of contamination as those of other objects (Table 1). Formerly mentioned transient flora including potentially pathogenic bacteria such as *S. aureus* and Gram negative bacilli can be obtained from various sources in the environment some of which have been mentioned earlier such as shopping cart handles, elevator buttons, and supermarkets. Other sources could be contaminated surfaces, shaking hands with carriers of diseases or with patients (Ulger et al., 2009). The hands of health care workers may become persistently colonized with such bacteria and consequentially spread it to others outside the healthcare premises through hand shaking or through touching various objects such as shopping carts, elevator buttons or computers.

The potentially pathogenic *S. aureus* was isolated from the four tested objects but in lower percentages (Table 2).The ecologic niche for *S. aureus* in humans is in the anterior nares (Miller and Diep, 2008). One-quarter to one-third of healthy persons harbor *S. aureus* in the nose at any time (Kluytmans et al., 1997) which can easily be transferred to hands by simply rubbing the nose. In the present study one sixth of the isolates were *S. aureus* (15±0.02%). This strengthens the possibility of transfer of potentially pathogenic bacteria through human hands which could include antibiotic resistant bacteria such as community associated –MRSA (Miller and Diep, 2008).

Inanimate objects have been known to play a role in the transmission of human pathogens either directly by surface to mouth contact or indirectly by contamination of fingers and subsequent hand to mouth contact (Rusin et al., 2002). Other routes of exposure include eyes, nose, and cuts on abraded skin. In the present study four inanimate objects have been shown to carry non pathogenic and potentially pathogenic bacteria. Even when contaminated surfaces containing relatively low numbers of organisms come into contact with the fingers and other surfaces, organisms may be transferred in sufficient numbers to represent a potential infection hazard (Scott and Bloomfield, 2008). On the other hand, the capability of pathogenic micro-organisms to exist in the viable but non-culturable (VBNC) state would pose risks of being overlooked during isolation. Furthermore, some investigators claim that non-culturable bacteria of selected species can be resuscitated to the culturable state as with *Vibrio cholerae* O1 that was isolated in the culturable form from stools of volunteers after ingestion of VBNC *V. cholerae* O1 (Colwell et al., 1996). Thus the use of conventional methods of isolation like those used in the present study would not necessarily reflect the actual bacterial contamination status on these objects and thus the actual microbial load may not have been elaborated.

As reported by Lowbury and Fox (1953) and Rathmachers and Borneff (1977) soiling is an important factor in preserving viability of bacteria on hard surfaces. Thus dirty surfaces would harbor more bacteria than clean ones. This makes the process of dusting and removal of soil and dirt by simple cleaning procedures of paramount influence on the reduction of surface contamination. Although drying plays an important part in maintenance of hygiene on surfaces and other environments, drying per se cannot be relied upon to prevent transfer of infection from laminate surfaces due to the resistance of some microbes to that measure (Scott and Bloomfield, 2008). Clinical investigations indicate that infection risks depend on numbers of organisms transferred and the immune status of the person (Scott and Bloomfield, 2008). Potentially pathogenic bacteria isolated from the four objects include *Staphylococcus aureus, Pseudomonas* spp. and other Gram -ve bacilli (Figure 1). These bacteria pose risk to the immunocompromised and immune suppressed persons.

This study demonstrates that microbial contamination of computer keyboards, computer mice, shopping carts and elevator buttons is prevalent and that commensal skin organisms are the commonest contaminating microbes. The study also shows that Gram positive bacteria are transmitted most readily from environmental surfaces followed by Gram negative bacteria. The present investigation emphasizes the importance of good hand hygiene and adequate decontamination procedures applied to laminate surfaces, computer keyboards, mice and shopping carts.

With the emergence of global infectious diseases like Swine flu and SARS a lot of supermarkets have been implementing measures of hygiene by providing disinfectants at entry and at several critical contamination points such as chicken and meat refrigerators. This could be taken as a step forward to minimize hand contamination. Such approaches should be undertaken in parallel with community education for hygienic standards, respiratory etiquette and hand washing. Methods of decontamination and disinfection of computers, cell phones and other sensitive electronics should be elaborated to consumers.

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