# Computer Keyboard and Mice: Potential Sources of Disease Transmission and Infections

D Tagoe, F Kumi – Ansah

**Citation**

D Tagoe, F Kumi – Ansah. *Computer Keyboard and Mice: Potential Sources of Disease Transmission and Infections*. The Internet Journal of Public Health. 2010 Volume 1 Number 2.

**Abstract**

Computers just like microbes are ubiquitous and continue to have an increased presence in everyday lives. The aim of this study was to investigate and compare the level, types and antibiotic susceptibility of bacterial contaminants of keyboards and mice in general offices and internet cafés. A total of 100 samples were collected by swabbing the surfaces of keyboards and mice. Serial dilution and aerobic colony counting was performed by pour plating on PCA (Plate Count Agar) for each sample. Isolates were identified by standard biochemical methods whilst the disc diffusion technique was applied in Antibiotic Susceptibility Testing of each bacterial isolate. All surfaces of keyboard and mice were contaminated ($>10^5$) with means of $5.664\times10^8$ and $1.305\times10^7$ CFU for office keyboard and mice respectively and $1.52\times10^9$ and $1.901\times10^7$ CFU for café keyboard and mice respectively. There was a 48.02% contamination difference between office and cafés which was significant; keyboards (P=0.000) and mice (P=0.001). Eight bacteria species were isolated with the highest B. cereus, 70(47.95%) and the least E. coli 3(2.05%). Majority of the contaminants were pathogenic 117(80.41%) made up of 42.47% from café samples and 37.94% from office. S.
pneumonia, Enterococcus spp. and Coagulase Negative Staphylococcus were the least susceptible organisms (25%) whilst Ampicillin was the least effective antibiotic (0%). These findings suggest high contamination of keyboard and mice with pathogenic bacteria and associated potential of transmission and infection.

## INTRODUCTION

Computers just like microbes are ubiquitous and they continue to have an increased presence in almost every aspect of our occupational, recreational, and residential environments.[1] The oldest and the most widely accepted keyboard layout is the "QWERTY keyboard" with the random distribution of characters requiring more finger movement on the keyboard.[2] An internet café is a place which provides internet access to the public usually for a fee. This business usually provides snacks and drinks hence the "Café" in the name.[3] In places where there are a lot of people moving in and out, such as offices and internet cafés, there is likely to be a good number of people sick, and through them comes new bacteria that will eventually settle on the keyboard through air or from physical contact.[4] Automated teller machine (ATM) keyboards were found to have more germs than a public restroom door.[5] One study in a hospital setting reported that microbial contamination of computer interface surfaces was so prevalent that various microorganisms were isolated from more than 50% of the keyboards of the hospital computers.[6] These fomites may be additional reservoirs for the transmission of microorganisms and become vectors for cross-transmission.[7] The contribution of hands contaminated with pathogenic microorganisms to the spread of infectious diseases has been recognized for many years.[8] The prevalence of bacterial infections in humans is increasing and has been shown to result in part from the hospital setting to the community and vice versa.[9-10] It has been realized that one main cause of bacterial contamination of computer keyboards and mice in non-hospital setting is through eating while working with the computer in the office or browsing the internet with the computer. As a result some food crumbs and spills can wind up on and between the keyboard keys and on the mouse buttons.[11] Given that computers are not routinely disinfected, the opportunity for the transmission of contaminating microorganism is potentially great.[12] Thus this research seeks to investigate into what kinds of microorganisms especially bacteria that actually contaminate keyboards and mice in offices and internet cafés in the University of Cape Coast community, Cape Coast, Ghana.

## MATERIALS AND METHODS

Study Area and Design: The study took place on University of Cape Coast where offices of the various departments and internet cafés located in surrounding communities where students not in residence and other members of the community patronise were randomly selected and sampled. The study was undertaken from September, 2010 to April, 2011.

Sampling: A total of 100 swab sample were taken by simple random sampling technique. This was done in batches of 50 each from internet cafés and general offices. Ten samples from 5 computers were taken from each of the 5 randomly selected internet cafés with each computer having 2 samples taken, the keyboard and the mouse. Twenty-five general offices selected at random had 2 samples taken from each computer.

## LABORATORY METHODS AND PROCEDURES

All laboratory work was undertaken in the Laboratories of the Department of Laboratory Technology of the University of Cape Coast, Cape Coast, Ghana.

Inoculation: Swab from sampled surfaces were inoculated in 10ml of bacteriological peptone water by cutting the swabs aseptically into the peptone water, shaking and incubating them over-night at $37^{o}C$.

Quantification of Bacteria: Serial dilutions from the resulting growth from the peptone water medium were pour-plated on count agar (PCA) and incubated for 24hrs at $37^{o}C$ under aerobic condition. The number of estimated Colony Forming Units (CFU) for each sample was then counted using the Quebec colony counter (Reichert, USA).

I solation of Organisms: All pure isolated colonies were sub-cultured onto blood agar plates (for growth of heterotrophic bacteria) and MacConkey agar plates (for coliforms) for 24hrs at $37^{o}C$ for colony isolation and morphological identification.

Identification of Organisms:Pure isolated colonies were Gram differentiated and then biochemically identified using Indole, Catalase, Citrate, Oxidase, Coagulase, and Urease tests.

Antibiotic Susceptibility Test (AST): Antibiotic susceptibility were determined by agar diffusion technique on Mueller-Hinton agar (Kirby-Bauer NCCLS modified disc diffusion technique) using 8 antibiotics discs (Biotec Lab. UK) corresponding to drugs commonly used in the treatment of human and animal infections caused by bacterial; Gram negative antibiotics includes: Ampicillin (AMP) (10µg), Cefuroxime (CRX) (30µg), Cotrimoxazole (COT) (25µg), Cefotaxime (CTX) (30µg), Tetracycline (TET) (30µg), Amikacin (AMK) (30µg), Gentamicin (GEN) (10µg), and Chloramphenicol (CHL) (30µg) whilst Gram positive antibiotics includes: Ampicillin (AMP) (10µg), Cefixime (CXM) (30µg), Cloxacillin (CXC) (5µg), Cotrimoxazole (COT) (25µg), Tetracycline (TET) (30µg), Penicillin (PEN) (10µg), Gentamicin (GEN) (10µg), and Erythromycin (ERY) (15µg).

Statistical Analysis:Data obtained in the study were descriptively and statistically analyzed using Statview from SAS Version 5.0. The means were separated using double-tailed Paired Means Comparison. ($P \leq 0.05$) is significant and ($P \geq 0.05$) is not significant.

## RESULTS

A simple random technique was used to sample 100 keyboard and mice from offices and internet cafés by swabbing their surfaces. All samples were contaminated with bacteria showing greater than $10^5$ ($>10^5$) CFU by aerobic counting technique. Internet Cafés had higher counts than offices which were significant ($P \leq 0.05$) (Table I). Eight (8) different bacteria were isolated from the samples of which seven (7) were pathogenic and one Coagulase Negative Staphylococcus was non-pathogenic. Bacillus cereus was the highest isolate in both samples and sample areas whilst more P. mirabilis was the highest isolate in Internet cafés keyboard and K. pneumoniae office mice. The highest (85.71%) and the least (75.00%) pathogenic isolates were found in Internet café keyboards and mice respectively (Table II). For Gram Positive bacterial, B. cereus and S. aureus showed the highest susceptibility (37.5%) to the antibiotics applied (Table III). All Gram positive bacterial isolates showed 100% resistant to Ampicillin (AMP) (10µg), Cloxacillin (CXC) (5µg) and Penicillin (PEN) (10µg) but 100% susceptible to Gentamicin (GEN) (10µg) and Cotrimoxazole (COT) (25µg) respectively (Table IV). K. Pneumonia was the most resistant Gram negative isolate (75.0%), followed by P. mirabilis (65.0%) with E. coli the least (50.0%) (Table V). Gram negative bacterial isolates were 100% resistant to Ampicillin (AMP) (10µg) and Cefuroxime (CRX) (30µg) but 100% susceptible to Amikacin (AMK) (30µg) and Cotrimoxazole (COT) (25µg) (Table VI).

**Figure 1**

Table I. Descriptive Statistics of Aerobic Colony Count of Bacteria Contaminants on Keyboard and Mice in Offices and Internet Cafés

| | Keyboard | | Mice | |
|---|---|---|---|---|
| **Descriptive Statistics** | **Office** | **Internet Cafés** | **Office** | **Internet Cafés** |
| Number | 25 | 25 | 25 | 25 |
| Minimum | $2.80\times10^8$ | $3.90\times10^8$ | $3.40\times10^6$ | $8.40\times10^6$ |
| Maximum | $21.8\times10^8$ | $29.0\times10^8$ | $27.9\times10^6$ | $29.15\times10^6$ |
| Mean | $5.66\times10^8$ | $16.36\times10^8$ | $13.06\times10^6$ | $19.01\times10^6$ |
| S.D | $4.13\times10^8$ | $7.44\times10^8$ | $5.55\times10^6$ | $6.29\times10^6$ |
| *P*-value | 0.000 | | 0.001 | |

**Figure 2**

Table II. Types of Bacteria Isolates, Frequency of Isolation and their Pathogenicity

| | Offices | | Cafés | |
|---|---|---|---|---|
| **Bacteria Isolates** | **Keyboards (%)** | **Mice (%)** | **Keyboards (%)** | **Mice (%)** |
| **Pathogenic bacteria** | | | | |
| *B. cereus* | 21 (51.22%) | 19 (50%) | 16 (45.71%) | 14 (43.75%) |
| *E. coli* | 0 (0%) | 2 (5.26%) | 1 (2.86%) | 0 (0%) |
| *K. pneumoniae* | 2 (4.88%) | 6 (15.79%) | 3 (8.57%) | 0 (0%) |
| *P. mirabilis* | 3 (7.32%) | 2 (5.26%) | 6 (17.14%) | 4 (12.5%) |
| *S. aureus* | 0 (0%) | 0 (0%) | 2 (5.71%) | 4 (12.5%) |
| *S. pneumoniae* | 3 (7.32%) | 2 (5.26%) | 1 (2.86%) | 0 (0%) |
| *Enterococcus* spp. | 3 (7.32%) | 0 (0%) | 1(2.86%) | 2 (6.25%) |
| **Non-pathogenic bacteria** | | | | |
| *CNS | 9 (21.95%) | 7 (18.42%) | 5 (14.29%) | 8 (25.00%) |
| | | | | |
| **Total bacteria** | 41 | 38 | 35 | 32 |
| **Pathogenic bacteria** | 78.06% | 81.57% | 85.71% | 75.00% |
| **Non-pathogenic bacteria** | 21.95% | 18.42% | 14.29% | 25.00% |

*CNS = Coagulase Negative *Staphylococcus*

**Figure 3**

Table III. Antibiotic Susceptibility Pattern of Gram Positive Bacteria Isolates

| | Gram Positive Bacteria | | | | |
|---|---|---|---|---|---|
| **Antibiotics** | ***B. cereus*** | ***S. aureus*** | ***S. pneumoniae*** | ***Enterococcus* spp.** | **CNS** |
| Ampicillin **(AMP)** (10µg) | R | R | R | R | R |
| Cefixime **(CXM)** (30µg) | R | S | R | R | R |
| Cloxacillin **(CXC)** (5µg) | R | R | R | R | R |
| Cotrimoxazole **(COT)** (25µg) | I | S | S | S | S |
| Tetracycline **(TET)** (30µg) | S | R | I | I | I |
| Penicillin **(PEN)** (10µg) | R | R | R | R | R |
| Gentamicin **(GEN)** (10µg) | S | S | S | S | S |
| Erythromycin **(ERY)** (15µg) | S | I | R | R | R |
| | | | | | |
| **Susceptible (S)*** | 37.5% | 37.5% | 25.0% | 25.0% | 25.0% |
| **Intermediate(I)**** | 12.5% | 12.5% | 12.5% | 12.5% | 12.5% |
| **Resistant (R)***** | 50.0% | 50.0% | 62.5% | 62.5% | 62.5% |

*S = effective therapy when administered; **I = therapy may fail at normal concentration but will be effective at higher concentration. ***R = therapy will not be effective when administered.

**Figure 4**

Table IV. Gram Positive Antibiotic Activity on Gram Positive Bacteria Isolates

| | Gram Positive Antibiotics | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Gram Positive Bacteria** | **AMP** | **CXM** | **CXC** | **COT** | **TET** | **PEN** | **GEN** | **ERY** |
| *B. cereus* | R | R | R | I | S | R | S | S |
| *S. aureus* | R | S | R | S | R | R | S | I |
| *S. pneumoniae* | R | R | R | S | I | R | S | R |
| *Enterococcus* spp | R | R | R | S | I | R | S | R |
| CNS | R | R | R | S | I | R | S | R |
| **Susceptible** | 0% | 20% | 0% | 80% | 20% | 0% | 100% | 20% |
| **Intermediate** | 0% | 0% | 0% | 20% | 60% | 0% | 0% | 20% |
| **Resistant** | 100% | 80% | 100% | 0% | 20% | 100% | 0% | 60% |

**Figure 5**

Table V. Antibiotic Susceptibility Pattern of Gram Negative Bacteria Isolates

| | Gram Negative Bacteria | | |
|---|---|---|---|
| **Antibiotics** | *E. coli* | *K. pneumoniae* | *P. mirabilis* |
| Ampicillin **(AMP)** (10µg) | R | R | R |
| Cefuroxime **(CRX)** (30µg) | R | R | R |
| Cefotaxime **(CTX)** (30µg) | R | R | I |
| Cotrimoxazole **(COT)** (25µg) | S | S | S |
| Tetracycline **(TET)** (30µg) | I | R | R |
| Chloramphenicol **(CHL)** (30µg) | S | R | R |
| Gentamicin **(GEN)** (10µg) | S | R | R |
| Amikacin **(AMK)** (30µg) | S | S | S |
| | | | |
| **Susceptible (S)*** | 50.0% | 25.0% | 25.0% |
| **Intermediate(I)**** | 12.5% | 0.0% | 12.5% |
| **Resistant (R)***** | 37.5% | 75.0% | 62.5% |

**Figure 6**

Table VI. Gram Negative Antibiotic Activity on Gram Negative Bacteria Isolates

| Gram Negative Bacteria | Gram Negative Antibiotics | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | AMP | CRX | CTX | COT | TET | CHL | GEN | AMK |
| *E. coli* | R | R | R | S | I | S | S | S |
| *K. pneumoniae* | R | R | R | S | R | R | R | S |
| *P. mirabilis* | R | R | I | S | R | R | R | S |
| **Susceptible** | 0% | 0% | 0% | 100% | 0% | 33.33% | 33.33% | 100% |
| **Intermediate** | 0% | 0% | 33.33% | 0% | 33.33% | 0% | 0% | 0% |
| **Resistant** | 100% | 100% | 66.67% | 0% | 66.67% | 66.67% | 66.67% | 0% |

## DISCUSSIONS

Computers continue to have an increased presence in almost every aspect of our occupational, recreational, and residential environments[1] whilst the contribution of hands contaminated with pathogenic and non-pathogenic microorganisms to the spread of infectious disease has been recognized for many years.[12,6] Results from the study shows high levels of contamination of these surfaces with the least mean bacterial count of $5.66\times10^8$ CFU. This confirms work by[11] who found between 99%-100% contamination on computer keyboard and mice in a research centre. Depending on environmental conditions, pathogens may remain infectious on surfaces for weeks after the contamination event. In humid conditions, pathogens may actively colonize surfaces, transforming a passive reservoir into an active one. Furthermore, formation of biofilm by one bacterial agent can affect the survival of other pathogens on the same surface.[13] In general, the greater the concentration of the microbe, the longer it survives and survival can range from minutes to months. The longer the survival of a bacterium on a surface like the keyboard or mouse, then the odds of that bacterium being picked up by someone becomes considerably increased.[14-15] Contamination of these surfaces are aided by personal hygiene and lifestyle of users of these equipments. Thus keyboard and mice in internet cafés were more contaminated than that of offices which was significant (P=0.000) and (P=0.001) respectively. This could be attributed to frequency and number of users in internet cafés compared with that of offices as well as selling and eating of food whilst using the computer. A total of 8 bacterial isolates were obtained from the samples of which Gram positive bacteria makes up 62.5%. This confirms research which suggests that "Gram-positive bacteria are transmitted most readily from environmental surfaces followed by viruses and Gram negative bacteria.[16] A five-year study of surfaces in the office environment which are usually cleaned found 11% to be positive for biochemical markers (such as those for blood, mucus, saliva, sweat, and urine).[17] Thus for surfaces of keyboard and mice which are frequently ignored yet receive a lot of traffic, one will expect greater levels of contamination. Pathogenic isolates (80.14%) were 4x greater than non-pathogenic isolates (19.86%) confirming research undertaken in a city college that found 70.8% of used computer keyboards to be contaminated with antibiotic-resistant staphylococci.[18] This is a cause for concern since these pathogenic isolates are capable of causing diseases in anyone who gets contaminated whilst using the keyboard or mice. Research has shown that 80% of infections are transmitted through the environment. The high isolation of Bacillus cereus confirms the ubiquitous nature of the Bacillus spp. giving it greater colonization ability as well as the ability of its spores to resist environmental changes, withstand dry heat and certain chemical disinfectants for moderate periods.[19] The presence of E. coli and Enterococcus spp. suggests faecal contamination of these surfaces which can result in community-acquired infections and disease outbreaks.

Susceptibility of isolates ranges from a least of 25% to a high of 50% indicating that most of the antibiotics used were ineffective. S. pneumonia, Enterococcus spp. and CNS showed 62.5% resistant to the antibiotics whilst E. coli (50%), K. Pneumonia and P. mirabilis showed 25% susceptibility each. This was similar to research undertaken on bacterial isolates in sachet water sold in the streets of Cape Coast.[20] Thus the well documented habit of eating whilst working on the computer could be the major route of contamination of these surfaces by these bacteria. Resistances (100%) of isolates to Ampicillin, Cloxacillin, Penicillin and Cefuroxime commonly used antibiotics has been observed in previous studies presenting a public health problem.[20-21] Overall, Cotrimoxazole was the most effective antibiotic 80% and 100% in Gram positive and negative organisms respectively. Gentamicin was 100% effective in Gram positive organism but 33.3% effective in Gram negative organisms. Amikacin was 100% effective in Gram negative organisms. A study in Cape Coast on antibiotic use showed that 66.9% of the populace sampled purchases antibiotics in the open market without any prescription.[22]

Surfaces of keyboard and mice in any environment can be a potential source of transmission of pathogenic organisms leading to diseases. This is more so due to the fact that these are sometimes shared facilities and can lead to community-acquired infections with possible public health implications. Further studies should sample hands of users of these keyboards and mice after to determine the level of contamination picked up from using them. Hand-washing should be encouraged

## ACKNOWLEDGEMENT

The authors express gratitude to all the Departmental offices and Internet Cafés in the University of Cape Coast and surrounding communities that consented to sampling as well as Research and Teaching Assistants at the Laboratories of the Department of Laboratory Technology, University of Cape Coast.

### References

1. Palmer, S. R. and Bray, S. L., (2001), "Longitudinal study of computer usage in flexible engineering education," Australia Journal of Educational Technology, 17:313.
2. Mishra, U., "Inventions on Computer Keyboard a TRIZ based analysis", http://www.creax.com; assessed on 14/07/2011.
3. Wikipedia, (2011), "Opportunistic infection", http://en.wikipedia.org/wiki/Opportunistic_infection assessed on 14/07/2011.
4. Lam, V., Chia-Wei Chou, Aquino, E., and Han, Y., "Computer Keyboard", http://microbewiki.kenyon.edu/index.php/Computer_Keyboard; assessed on 09/07/2011
5. Thibodeau, P., "Is Your Keyboard a Health Hazard? Here's Help, in Computerworld", 2007.
6. Rutala, W. A., White, M. S., Gergen M. F., and Weber, D. J. (2006), "Bacterial contamination of keyboards: efficacy and functional impact of disinfectants", Infection Control and Hospital Epidemiology Journal, 27(4):372-377.
7. http://www.globalspec.com/Supplier/Profile/EsterlineInterfaceTechnologies Assessed on 06/06/2011.
8. Hilton, A. and Armstrong, R. A., (2007), "The one-way analysis of variance (random effects model): The 'nested' or 'hierarchical' design", Microbiologist Vol. 5: No. 4, pp 40-41.
9. Eguia, J.M. and Chambers, H.F., (2003), "Community-acquired methicillin-resistant Staphylococcus aureus: Epidemiology and potential virulence factors". Curr. Infect. Dis. Rep., 5: 459-466.
10. Hidron, A.L., Kourbatova, E.V., Halvosa, J., Terrell, B.J., McDougal, L.K. and Tenover, F.C. (2005). "Risk factors for colonization with methicillin- resistant Staphylococcus areus (MRSA) in patients admitted to on urban hospital; emergence of community-associated MRSA nasal carriage", Clin. Infect. Dis., 41: 159-166.
11. Eltablawy, S.Y. and Elhifnawi, H.N., (2009), "Microbial Contamination of Some Computer Keyboards and Mice in National Center for Radiation Research and Technology (NCRRT)", World Applied Sciences Journal 6 (2): 162-167.
12. Anderson, G. and Palombo, E. A., (2009), "Microbial contamination of computer keyboards in University Setting", American Journal of Infection Control, Vol. 37, No. 6: 507-509.
13. Hassan A.N., Birt, D.M., and Frank J.F., (2004), "Behavior of Listeria monocytogenes in a Pseudomonas putida biofilm on a condensate-forming surface", J Food Prot. 2004 Feb; 67(2):322-7.
14. Neely, A. N. and Orloff, M. M., (2001), "Survival of some medically important fungi on hospital fabrics and plastics", Journal of Clinical Microbiology, 2001(39): 3360–1.
15. Neely, A. N. and Sittig, D. F., (2002), "Basic Microbiologic and Infection Control Information to Reduce the Potential Transmission of Pathogens to Patients via Computer Hardware", JAMIA, 2002 (9): 500-508.
16. Ellis, K., (2006), "Fomites and Infection Transmission", http://www.infectioncontroltoday.com/articles/2006/11/fomites-and-infection-transmission.aspx assessed on 23/04/2011.
17. Reynolds, K. A., P. Watts, S. A. Boone, and C. P. Gerba. 2005. Occurrence of bacteria and biochemical biomarkers on public surfaces. Int. J. Environ. Health Res. 15:225-234.
18. Kassem, I. K., Sigler, V., and Esseili, M. A., (2007), "Public computer surfaces are reservoirs for methicillin-resistant Staphylococci", The ISME Journal (2007) 1: 265–268.
19. Brooks GF, Carrol KC, Butel JS, Morse SA. Jawetz, Melnick, and Adelberg's Medical Microbiology, 24th Ed. McGrawHill, 2007; USA.
20. Tagoe, D.N.A; Nyarko, H; Arthur, S.A; & Birikorang, E. A study of antibiotic susceptibility pattern of bacteria isolates in sachet drinking water sold in the cape coast metropolis of Ghana. Res. J. Microbiol. 2011; (6): 453-458.
21. Khan, R.M.K and Malik, A. Antibiotic resistance and detection of â-lactamase in bacterial strains of Staphylococci and Escherichia coli isolated from foodstuffs. World J. Microbiol. Biotechnol. 2001; 17:863-868
22. Tagoe, D. & Attah, C. A Study of Antibiotic Use and Abuse in Ghana: a case study of the Cape Coast Metropolis. The Internet Journal of Health 2010; Volume 11 Number 2

### Author Information

**D. N. A. Tagoe**
Department of Laboratory Technology, University of Cape Coast

**F Kumi – Ansah**
Department of Laboratory Technology, University of Cape Coast