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Computer Keyboards And Mice: As Reservoirs For Bacteria Pathogens

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Abstract: *Improvement in science and technology brings about massive utilization of computers which help to reduce difficulties in organizations. This study explored the antibacterial resistance pattern of bacteria isolated from the keyboards and mice by single and multiple users at the Southern Delta University, Ozoro. A total of 157 samples comprising of 136 multiple users and 21 single users. Eight (8) bacteria genera were isolated from samples and they include Pseudomonas aeruginosa, Staphylococcus aureus, Bacillus species, Escherichia coli, Salmonella typhi, Morganella morganii, Streptococcus species and Citrobacter freundii. The study also revealed that Staphylococcus aureus has the highest prevalence of occurrence from multiple users 58(32.2%) followed by Bacillus species 41(22.8%) while the least was Citrobacter freundii 4(2.2%). The occurrence of these pathogenic bacteria on the surfaces of the keyboards and mice, resulting to reservoirs and sources of cross-contamination of pathogenic bacterial infections among the students and the university community. Almost all the bacteria isolates obtained in this study were noted to present a resistant population of 74% and above to the antibiotics tested except for Streptococcus species that was 13%, 17%, 46% and 50% for penicillin, ampicillin, cefazolin, and cefuroxime respectively. This shows that most of these bacteria are highly resistant to the commonly used antibiotics and this implies a public health risk. Hence, proper cleaning, personal hygiene should be adopted before and after using the computers to reduce microbial transmission. Also the keyboards and mice should be properly covered to prevent dust from settling on the computer surfaces.*

KEYWORDS: Computer, Keyboards, Mice, Multiple users, Single users, Reservoirs, Bacteria isolates, and antibiotics.

INTRODUCTION

Computers are electronic systems that receives raw data as input, process the data through some algorithms and return a meaningful result(s) known as output. The computer keyboards and mice are common devices used by millions of people all over the World. Computer keyboards are input device use to send alphanumeric data and commands to the computer. They are used for typing (inputs letters, numbers and symbols), shortcut commands (uses key combination eg., Ctrl + C for copy), navigation (uses arrow keys, Home, End, Page up and Page down to move through documents), control keys like Ctrl, Alt, Shift, and Windows key to execute special commands. It also uses the function keys (F1 - F12) to perform specific tasks like F1 for opening help or F5 for refreshing a page. The computer mice on the other hand, are input device used to control the computer graphical user interface. Its use to control the mice pointer, click and drag items around the screen. They are employed for pointing and selecting (moves the cursor and selects icons, files and text), clicking (opens files, programs, and performs actions), right-clicking (accesses context menus for additional options), dragging and dropping (moves files or objects by clicking and holding). The mice can also be used for scrolling in other to navigate through pages or zoom in and out. The keyboards and mice of computers are commonly used in different settings, like religious places of worship, schools, government offices, healthcare centres, homes and private offices. Regardless of their use worldwide, they have shown to act as reservoirs for microorganisms like bacteria, fungi and viruses. According to Ali (2024), Computers have become an inherent part of human daily life, both in homes, offices and with the increasing use of these devices, the users' health and safety faces new health challenges.

Microorganisms being ubiquitous in nature can survive almost in all the environments. Though some groups of microorganisms can thrive or tolerate a broad range of environmental conditions and are said to be more likely to be ubiquitous. Microbes such as bacteria, fungi, viruses can be found on fomites (inanimate objects), different parts of human bodies, animals, plants, water, soil, ice, air, and even in thermal vents. Bacteria can thrive in small surface cracks, allowing them to survive unnoticed. Bacteria isolates were isolated from daily used gadgets like computer, door handles, microphones, money, mobile phones, stethoscopes, faucets, fabrics and plastics (Oluduro *et al.*, 2011; Malik and Naeem, 2014; Chandra *et al.*, 2014; Jack *et al.*, 2024). Computers are increasingly integrated into all areas of life, including home, work, and leisure and if the popularity of such facilities increases, there is a need to recognize that computer equipment may act as a potential reservoir for the dispatch of potentially hazardous or pathogenic microorganisms (Glenn and Enzo, 2009; Agersew *et al.*, 2015). The role of computers as fomites has been documented in hospital and health care environments and the bacterial contamination of the computer keyboards nowadays have got special recognition in various parts of the world (Hubar and Pelon, 2005; Rutala *et al.*, 2006; Opere *et al.*, 2020).

Computer keyboards and mice are among the most often touched surfaces and can become breeding grounds for microorganisms (Ali, 2024). Frequent contact of the keyboarda and mice by single or multiple users can lead to the accumulation of microorganisms, which poses potential health risk to the users. The increasing availability of computers by single or multiple users means that these devices are used by many on daily basis in schools, private and government offices. Due to the lack of regular disinfection of keyboards and mice, they tend to act as reservoirs and means of transmitting microorganisms. Hence, this study explored the antibacterial resistance pattern of bacteria isolated from keyboards and mice by single and multiple users at the Southern Delta University, Ozoro, Nigeria.

MATERIALS AND METHODS

Description of Study Area

This research was conducted in Southern Delta University, Ozoro, situated in Isoko North Local Government Area of Delta State, Nigeria. The university is located in the Niger Delta region, along the high-way between Ughelli and Kwale town and approximately 115 kilometers northwest of the state capital (Asaba). The university is located at a latitude of 5.5562^{o} N and longitude of 6.2472^{o}E. Southern Delta University, Ozoro was formally called Delta State University of Science and Technology, Ozoro and was established in the year 2021 from the defunct Delta State Polytechnic Ozoro.

Collection of Samples

Sterile cotton swab sticks were used to carefully collect samples from the surfaces of the computer keyboards and mice from the three sample sites (Southern Delta University, Ozoro Computer Based Test (CBT) Centre, Computer Science Department Demonstration Laboratory and Staff Personal Laptops) within the institution as depicted in Table 1. Before the samples were collected, both the swab sticks and sterile media were appropriately labelled to ensure the accurate identification of samples. In other to avoid contamination, the keyboards and mice were swabbed with sterile cotton swabs to collect samples before cleaning with alcohol and a damp sterile cloth. To maintain sample integrity during transportation, both the swab sticks and sterile media were carefully placed on an ice pack medium before being transported to the laboratory for microbiological analysis.

Table 1: Study Areas, Types of users and Number of Samples Collected

Code	Study Area	Type of Users	Number of Samples Collected
A	Southern Delta University, Ozoro CBT Centre	Multiple users (MU)	97
B	Computer Science Department Demonstration Laboratory	Multiple users (MU)	39
C	Staff Personal Laptops	Single users (SU)	21
Total			**157**

Bacteria Cultivation and Identification

After the incubation, the samples were vortexed for one minute and cultured onto MacConkey agar, Blood agar, Mannitol salt agar, Salmonella-Shigella agar, Pseudomonas agar media and then incubated for 24 hours at 37°C as described by Atlas, 2010; Agersew *et al.,* 2015; Ali, 2024. The preliminary identification of the pure cultures of isolates was achieved according to their colonial, morphological characteristics, Gram-staining reaction and subjected to nine (9) biochemical tests in accordance with standard procedures. These biochemical tests include: motility, oxidase, citrate, indole, coagulase, urease, catalase, H_2S production and methyl red tests. Isolates were then identified by combination of colonial, morphological characteristics, Gram reaction and standard biochemical tests as described by Hamzeh and Na'was, 2015; Opere *et al.*, 2020.

Ethical Clearance

The Ethical clearance was obtained from the Heads of the CBT centre and the Computer Science Department Demonstration Laboratory of the Southern Delta University, Ozoro. Consent was sought and obtained verbally from the individual owners of the laptops who are staff of the institution, and with the letter of introduction from the Department of Microbiology, Southern Delta University, Ozoro.

Antibiotic Sensitivity Testing

The inocula used in this research were prepared from each of the bacterial isolates and was done by adjusting the turbidity to 0.5 McFarland standard and were then spread on plates containing Muller Hinton agar. The antibiotic sensitivity of the bacterial isolates was analyzed based on the Clinical and Laboratory Standards Institution (2007) guidelines. The antibiotic sensitivity discs of commonly used antibiotics which includes Gentamicin (10 µg), Ciprofloxacin (5 µg), Amoxicillin (10 µg), Ampicillin (10 µg), Imipenem (10 µg), Vancomycin (30 µg), Cefazolin (30 µg), Cefuroxime (30 µg), Linezolid (30 µg), and Penicillin (10 µg). The plates were allowed to stabilized and incubated at 37^0C for 24 hours. The inhibition zones of the various antibiotics were measured in millimeter (mm) and the isolates were grouped as Resistant (R), Intermediate (I) and Sensitive (S) as outlined by CLSI, 2007.

Data Analysis

Descriptive statistics such as frequency (%) and mean was Calculated using Microsoft Excel 2010 software.

RESULTS AND DISCUSSION

Results

Table 2: Morphological and biochemical tests for the bacteria isolated from computer keyboards and mice

Cell Morphology	Cell Arrangement	Gram Reaction	Motility	Oxidase	Citrate	Indole	Coagulase	Urease	Catalase	H_2S Production	Methyl Red (MR)	Probable Organisms
Rod	Single	-	+	+	+	-	-	-	+	-	-	*Pseudomonas aeruginosa*
Rod	Chain	+	+	+	+	-	-	-	+	-	-	*Bacillus* species
Rod	Pair	-	+	-	-	-	-	-	+	+	+	*Salmonella typhi*
Rod	Single	-	+	-	-	+	-	-	+	-	+	*Escherichia coli*
Cocci	Cluster	+	-	-	-	-	+	-	+	-	+	*Staphylococcus aureus*
Rod	Single	-	+	-	-	+	-	+	+	-	+	*Morganella morganii*

Cocci	Chain	+	-	-	-	-	-	-	-	-	+	*Streptococcus* species
Rod	Single	-	+	-	+	-	-	-	+	+	+	*Citrobacter freundii*

Table 3: Distribution of Bacteria isolated from the study Areas

	Prevalence of Bacteria isolates from the Sample sources (sites)				
Bacteria Isolates	A (%)	B (%)	A+B(%)	C (%)	Total (%)
Escherichia coli	13(12.3)	12(16.2)	25(13.9)	3(7.9)	28(12.8)
Staphylococcus aureus	37(34.9)	21(28.4)	58(32.2)	10(26.3)	68(31.2)
Citrobacter freundii	3(2.8)	1(1.4)	4(2.2)	0(0.0)	4(1.8)
Pseudomonas aeruginosa	8(7.5)	4(5.4)	12(6.7)	6(15.8)	18(8.3)
Streptococcus species	9(8.5)	6(8.1)	15(8.3)	9(23.7)	24(11.0)
Salmonella typhi	10(9.4)	9(12.2)	19(10.6)	1(2.6)	20(9.2)
Bacillus species	22(20.8)	19(25.7)	41(22.8)	9(23.7)	50(22.9)
Morganella morganii	4(3.8)	2(2.7)	6(3.3)	0(0.0)	6(2.8)
Total	106(100)	74(100)	180(100)	38(100)	218(100)

Key:

A = Southern Delta University, Ozoro, CBT Centre

B = Computer Science Department Demonstration Laboratory.

A+B = Multiple Users (MU)

C = Staff Personal Laptops (Single Users (SU))

Table 4: Prevalence of Gram-Positive and Gram-Negative Bacteria from the different Sampling sites within the Southern Delta University, Ozoro

	Prevalence of Bacteria isolates from the Sample sources (sites) based on Gram Reaction			
Bacteria Isolates	A (%)	B (%)	C (%)	Total (%)
Gram-Positive Bacteria (GPB)				
Staphylococcus aureus	37(34.9)	21(28.4)	10(26.3)	68(31.2)
Streptococcus species	9(8.5)	6(8.1)	9(23.7)	24(11.0)
Bacillus species	22(20.8)	19(25.7)	9(23.7)	50(22.9)
Total for GPB	**68(64.2)**	**46(62.2)**	**28(73.7)**	**142(65.1)**
Gram-Negative Bacteria (GNB)				
Escherichia coli	13(12.3)	12(16.2)	3(7.9)	28(12.8)
Citrobacter freundii	3(2.8)	1(1.4)	0(0.0)	4(1.8)
Pseudomonas aeruginosa	8(7.5)	4(5.4)	6(15.8)	18(8.3)
Salmonella typhi	10(9.4)	9(12.2)	1(2.6)	20(9.2)
Morganella morganii	4(3.8)	2(2.7)	0(0.0)	6(2.8)
Total for GNB	**38(35.8)**	**28(37.9)**	**10(26.3)**	**76(34.9)**

Table 5: Antibacterial Resistance patterns of Gram-Positive and Negative Bacteria Isolates from Southern Delta University, Ozoro

	Bacteria Isolates							
Antibiotics	*Staphylococcus aureus* (N= 68) n (%)	*Streptococcus* species (N= 24) n (%)	*Bacillus* species (N= 50) n (%)	*Escherichia coli* (N= 28) n (%)	*Citrobacter freundii* (N= 4) n (%)	*Pseudomonas aeruginosa* (N= 18) n (%)	*Salmonella typhi* (N= 20) n (%)	*Morganella morganii* (N= 6) n (%)
GEN	13(19)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)
CIP	6(9)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)
AMO	62(91)	0(0)	31(62)	19(68)	0(0)	13(72)	17(85)	6(100)
AMP	58(85)	4(17)	43(86)	26(93)	4(100)	14(78)	20(100)	6(100)
IMI	16(24)	0(0)	0(0)	0(0)	0(0)	3(17)	6(30)	0(0)
VAN	3(4)	0(0)	0(0)	0(0)	0(0)	1(6)	4(20)	5(83)
CEFA	50(74)	11(46)	47(94)	26(93)	4(100)	18(100)	19(95)	6(100)
CEFU	52(76)	12(50)	44(88)	24(86)	4(100)	16(89)	19(95)	6(100)
LIN	7(10)	0(0)	0(0)	7(25)	0(0)	4(22)	6(30)	5(83)
PEN	65(96)	3(13)	41(82)	27(96)	4(100)	14(78)	20(100)	6(100)

KEY: GEN (Gentamicin), CIP (Ciprofloxacin), AMO (Amoxicillin), AMP (Ampicillin), IMI (Imipenem), VAN (Vancomycin), CEFA (Cefazolin), CEFU (Cefuroxime), LIN (Linezolid), PEN (Penicillin).

Discussion

Bacteria contamination of campus computer keyboards and mice could serve as potential source for community acquired infections. As reported by Li *et al.,* 2009, fomites are majorly the source for spreading community acquired infections. Fomites play a significant role in spreading infectious diseases when frequently touched by humans or exposed to pathogens (Osterhoim *et al.,* 1995). Many bacteria have been detected on computer keyboards and mice across the globe, including in industrialized nations (Agersew *et al.,* 2015). Out of 157 samples examined, bacterial growth was observed in all the samples (100%) collected from the keyboards and mice from the CBT center, Computer Science department demonstration laboratory and staff personal laptops, Southern Delta University, Ozoro. Eight (8) bacteria genera were isolated from samples and they include *Pseudomonas aeruginosa, Staphylococcus aureus*, *Bacillus* species, *Escherichia coli, Salmonella typhi, Morganella morganii, Streptococcus* species and *Citrobacter freundii* as depicted in Table 2. This study, corresponds with the previous reports of Ali *et al.,* 2013; Malik and Naeem, 2014; Opere *et al.,* 2020; Jack *et al.,* 2024; Ali, 2024 who isolated similar organisms with little variation. This study may be the first work to report the isolation of *Morganella morganii* from keyboards and mice of computers, as there was none known to the authors. Bacteria pathogens that are capable of surviving for a long duration and resist disinfection are commonly associated with keyboards and mice of computers (Kramer *et al.,* 2006). According to Orogu *et al.,* 2018, the presence of these pathogenic organisms re-occurring in their study considering that these organisms cause disease and infection to students and staff on campus. They stated that to protect public health on campus, it is therefore, important to highlight the need for, effective disinfection to minimize bacterial and fungal contamination on campus.

A total of 218 bacteria were isolated from the three sample sites which comprise of 106 bacterial isolates from site A (Southern Delta University, Ozoro CBT centre), 74 isolates from site B (Computer Science department demonstration laboratory) and 38 isolates from site C (Staff personal laptops). The result, shows that keyboards and mice of the computers were heavily contaminated with bacteria pathogens. The contamination rate was higher in the CBT center followed by the Computer Science department demonstration laboratory while the least was from staff personal laptops. This implies that the level of contamination in multiple users (MU) is higher than the single users (SU) as presented in Table 3. This may be due to the health conditions and level of personal hygiene of the multiple users who are majorly students. According to Enemuor *et al.,* 2012, it is likely that most of them are sick, and this can introduce new bacteria that will eventually settle on the computer keyboards and mice through droplets or physical contact. Hence, making the keyboards and mice of the computer potential reservoirs for bacteria pathogens. The contamination of keyboards and mice may also be as a result of poor personal hygiene like coughing, sneezing, or digging nose by the multiple and single users of computer. The hygiene practices in computer environments are inadequate, suggesting that users may be unaware of the health risks of computer surfaces harboring potential pathogens and these surfaces could act as fomites of potential pathogens (Muhammad *et al.,* 2016).

Similarly, several studies like Anderson and Palombo, 2009; Enemuor *et al.,* 2012; Ali *et al.,* 2013; Malik & Naeem, 2014; Hamzeh & Na'was, 2015; Agersew *et al.,* 2015; Muhammad *et al.,* 2016; Opere *et al.,* 2020; Jack *et al.,* 2024 have reported the isolation of bacteria from higher education settings. The occurrence of these pathogenic bacteria on the surfaces of keyboards and mice, resulting to reservoirs and sources of cross-contamination of pathogenic microbial infections among the students and the university community. The total prevalence of Gram-positive bacteria (GPB) isolated from computer keyboards and mice was 142(65.1%) while the Gram-negative bacteria (GNB) was 76(34.9). This indicates that the population of GPB is higher than that of the GNB. This may be as a result of their frequent association with human skin, hence can easily contaminate surfaces by touching. As such, the keyboards and mice of the computers can serve as reservoirs for GPB as they are frequently touched. This is in accordance with report of Agersew *et al.,* 2015 who stated that, from the total bacteria isolated, 208(60.5%) were GPB and 136(39.5%) for GNB. Similarly, Srikanth *et al.,* 2012 from India reported 75% and 25% for GPA and GNB respectively. *Staphylococcus aureus* as a GPB has the highest prevalence of 68(31.2%) followed by *Bacillus* species 50(22.9%) while for the GNB *Escherichia coli* was 28(12.8%). This is in line with the earlier findings of Ali *et al.,* 2013; Muhammad *et al.,* 2016; Opere *et al.,* 2020; Ali, 2024; Jack *et al.,* 2024.

This study also revealed that higher number of *Staphylococcus aureus* was isolated from multiple users 58(32.2%) than the single users 10(26.3%). This is in agreement with the findings of Anderson and Palombo (2009); Messina *et al.,* 2011 who in their studies carried out in Australia and Italy respectively, reported that *Staphylococcus aureus* was more commonly isolated from multiple-user keyboards than single user keyboards. *Staphylococcus aureus* is commonly found on the human skin and nasal passages, where it can exist harmlessly, but also has the potential to cause a range of diseases. The front part of the nasal passages is a typical habitat for *Staphylococcus aureus,* with approximately 25-33% of healthy individuals intermittently carrying it in their nasal passages (Ali, 2024). Hence this bacterium can easily be transferred to the hands by frequent touching of the noses.

In this present study, *Bacillus* species has the second highest percentage of occurrence of 50(22.9%) representing 41(22.8%), 9(23.7%) for MU and SU respectively. The isolation of *Bacillus* species from keyboards and mice from a university setting is an indication of its ubiquitous nature and possession of resistant spores. The contamination of *Streptococcus* species, with a prevalence of 24(11%) accounting for MU 15(8.3%) and SU 9(23.7%), with a higher contamination rate found in MU of computer keyboards and mice. This is an indication that the possible route of contamination of *Streptococcus* species is through the mouth, as they are usually found in the oral cavity. This implies the high risk of transferring pathogens via mouths to the computer keyboards and mice to hands of other individuals, particularly multiple users such as in university settings. The presence of Gram-negative bacteria *Escherichia coli* and *Salmonella typhi*, is an indication of fecal contamination as a result of poor practices of personal hygiene and this can result to urinary tract infection, diarrhoea and Salmonellosis respectively. The enteric bacteria like *E. coli, Salmonella typhi, Citrobacter freundii* and *Morganella morganii* isolated in this study are ubiquitous microorganisms which can cause several diseases. According to Itah & Ben, 2004, these organisms can be shed from the body, clothing, beddings, nostrils and carried in the dust particles to other surfaces, hence their presence on the keyboards and mice. *Morganella morganii* is capable of causing urinary tract infections and other opportunistic infections.

Almost all the bacteria isolates obtained in this present study were noted to present a resistant population of 74% and above to the antibiotics tested except for *Streptococcus* species that was 13%, 17%, 46% and 50% for penicillin, ampicillin, cefazolin, and cefuroxime respectively. This shows that most of these bacteria are highly resistant to the commonly used antibiotics. This high resistance to the tested antibiotics by the bacteria isolates is suggestive of a public health risk as these commonly used antibiotics are usually administered for the treatment of common bacterial infections, thereby making computer keyboards and mice in university settings as significant sites for the acquisition of antibiotic resistant strains. This high resistance to the commonly used antibiotics has been reported by previous studies like Khan and Malik (2001); Tagoe and Kumi-Ansah (2011); Agersew *et al.,* 2015. According to DubMendal, 2005, the misuse, overuse and possession of drug resistance plasmids has resulted to drug resistance of bacteria to antibiotics. All the bacteria isolated in this present study were susceptible at 0% to all the tested antibiotics except *S. aureus* that was 19% and 9% resistant to gentamicin and ciprofloxacin respectively. Also, the study revealed that *S. aureus* was resistant to all the antibiotics at varying range of 96% to 4% resistant.

CONCLUSION

The high rate of bacterial contamination on the computer keyboards and mice was demonstrated in all samples examined. In this study, the bacteria isolated from the computer keyboards and mice are both pathogenic and opportunistic bacteria. Eight (8) bacteria genera that was isolated include *Staphylococcus aureus, Escherichia coli, Streptococcus* species, *Salmonella typhi, Morganella morganii, Pseudomonas aeruginosa, Bacillus* species and *Citrobacter freundii* are the frequently occurring bacteria in our environment, making it unhealthy and also spread a number of diseases. This shows that most of these bacteria are highly resistant to the commonly used antibiotics. This high resistance to the tested antibiotics by the bacteria isolates is suggestive of a public health risk as these commonly used antibiotics are usually administered for the treatment of common bacterial infections. Microbes are everywhere, hence it is therefore recommended that proper cleaning and personal hygiene like hand washing should be adopted before and after using the computers to reduces the microbial transmission. Also the computer keyboards and mice should be properly covered to prevent dust from settling on the computer surfaces.

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CONFLICT OF INTEREST

None

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