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# Bacterial Profile and Their Antimicrobial Susceptibility Patterns of Computer Keyboards and Mice at Gondar University Hospital, Northwest Ethiopia

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**Abstract** **Background**: The microorganisms can found in every environment and pathogenic bacteria pose serious health problems. Computer keyboards and mice have been documented as an environmental object or fomites serving as sources of microorganisms particularly in the hospital setting. According to some reports, due to the application of the computer in the hospital environment, cross contamination of microorganism from healthcare provider to the patient is common. **Objective**: the aim of this study was to assess bacterial isolates and their drug susceptibility patterns from computer keyboards and mouse from Gondar University Hospital, Northwest Ethiopia. **Methodology**: A cross sectional study was conducted in Gondar University Hospital from April 30 to June 30/ 2013. Samples were collected from computers located in Gondar University Hospital by using sterile cotton swaps. Then the collected samples were inoculated on BAP, CAP and MAC media. The bacterial isolates were examined and identified by colonial morphology, Gram reaction and biochemical characteristics. Antibiotic susceptibility test was done by disc diffusion method. Data analysis was done by using SPSS version 20 and P – values less than 0.05 were considered statistically significant. **Result**: Growth was seen in all samples. From the total bacterial isolates, 208 (60.5%) were Gram positive bacteria and 136 (39.5%) were Gram negative bacteria. The isolates included Coagulase negative staphylococcus (CoNs), Bacillus spp. and *Staphylococcus aureus*. *Providential* spp., *Citrobacter spp*. *Enterobacter spp, E.coli, Acenitobacter spp, Seratia spp P. aeruginosa,* and *Proteus spp*. It is very dreadful to observe that some of these bacteria are highly resistant to the commonly used antibiotics. Moreover, multidrug resistance was observed. **Conclusion:** Isolation of bacteria from "high-touch" surfaces such as computer keyboardsa and mice is indicative of the need for awareness on cleaning of such surfaces or disinfection and adequate hand hygiene. These bacteria identified have pathogenic potential and hence their presence on computer surfaces may be additional reservoirs for the transmission of microorganisms and become vectors for cross-transmission of bacterial infections in the hospitals/health care setting and its surroundings.

***Keywords:*** *computer keyboard, mice, bacterial profile, antimicrobial resistant, Ethiopia*

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## 1. Introduction

Bacterial pathogens are colonized on human host and inanimate objects but most people do not realize that microbes are found on many common objects in the outdoors, in their offices, and even in their homes [1]. The common objects include; keyboards, kitchen sinks, office desks, computer keyboards, computer mice, and elevator buttons. A persons who contact with these inanimate objects in the working place, persons harbor microbes especially contact with computer keyboards and mice than other inanimate objects [2].

Computers continue to have an increased presence in almost every aspect of our occupational, recreational, and residential environments and if 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 [3]. The ability for computers to act as fomites has been documented in hospital and health care environments and contamination of the environment including the computer keyboard with bacteria is nowadays have got special recognition in various parts of the world [4,5].

Some investigators have suggested that computer keyboards may serve as a reservoir for some pathogens because of the increased use of computers in patient areas and contribute to cross-transmission because of acquisition of transient hand carriage by healthcare personnel during contact with the contaminated computer keyboard surface [6,7]. The concern has been raised that contact with contaminated computer keyboards might serve as a

mechanism for contaminating the hands of healthcare workers with potential pathogens, thereby leading to cross-contamination of patients [8]. Even though the role of the hospital environment as a reservoir of nosocomial pathogens is controversial, the introduction of bedside computers into the patients' rooms in the critical care environment may play a role in the transmission of nosocomial pathogens [9]. Undisputedly hands are the main source of pathogen transmission. Cross-transmission of microorganisms by the hands of care personnel from computer components at the patients' bedside, might introduce an additional risk for critically ill patients considering the frequent contact of nursing and medical staff during patient care with these fomites [10].

These healthcare-associated infections are an important cause of morbidity and mortality in hospitals and in each year more than 2 million patients acquire healthcare-associated infections, resulting in 90,000 deaths and healthcare costs that are estimated to exceed $5 billion [11]. Computers have become a vital component of healthcare delivery for improved and effective care. Valuable patient related information is available in computers at the click of a button. Healthcare providers move back and forth, between computers and patients while delivering healthcare, as a part of the daily routine. There are some reports on the microorganisms colonizing computer keyboards in different locations of hospital environment, including clinical areas [12].

Many bacteria have been isolated from computer keyboards and mice in worldwide including developed countries. Bacteria pathogens commonly found from computer key boards and mice that can able to survive for long period of time and resist disinfection are important for computer keyboard and mice contamination [13]. In different literatures from nosocomial pathogens indicated that Gram-positive bacteria, such as *S.aureus*, *Enterococcus* species, and *Streptococcus pyogenes* survive for months on computer keyboards and mice [2,14]. Many Gram-negative bacteria, such as, *Escherichia coli*, *Klebsiella* species, *Acenitobacter* species and *Pseudomonas aeruginosa* can survive on computer keyboards and mice surfaces even for months [14]. The degree to which computers keyboards and mice are contaminated is different. One study reported, for example studies from 100 keyboards in" 29 clinical areas, 95%" keyboards were positive for microorganisms [15]. Based on the level of pathogen on keyboards 25% of keyboards in hospitals carry pathogens at any given time more than double that of other commonly-touched surfaces [2].

Antimicrobial resistance is a global phenomenon that has resulted in high morbidity and mortality as a result of treatment failures and increased health care costs [16]. Research has shown that contaminated fomites or surfaces play a key role in the spread of bacterial infections and antimicrobial resistance. Some investigation confirms that antibiotic resistant bacteria contaminate computer keyboards and mice might play an important role in the transmission of pathogenic microorganisms as well as in the spread of Antimicrobial-resistant organisms,for example in USA, University of North Carolina (UNC) Health Care System, oxacillin-resistant S.aureus (ORSA (4%) [17], Colombia teaching hospital, Meticillin- resistant S.aureus (MRSA*)* 5(1%) [18], and China from all ward stations of Kaohsiung Medical University Hospital, (MRSA*)* 1.1% [19]. Different studies in various parts of the world had assessed the extents of bacterial contamination of computer keyboard and mice. For example, a study in USA the isolated bacteria Pathogenic microorganism were ORSA (4%*)*, OSSA) (4%), vancomycin-susceptible *Enterococcus* species (12%), and non fermentative Gram-negative rods (36%) [20].

A Study from notebook computers in Pennsylvania, the bacterial colonization rate was 43%, but only 1.7% of culture results were pathogens. The isolated pathogenic bacteria included *S.aureus*, *streptococcus species*, and *gram-negative bacilli* [20]. In Thailand, the overall colonization rate of pathogens on the keyboards was 96.2% from patient care areas and 92.3% from the offices. Non-fermentative Gram negative bacilli on the keyboards located in the patient care areas and the offices were 11.5 % and 0 %, respectively [21].

A study from Germany identified MRSA 2 (5.1%), MSSA 14(35.9%), *Entrococcus* 3 (7.7%), *Gram-negative rods* 3 (7.7%), and Bacillus species 17 (43.5%) from computer keyboard and mice (10). Another study from the same area also reported S.aureus 21 (20%) and MRSA 6.67 % [15]. four cfu of MSSA and *β-hemolyzing streptococcus* were also isolated from laptops [22].

A study conducted in Italy showed that *S.aureus* was more commonly isolated from multiple-user keyboards than single user keyboards [23]. This finding is supported by a report from Australia in which (47%) of multiple-user keyboards were found to harbor *S.aureus* than only single-user keyboards (20%) [24]. in India from a total of 80 samples 105 microorganisms were isolated (63% from hospital setting and 37% from non hospital setting). The most isolated bacteria were *S.aureus, Pseudomonas* species, *Eschercia.coli and Klebsiella pneumoniae. Gram-positive cocci* (80%) was isolated in hospital setting more predominant than Gram-negative bacilli in outside the non hospital setting. From the isolated *S.aureus*, 6 MRSA and 11 MSSA were in hospital setting and 4 MRSA and 9 MSSA were in non-hospital setting [25].

Despite the advance in modern medicine nosocomial infection still poses a risk of increased morbidity and mortality to patients. For this, the environmental surfaces may contribute a significant role. It is thereby important to identify environmental surfaces that are rich in bacteria and have the potential to harbor pathogens. Therefore; this study was aimed to show the level of bacterial profile and their antimicrobial susceptibility patterns of computer keyboards and mice at Gondar University Hospital, Northwest Ethiopia.

## 2. Materials and Methods

A cross-sectional study was conducted at Gondar University Hospital, Gondar town from April 30 to June 30/ 2013. Gondar is one of the ancient historic towns in Ethiopia located 737 Kms North from the capital city, Addis Ababa. A total of 206 samples were collected (103from computer keyboards and 103from mice). The computers were in use by a wide variety of clinical staff including doctors, nurses, physiotherapists, laboratory technologists, recording officers, and personal computers from different health care works, all of whom had direct or in direct patient contact. The computers were situated in

the following clinical areas: general medical wards [35], laboratory rooms [11], Recording rooms [11], different clinical staff offices [25] and 21 personal computers from health care works. Information regarding possible risk factors collected through semi-structured questionnaire

**Sample collection:** Samples were aseptically collected from each computer keyboard and mouse by using sterile moisten cotton swabs before cleaning or disinfecting computer keyboards and mice with damp cloth and alcohol. A separate sterile cotton swab moistened with brain heart infusion solution was rotated over all the keys (letter keys, space bar, enter key, function keys, number keys and other keys) and from mice in the palm rest, left and right click buttons of the mouse were aseptically collected and put in to separate sterile test tubes which contains 5 ml Brain Heart Infusion (BHI) transport medium. Swabs were immediately taken to the microbiology laboratory, where they were inoculated onto MacConkey agar (Oxoid Ltd Basingstoke, Hampshire, UK), Blood agar (BAP) (Oxoid, LTD), Mannitol salt agar and Pseudomonas agar media (Cetrimide) and incubated at 35°C for 18-24 hours. Chocolate agar (CAP) was incubated in a humid, 5% $CO_2$ atmosphere for 18–24 hours at 35°C (26). All the plates were incubated aerobically and initially examined for growth after 24 hrs; the one without growth was further re-incubated for up to 48 hrs. Bacterial colonies differing in size, shape and colour were selected from the different plates and further sub cultured onto initially inoculated media. After obtaining pure colonies, further identifications were done by using the standard microbiological technique, which includes Gram staining, colony morphology and biochemical tests (Oxoid, LTD). The preliminary identification of bacteria was based on Gram staining and colony characteristics of the bacteria like hemolysis on blood agar.

**Biochemical tests:** Biochemical tests were performed on colonies from pure cultures for final identification of the isolates. Gram-negative rods were identified by performing a series of biochemical tests which include triple sugar iron agar, indole, Simon's citrate agar, lysine iron agar, urea and motility. Oxidase reagent strip was also used (27).Gram-positive bacteria were identified based on their Gram staining, catalase, Coagulase test, and bacitracin and optochin sensitivity test results [27].

**Antimicrobial susceptibility test** (AST) was determined by disk diffusion technique on Mueller-Hinton agar for the Antimicrobials testing. Pure colonies were taken and emulsifies in sterile normal saline. The turbidity was compared with 0.5MacFarland standard then the suspension was inoculated in Muller Hinton agar (MHA) according to modified Kirby- Bauer disk-diffusion technique [26,27]. The appropriate antibiotic discs were aseptically placed on the inoculated Muller Hinton agar using sterile forceps. The plates were then be incubated at 35°C for 18-24h.The antimicrobial agents tested was include vancomycin (30µg), oxacillin (5µg), gentamicin (10µg), erythromycin (15µg), ciprofloxacin (5µg), ceftriaxone (30µg), trimethoprim-sulfamethoxazole (25µg), chloramphenicol (30µg), tetracycline (30µg), amoxicillin, (10 µg), penicillin (10 IU), nalidixic acid, and nitrofurantoin (300 µg). The degree of susceptibility of the test isolate to each antibiotic was interpreted according to the principles established by CLSI as susceptible (S) or resistant (R) by measuring the zone diameter of inhibition in millimeter using ruler interpreted according the guideline [27].

**Quality Control:** All prepared culture plates were stored at recommended refrigeration temperature (2-8°C). The sterility of culture media was ensured by incubating 5% of each batch of the prepared media at 35°c for 24 hours. Performance of all prepared media was also checked by inoculating international standard-strains such as *E.coli* (ATCC 25922), *S. aureus* (ATCC 25923) and *P. aeruginosa* (ATCC 27853). To standardize the inoculums density of bacterial suspension for the susceptibility test, 0.5 McFarland standard was used [27].

**Data Analysis and Interpretation:** Data were entered into a database designed using MS Excel spreadsheet and analyzed using SPSS statistical software package (version 16). Study findings were explained in words and tables. Proportions for categorical variables were compared using chi-square test. In all cases *P-value* less than 0.05 was taken as statistically significant.

**Ethical Consideration:** The Ethical clearance was obtained from Research and Community Service Core Process of University of Gondar. Official permission was obtained from the Gondar University Hospital Clinical director and the respective heads of each sampled area.

# 3. Result

## 3.1. Bacterial Profile of GUH and Internet Café Computers

A total of 206 (103 from computers keyboards and 103 from mice) samples were collected, from which 344 bacteria were isolated. Of the swabbed computers, 83 were multiple- user's computers and had been contaminated 284 (82.6%). Moreover, 312(90.7%) of the unclean computers and (59%) of uncovered computers were contaminated with bacteria. All the samples collected yielded growth; however the extent of contamination varied.

**Table 1. Bacterial profile from GUH computer keyboards and mice isolates in Gondar Town, Northwest Ethiopia, 2013**

| Bacterial isolates | Hospital computer isolates | | |
|---|---|---|---|
| Bacteria | Keyboards No (%) | Mice No (%) | Total No (%) |
| **Gram positive** | **108 (51.9)** | **100 (48.1)** | **208 (60.5)** |
| CoNs | 38 (35.2 ) | 45 (45 ) | 83(39.9) |
| Bacillus species | 27 (25 ) | 24 (24 ) | 51(24.5) |
| *S.aureus* | 26 (24.1 ) | 23 (23 ) | 49(23.6) |
| *Entrococcus species* | 9 (8.3 ) | 5 (5 ) | 14 (6.7 ) |
| *S.pyogenes* | 8 (7.4 ) | 3 (3 ) | 11 (5.2 ) |
| **Gram negative** | **84 (61.8)** | **52 (38.2)** | **136(39.5)** |
| *Klebsiella species* | 14 (16.7 ) | 7 (13.5 ) | 21 (15.4 ) |
| *Enterobacter species* | 17 (20.2 ) | 6 (11.5 ) | 23(16.9 ) |
| *Citrobacter species* | 15 (17.9 ) | 12 (23.1 ) | 27(19.9 ) |
| *Providential species* | 17 (20.2) | 14 (26.9) | 31 (27.8 ) |
| *Acenitobacter sp* | 7 (8.3 ) | 2 (3.8 ) | 9 (6.6 ) |
| *Serratia species* | 6 (7.1 ) | 0 (0) | 6 (4.4 ) |
| *E.coli* | 3 (3.6 ) | 9 (17.3) | 12 (8.8 ) |
| *P.aeruginosa* | 3 (3.6 ) | 1 (1.8 ) | 4 (2.9 ) |
| *Proteus species* | 2 (2.4 ) | 1 (1.8 ) | 3 (2.2 ) |
| Total bacteria | **192 (55.8)** | **152 (44.2)** | **344(100)** |

From the total bacterial isolates, 208 (60.5%) were Gram positive bacteria and 136 (39.5%) were Gram negative bacteria. Majority of the Samples collected from computers keyboards and mice had multiple bacterial growth, 86 (82.5 %) and 48 (46 %) while 17 (17.5%) and 55 (54 %) had pure (single) bacterial growth, respectively.

Among Gram positive bacteria isolates, CNS was predominant (n=38; 39.9%). *Staphylococcus aureus* was also isolated (n=49; 23.6 %), of which 11 (28%) were sensitive to methicillin and six (15%) were methicillin resistant. A total of 136 Gram negative bacteria were isolated (84 from computer keyboards, 52 from computer mouse), of which *providential* spp. 31 (27.8 %) was the predominant. Other Gram negative bacteria isolated include *Citrobacter spp*, 27(19.9%), *Enterobacter species*, 23(16.9%), *E.coli*, *12 (8.8)*, *Acenitobacter spp*, 9 (6.6 %), *Seratia spp*, 6 (4.4%), *P. aeruginosa*, 4 (2.9%), and *Proteus species*, 3 (2.2%) (Table 1).

## 2.2. Antimicrobial Susceptibility Patterns of Bacterial Isolates

The results of antimicrobial resistant patterns were indicated in Table 2 and Table 3 below. Antimicrobial resistance of CoNs isolates to Penicillin, oxacillin, amoxacillin, and ampicilline were (87%), (83%), (76%), and (73%), respectively. Isolates of Bacillus species, were resistant to ampicilline (78 %), amoxacillin (71 %), and chloramphenicol (77%).

**Table 2. Antimicrobial resistance patterns of Gram positive bacteria isolates from GUH and Internet cafe computers in Gondar Town, Northwest Ethiopia, 2013**

| Bacteria isolates | | Percentage of no of resistance to antimicrobial agents n (%) | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | GEN | ERY | CIP | TE | PEN | AMP | CRO | SXT | OXA | NA | VN | C | NIT | AML |
| **CoNs** | (83) | 21(26) | 7(8) | 0 (0 | 62(74) | 73 (87) | 61(73) | 5 (7) | 53 (64) | 69 (83) | 48 (58) | 0 (0 | 47(57) | 50(60) | 63(76) |
| **Bacillus Species** | (51) | 11(22) | 21(42) | 14(18) | 32(62) | 37(72) | 40(78) | 11(12) | 26(51) | 31 (60) | 29(57) | 0 (0 | 39(77) | 30(58) | 36(71) |
| ***S.aureus*** | (49) | 10(21) | 11(23) | 4 (9) | 34(70) | 43(87) | 41 (74) | 1(3) | 29(60) | 43 (87) | 25 (51) | 0 (0 | 35(77) | 27(55) | 39(80) |
| ***Enterococcus Species*** | (14) | 0 (0) | 0 (0) | 0 (0) | 0 (0) | 14(100) | 0 (0) | 0 (0) | 0 (0) | 14(100) | 0 (0) | 0 (0) | 0 (0) | 10(72) | 0 (0) |
| ***S.pyogenes*** | (11) | 0 (0) | 0 (0) | 0 (0) | 0 (0) | 0 (0 | 0 (0) | 0 (0) | 0 (0) | 0 (0 | 0 (0) | 0 (0) | 0 (0) | 0 (0 | 0 (0) |
| **Total** | (208) | 42 (20) | 39 (19) | 18(8.7) | 128(61) | 167(80) | 142(68) | 17(8.1) | 108(52) | 157(75) | 102(49) | 0 (0) | 121(58) | 117(56) | 138(66) |

**VN**-Vancomycin, **OXA**-Oxacillin, **PEN**-Penicillin, **ERY**-Erythromycin, **NIT** Nitrofurantoin, **TE**-Tetracycline, **C**-Chloramphenicol, **CRO**-Ceftriaxone, **AMP**-Ampicillin, **AML**- Amoxicillin, **GEN**-Gentamicin, **NA**-NalidixicAcid, **CIP**-Ciprofloxacin, **SXT**-Trimethoprim-sulfamethoxazole, **NIT**-Nitrofurantoin.CoNs=Coagulase negative staphylococcus.

Among the Gram positive bacteria, *S.aureus* demonstrated high level of resistance to penicillin (87%), oxacillin (87%), and amoxacillin (80%), and *S.aureus* were susceptible to ceftriaxone (97%), ciprofloxacin (91%), and vancomycin (100%).

Among the Gram negatives, the predominant isolate was *providential species demonstrated* high level of resistance to tetracycline (100%). All isolates of *providential species were* sensitive to ciprofloxacin and ceftriaxone (100 %). *Citrobacter species*, the second predominate Gram negative isolates, also showed high level of resistance to amoxacillin and Ampicilline (100%). isolates of *Citrobacter species were* sensitive to gentamicin (78%) followed by ciprofloxacin (74%). All *Enterobacter species* were resistant to ampicilline (95%), amoxacillin (91), and tetracycline (87%) where as sensitive to ciprofloxacin (78%). *Klebsiella species* were highly resistant to amoxacillin (100%), followed by ampicilline (95%), and nitrofrantoin (90%), but sensitive to gentamicin (86%). *E.coli* was resistant to trimethoprim sulfamethoxazole (92 %,), tetracycline, amoxacillin, and nalidixic acid (84%). All isolates of E.coli were sensitive to ceftriaxon and ciprofloxacin (100%).

All isolates of *Acinetobacter species* demonstrated high level of resistance to chloramphenicol and ciprofloxacin 9 (100%). Isolates of *Serratia species* were resistant to ampicilline (100%) followed by nitrofrantoin (84%). All isolates of *Proteus species* were resistant to nitrofrantoin, ampicilline, ciprofloxacin and chloramphenicol (100%). (Table 3).

**Table 3. Antimicrobial resistance patterns of Gram negative bacteria isolates from GUH and Internet cafe computers swab cultures in Gondar Town, Northwest Ethiopia, 2013**

| Bacterial isolates | | **Antimicrobial resistance** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **GEN** | **CIP** | **TE** | **AMP** | **CRO** | **SXT** | **NA** | **C** | NIT | AML |
| ***Klebsiella species*** | (n=21) | 3(14) | 7 (33) | 16(77) | 20(95) | 13(62) | 17(81) | 13(62) | 17(81) | 19(90) | 21(100) |
| ***Enterobacter species*** | (n=23) | 15(65) | 5(22) | 20(87) | 22(95) | 3 (27) | 13(56) | 7(31) | 9(40) | 17(74) | 21(91) |
| ***Citrbacter species*** | (n=27) | 6(21) | 2 (29) | 20(75) | 27(100) | 20 (75) | 20(75) | 20(75) | 20(75) | 20(75) | 27(100) |
| ***Providentia species*** | HC(n=31) | 25(81) | 0 (0) | 31(100) | 21(68) | 0 (0) | 16(52) | 18 (70) | 16(52) | 17(55) | 16(52) |
| ***Acenitobacter*** | (n=9) | 8(88) | 9 (100) | 7(78) | 6(78) | 0(0) | 0(0) | 8(88) | 9(100) | 6(67) | 7(77) |
| ***Serratia species*** | (n=6) | 0(0) | 0 (0) | 0(0) | 6(100) | 0(0) | 0(0) | 0(0) | 0(0) | 5(84) | 0(0) |
| ***E.coli*** | (n=14) | 4(33) | 0(0) | 10(84) | 10(84) | 0(0) | 11(92) | 10(84) | 8(67) | 4(33) | 4(33) |
| ***p.aurgenosa*** | (n=4) | 1(25) | 1(25) | 3(75) | 3(75) | 1(25) | 3(75) | 3(75) | 3(75) | 3(75) | 3(75) |
| ***Proteus species*** | (n=3) | 1(24) | 3(100) | 1(24) | 3(100) | 2(66) | 2(66) | 2(66) | 3(100) | 3(100) | 3(100) |
| **Total** | **(n=136)** | **63 (46)** | **27 (20)** | **108(79)** | **118(87)** | **39 (29)** | **82 (60)** | **81 (59)** | **85 (63)** | **94(69)** | **102 (75)** |

**TE**-Tetracycline, **C**-Chloramphenicol, **CRO**-Ceftriaxone, **AMP**-, **AML**- Amoxicillin, **GEN**-Gentamicin, **CIP**- Ciprofloxacin, **SXT**-Timethoprim-sulfamethoxazole, **NIT**- Nitrofurantoin, **NA**- Nalidixic Acid.

## 2.3. Multiple Drug Resistance Patterns of the Isolates

Among the total isolates (n = 344) multi drug resistance (MDR = resistance in ≥ 2 drugs) were recorded in 286 (83.1 %) of all bacterial isolates. Gram negative bacteria, 89.2% and Gram positive bacteria, 78.7% showed resistance for two or more drugs. Among Gram positives, S.aureus showed 87.5% resistance for two or more antimicrobials. Moreover, Klebsiella sp., and proteus sp.,

(95%, and 100%) showed 87.5% resistance for two or more antimicrobials (Table 4 and Table 5).

**Table 4. Multi-drug resistance patterns of Gram positive bacteria isolates from GUH computers in Gondar Town, Northwest Ethiopia, 2013**

| Isolates | Total | Anti- biogram patterns n (%) | | | | | |
|---|---|---|---|---|---|---|---|
| Bacterial isolates | | **RO** | **R1** | **R2** | **R3** | **R4** | **>R5** |
| **CoNs species** | (n=83) | 10(12) | 4(4.8) | 6 (7.2) | 1(1.2) | 1 (1.2) | 61 (73.4) |
| **Bacillus species** | (n=51) | 11(21.5) | 1(1.9) | 2 (3.9) | 1(7.8) | 4 (7.8 | 32 (62.7) |
| ***S.aureus*** | HC(n=49) | 6(12.2) | 0 (0) | 2 (4) | 2 (4) | 4 (8.1) | 35(71.4) |
| ***Entrococcus species*** | (n=14) | 0 (0) | 0 (0) | 4 (28.5) | 10(71.4) | 0 (0) | 0 (0) |
| ***S. pyogenes*** | (n=11) | 11(100) | 0 (0) | 0 (0) | 0 (0) | 0 (0) | 0 (0) |
| Total | **(n=208)** | **38 (18)** | **5 (2.4)** | **14 (6.7)** | **14 (6.7)** | **9 (4.3)** | **128 (61)** |

**R0**- No antibiotic resistance, **R1**- Resistance to one antimicrobial, **R2**-Resistance to two antimicrobials, **R3** Resistance to three antimicrobials, **R4**-Resistance to four antimicrobials, **R5**-resistance to five and more antimicrobials, CoNs-coagulase negative staphylococcus.

**Table 5. Multi-drug resistance patterns of Gram negative bacteria isolates from GUH and Internet cafe computers in Gondar Town, Northwest Ethiopia, 2013**

| **Isolates** | **Total** | **Anti- biogram patterns (%)** | | | | | |
|---|---|---|---|---|---|---|---|
| **Bacteria isolates** | | RO | R1 | R2 | R3 | R4 | >R5 |
| ***Klebsiella species*** | (n=21) | 0 (0) | 1(4.7) | 0 (0) | 3(14.2) | 0 (0) | 17(80.4) |
| ***Enterobacter species*** | (n=23) | 1(4.3) | 1(4.3) | 1 (4.3) | 3 (13) | 2 (8.6) | 15 (65) |
| ***Citrobacter species*** | (n=27) | 0 (0) | 0 (0) | 7 (25.9) | 0 (0) | 0 (0) | 20 (74) |
| ***Providential species*** | (n=31) | 0 (0) | 6(19.3) | 4 (12.9) | 3(9.6) | 1(3.2) | 17 (54) |
| ***E. coli*** | (n=12) | 1 (8.3) | 1 (8.3) | 0 (0) | 0 (0) | 2 (16.1) | 8 (66.6) |
| ***Acenitobacter species*** | (n=9) | 0 (0) | 0 (0) | 1 (11.1) | 0 (0) | 1(11.1) | 7 (77.7) |
| ***Serratia species*** | (n=6) | 0 (0) | 0 (0) | 0 (0) | 0 (0) | 0 (0) | 6 (100) |
| ***P. aeruginosa*** | (=4) | 1 (25) | 0 (0) | 0 (0) | 0 (0) | 0 (0) | 3 (75) |
| ***Proteus species*** | (n=3) | 0 (0) | 0 (0) | 0 (0) | 0 (0) | 0(0) | 3 (100) |
| Total | **(n=136)** | **3 (2.2)** | **9 (6.6)** | **13 (9.5)** | **9 (4.3)** | **6 (4.4)** | **96 (71)** |

**R0**- No antibiotic resistance, **R1**- Resistance to one antimicrobial, **R2**-Resistance to two antimicrobials, **R3** Resistance to three antimicrobials, **R4**-Resistance to four antimicrobials, _ **R5**-resistance to five and more antimicrobials.

## 4. Discussion

Today we are living in an environment which is totally unsafe. The water we drink, the food we eat, and the environment in which we live have become an asylum of myriads of pathogenic microorganisms. More than 90 percent of the urban dwellers and children avoid unsafe drinking water fearing microbial contamination. Many dreadful bacteria have developed resistant to many common drugs we are using. Sensitivity of bacteria to antibiotics got weakened. Many infections are unable to be controlled and temperature rises. The high temperature also affects the physiological functions of the body. So the threat from pathogenic microorganisms is a matter of serious concern. Unfortunately such pathogenic microbes are dwelling in high concentration in many places of public utility. Knowingly or unknowingly they can easily infect the users and may dwell in their body. When their load increases or one's immunity gets weakened, they become a serious threat.

In this study, all the samples collected yielded growth, 206 (100 %); however the extent of contamination varied. This finding is greater than a report from Thailand 25 (96%) [9], Republic of Korea, 93 (92%) [2], 95 % [15] and Pennsylvania 52 (43 %) [20]. In our study, Gram-positive bacterial isolate were more prevalent (60.5 %) than Gram-negative bacterial isolates (39.5%). Comparable rate of isolation of Gram- positive and Gram negative bacteria, 75 % and 25 %, were reported in India [25]. Gram positive bacteria is abundant in human body especially as a normal flora of the skin, and that survival of Gram positive bacteria on laminate surfaces is greater than that of Gram negative bacteria [28]. A lower finding of Gram- positive and Gram negative bacteria, 13.8 % and 6.3%, was reported from China [19]. Multiple growths were reported in this study, 134 (65 %). This finding is higher than a report from Republic of Korea 38 (33.1%) [2]. But this finding is lower than a report from Saudi Arabia (95.5%) [1].

CoNs was the most predominant pathogen with over all isolation rates of, 24.1% (n=38; 39.9% among Gram positive bacteria isolates). A higher finding was reported from USA, 25 (100%) (17), India, 33 (31.4%), 22 (55 %), and 22 (88 %) [29,25,30], and Nigeria 45 % [31]. Combination of Constant handling in one restriction place and heat generated by the computers creates a prime breeding ground for CoNs that are normally found in our skin because this types of bacteria increase in optimum temperature [32]. CoNs which was isolated from most of the samples is a normal habitat of the skin but can occasionally assume an opportunistic pathogenic role in causing human infection such as endocarditis [33]. CoNS are known to be present in the hospital environment, and can be a source of cross infection, causing Hospital Acquired Infections (HAI) especially in immuno-compromised hosts. The isolation rate of Bacillus species in this study were 24.5% (27 (25% from keyboard and 24 (24% from mouse). This result is higher than a report from Nigeria, (7.7 % and 6.8 %) [34].

A study from Turkey documented skin flora to be the predominant isolates from computer keyboards; *Bacillus* spp. was cultured most frequently, and no methicillin resistant *S aureus* (MRSA) was isolated [35]. Another study from Japan reported CNS and *Bacillus* spp, including MRSA from keyboards of computers used by anaesthetists for entry of patients related Data [36].

In this study, the prevalence of *S.aureus* was 23.6% (26 (24.1 % from keyboard and 23 (23 % from mouse). This

finding is higher than a study from Nigeria 3 (10.6%) and India 3 (3.3 %) keyboards [19,31], in India 21 (20 %), 17 (43 %) keyboards (29,25), and Saudi Arabia (20 % and 19 %) keyboards and mice [1]. This may be contamination from the skin, mouth or nose of the computer handlers and soil which might be introduced directly into the computers was responsible for the colonization of computers [37]. Previous studies have reported that bacterial contamination occur on computer surfaces located in a college setting and may reflect the multiple-user environment where the possibility of contamination by individuals who are carriers of bacteria such *Staphylococcus aureus* is greater and the isolation of viable microorganisms suggest that the species present are able to persist for a period of time on these surfaces. As with hospital settings [33], computer keyboards and mice in tertiary institutions may act as a vehicle for the transmission of pathogenic organisms.

*In this study*, *Staphylococcus aureus* was also isolated (n=49; 23.6 %), of which 11 (28%) were sensitive to methicillin and 6 (15%) were methicillin resistant. Previous studies have reported that MRSA were isolated in small percentage (12%) of computer keyboards [10,17,18,19,25,36]. however, no MRSA S.aureus was isolated in Turkey [35] Thus, there appears to be an additional source for colonisation of MRSA in the hospital environment; infection control guidelines for control of MRSA must consider disinfection of computer keyboards to prevent inadvertent transmission.

Providential *species* were the second dominant pathogen with overall isolation rate of 27.8 %( 17 (20.2 % from keyboard and 14 (26.9 % from mouse). In the present study, the isolation rate of other Gram negative bacteria isolated include *Citrobacter spp*, 27(19.9%), *Enterobacter species*, 23(16.9%), *E.coli, 12 (8.8)*, *Acenitobacter spp*, 9 (6.6 %), *Seratia spp*, 6 (4.4%), *P. aeruginosa*, 4 (2.9%), and *Proteus species*, 3 (2.2%). A lower finding of *Citrobacter species* 7 (4.6 %), *E.coli*, 3 (1.33) and *Enterobacter species* 2 (2.4%) was reported from India [2,38]. In India, nosocomially significant pathogens such as *Pseudomonas* spp., *Acinetobacter* spp., *E. coli*, and *K. pneumonia* were reported [25]. *Escherichia coli* are the most widely adopted indicator of faecal pollution and they can also be isolated and identified simply, with their numbers usually being given in the form of faecal coliforms/100 ml of waste water [39]. *E. coli* cause urinary tract infection and diarrhea [40]. Isolation of the bacteria from computer keyboards and mouse is a clear indication that the sterilization/aseptic procedures/methods adopted by the operators if at all, is not effective in significantly reducing the level of the organism on these surfaces to an acceptable level [36].

The overall range of resistance for Gram positive bacteria was from 0% to 80%.In this study; most of the Gram- positive bacteria isolates were resistant to penicillin (80%), oxacillin (75%), ampiciline (68%) and amoxacillin (66%). Our finding is lower than a report from Ghana, all Gram positive bacteria isolates were 100% resistant to penicillin [12]. Gram positive were resistant for Trimethoprim-sulfamethoxazole (52 %) and gentamicin (20%), which is higher than study conducted in Ghana (20% and 0%) [41]. The variation might be because of variation in geographical locations, environmental conditions and genetic background of the organism and the abuse of antimicrobials in a location which leads to antimicrobial resistant [42].

It is very shocking to observe that some of these bacteria are highly resistant to the commonly used antibiotics (*S.aureus* demonstrated high level of resistance to penicillin (87%), oxacillin (83), and amoxacillin (80%). *Providential species* was resistance to tetracycline (100%). *Citrobacter species was* resistance to amoxacillin and Ampicilline (100%). All *Enterobacter species* were resistant to ampicilline (95%), amoxacillin (91), and tetracycline (87%). *Klebsiella species* were resistant to amoxacillin (100%), ampicilline (95%), and nitrofrantoin (90%). *E.coli* was resistant to trimethoprim sulfamethoxazole (92 %), tetracycline, amoxacillin, and nalidixic acid (84%). *Proteus species* was (100%) resistant to Ciprofloxacin, Ampicilline, Amoxicillin, Chloramphenicol and Nitrofurantoin.

Among the total isolates (n = 344) multi drug resistance (MDR = resistance in ≥ 2 drugs) were recorded in 286 (83.1 %) of all bacterial isolates. Gram negative bacteria, 89.2% and Gram positive bacteria, 78.7% showed resistance for two or more antimicrobials tested. A lower finding was reported in Nigeria 79.1% (28).This indicates that multi drug resistance was found to be very high to the commonly used antibiotics. Antibiotic resistance has been recognized as the consequence of antibiotic use and abuse [43]. Therefore, the reasons for this alarming phenomenon might be inappropriate and incorrect administration of antimicrobial agents in empiric therapies and lack of appropriate infection control strategies, which can cause a shift to increase prevalence of resistant organism in the community.

## 5. Limitation of the Study (Conclusion)

Computer keyboards and mice in hospital settings harboured microorganisms such as *CoNs*, Bacillus spp. *S.aureus*, *providential spp*, *Citrobacter spp*, and *Enterobacter spp. E.coli* and *Klebsiella* spp. *In this study* some of the isolated bacteria were highly resistant to the commonly used antibiotics. High rate of multiple antimicrobial resistance to majority of the common antimicrobial agents were also found. Thus presence of pathogenic microorganisms on computer keyboards is a cause of concern. Since computer keyboards are providing a surface for colonisation, infection control guidelines must target appropriate surface disinfection and adequate hand hygiene, and awareness on cleaning of such surfaces or disinfection needs to be addressed.

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