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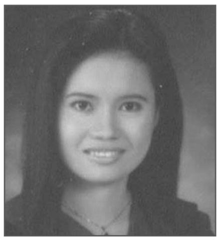

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Common Bacterial Pathogens and their Antimicrobial Susceptibility in a Tertiary Hospital in the Philippines

Abstract

Indiscriminate or extensive use of broad-spectrum antimicrobial agents has largely contributed to the spontaneous development of resistance of bacterial pathogens to antibiotics. Hence, there is a need to determine the prevalent pathogenic microorganisms and their antimicrobial susceptibility in hospitals.

The general objective of the study is to determine the commonly-occurring bacterial pathogens in a hospital and to identify the susceptibility of these to antimicrobial agents. Specific objectives include: (1) to determine the occurrences of these pathogens in terms of body site (from which the organism was isolated) and clinical and special areas in the hospital; (2) to determine the antimicrobial susceptibility patterns of these bacterial pathogens; and (3) to illustrate the trend of antimicrobial susceptibility of these pathogens to antimicrobial agents for a three year period (2012-2014).

A quantitative, descriptive study was conducted to determine the frequency distribution of the bacterial pathogens for the year 2014 and identify their susceptibility patterns to antimicrobials over a three-year period (2012-2014). The research investigators reviewed laboratory records of different types of specimens from all inpatient and outpatient subjects that were submitted to the Philippine Orthopedic Center Laboratory Department (POCLD) for culture and sensitivity testing daily from January 2012-December 2014. The data were then collated and tabulated for statistical analysis using Epi InfoTM version 7. The research study underwent a technical review by the POC Research Committee (POCRC) and an ethical review by the POC Ethics Review Board (POCERB).

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Results showed that in 2014, gram-negative bacteria, Enterobacter spp. and Proteus spp., and gram-positive bacterium Staphylococcus aureus, were the most commonly occurring bacterial pathogens in this institution. Most of the bacterial pathogens were from the respiratory tract, urine, and wound. The clinical and special areas where most of the bacterial pathogens were obtained came from Spinal/Rehabilitation ward, followed by the Observation Unit, and Male Service A. Gram-negative bacterial pathogens are most susceptible to cefepime, amikacin, and ceftazidime while gram-positive pathogens are most susceptible to vancomycin and gentamycin.

From 2012-2014, there was a decrease in susceptibility of Enterobacter spp. to amoxicillin-clavulanic acid while the susceptibility profiles for Proteus spp. remained steady for most agents except for cefazolin and amoxicillin-clavulanic acid which showed an increased resistance rate. Similarly, the susceptibility profiles for Staphylococcus aureus remained steady for almost all the agents for the study period except for an increased resistance to amoxicillin in 2014.

In conclusion, the study showed that the variability in the resistance patterns might be attributed to the status of antibiotic use in the hospital. Fostering rational antibiotic use is an important step in formulating infection control guidelines that will match the unique setting of the institution.

Keywords: Bacteria, pathogens, and antimicrobial susceptibility

Introduction

Various types of infections are considered the leading causes of morbidity and mortality in developing countries like the Philippines. Majority of the patients that are being brought to thris institution are mostly patients with open wounds sustained from vehicular accidents (Various types of infections are considered the leading causes of morbidity and mortality in developing countries like the Philippines. Majority of the patients that are being brought to this institution are mostly patients with open wounds sustained from vehicular accidents. Other common orthopedic-related cases in the hospital are cellulitis, pyomyositis, septic arthritis, and osteomyelitis. Many patients are being admitted for surgery and treatment of musculo-skeletal infections, and unfortunately, some also develop healthcare-associated infections (HAIs) after admission. The spread of HAIs is a complex problem driven by many factors and complete infection eradication is a challenging endeavor.

Due to the urgency of starting antibiotics in many medical situations and the time needed to grow cultures and determine sensitivities, the empirical treatment given by practitioners to patients remains substantial in determining patient outcome. Empirical treatment may also be a useful approach most especially in developing countries where resources are scarce and routinely performing antibiotic sensitivity tests is impractical.

However, the customary routine of indiscriminate or extensive use of broad-spectrum antimicrobial agents, even when properly indicated, has largely contributed to the spontaneous development of resistance of bacterial pathogens to these antibiotics . Also, the spectrum of bacterial isolates varies with time and geographical area, even within the same country . Therefore, an empiric treatment as recommended by guidelines from another country may not be applicable or ineffective in our setting, given the potential difference in predominant strains and susceptibility patterns.

Thus, there is a need to develop extensive knowledge in prevalent pathogenic microorganisms and their antimicrobial susceptibility patterns in the hospital. This antibiogram will be a useful epidemiologic tool in the investigation of HAIs and for clinical decisions about therapy. The development of drug resistance can be reduced if the empirical treatment is based on hard and updated evidence tailored to the unique environment of the hospital. Also, efficient resource utilization will also be sustained if the antibiogram is regularly updated to match continuously changing susceptibility patterns.

At present, there are no surveillance studies that were developed to monitor the clinical isolates of bacterial pathogens and their antimicrobial susceptibility rates obtained from patients at the areas of the Philippine Orthopedic Center (POC). It is significant to have information on the bacteriological profile of the hospital to guide the modification of drug regimen strategy as well as fostering rational antibiotic use that will be an important step in formulating infection control guidelines that will match the unique setting of the institution.

Objectives of the Study

The general objective of the study is to determine the frequency distribution of the commonly occurring bacterial pathogens in the hospital for the year 2014 and to identify the susceptibility patterns to antimicrobial agents of these pathogens for the year 2012-2014.

The specific objectives are as follows: (1) to determine the occurrences of these pathogens in terms of body site from which the organism was isolated and clinical and special areas in the hospital, (2) to determine the antimicrobial susceptibility patterns of the bacterial pathogens for the year 2012-2014, and (3) to illustrate the trend of antimicrobial susceptibility of these pathogens to antimicrobial agents for a three year period (2012-2014).

Methodology

Study Design

A quantitative, descriptive study was conducted to determine the frequency distribution of the bacterial pathogens for the year 2014 and to identify their susceptibility patterns to antimicrobials over a three-year period (2012-2014). A retrospective cross-sectional research design was used since the study investigated a phenomenon/issue that has occurred in the past and it allowed the investigators to get a "snapshot" of the description of the bacterial pathogens and their antibiotic susceptibility patterns at a specific point in time.

Study Setting

The study was conducted at a tertiary specialty government hospital under the Department of Health (DOH) of the Republic of the Philippines that caters mainly to patients with orthopedic, musculoskeletal problems, and neuromuscular conditions (Philippine Orthopedic Center, 2014) since comprehensive data on trends over time are lacking. The data were obtained from the medical records of the Philippine Orthopedic Center Laboratory Department (POCLD) for the time period. These records were gathered from patients in the different areas of the hospital.

Sampling Technique

The investigators collaborated with the POCLD to obtain pertinent data for the year 2012, 2013, and 2014, and POC Infection Control Committee for further information relating to the study. The research investigators reviewed laboratory records of different types of specimens from all inpatient and outpatient subjects that were submitted to the POCLD for culture and sensitivity testing daily from January 2012-December 2014. Repetitive (more than one isolate per patient) isolates submitted to the POCLD for three years (2012-2014) were included in the study. Processing of the clinical specimens was performed by the POCLD according to their local standard protocols. This study was performed according to the Clinical and Laboratory Standards Institute (CLSI) breakpoints updated in 2009, in order to avoid probable differences in susceptibility of the strains isolated.

Data from patients from different institutions and types of specimen not examined in the POCLD, as well as, laboratory results such as "Please correlate clinically (PCC)" and "Please send another specimen (PSAS)" were excluded in the study. Other types of tests that are beyond the capability of the laboratory (e.g., test for other anaerobic and resistant microorganisms) are also not included in the study.

Data Collection Procedure

Results of the culture and sensitivity testing were encoded in a standard data collection template containing patients' clinic-demographic details. Presenting clinical history and underlying illness were also noted wherever applicable.

The antimicrobial agents that were included in this study were the ones that were available in the hospital which included the following: Amoxicillin-Clavulanic acid (AMC), Oxacillin (OX), Amikacin (AK/AN), Netilmicin (NET), Chloramphenicol©, Cefazolin (CZ/KZ), Cefepime (FEP), Ceftazidime (CAZ), Ceftriaxone (CRO), Cefuroxime (CXM), Cefalexin (CL), Ciprofloxacin (CIP), Nitrofurantoin (F), Amoxicillin (AX/AXL), Vancomycin (VA), and Gentamycin (CN/GN/GEN). The isolates were classified as susceptible (S), intermediate (I), or resistant (R) according to the breakpoints established by the Clinical and Laboratory Standards Institute (CLSI) (Clinical and Laboratory Standard Institute, 2010). The study included different types of specimen (blood, wound, cerebrospinal fluid, soft tissue, bone, joint, urinary tract, and respiratory tract) submitted to the POCLD for culture and sensitivity analysis from patients on all areas of the hospital from January 2012-December 2014.

To illustrate the antimicrobial susceptibility patterns and trends of the bacterial pathogens for a three-year period (2012-2014), the research investigators obtained the data on the microorganisms tested using an antibiotic susceptibility assay from the POCLD. The data were then collated and tabulated for statistical analysis using Epi Info™ version 7. All data collected were kept private, confidential, and were not accessed by anyone other than the research investigators and were used only for the purpose of the study. The research study underwent a technical review by the POCRC and an ethical review by the POCERB.

Results

The total number of specimens sent to POCLD for culture and sensitivity testing that were assessed for eligibility for the year 2014 in consideration of the inclusion and exclusion criteria was shown in Figure 1. A total of 3,929 specimens were sent to the POCLD for culture and sensitivity testing and more than half (59%) of these had no growth.

The most common species identified in this study was *Enterobacter spp.* (26%), followed by *Proteus spp.* (16%),

Figure 1. *Data collection flow chart*

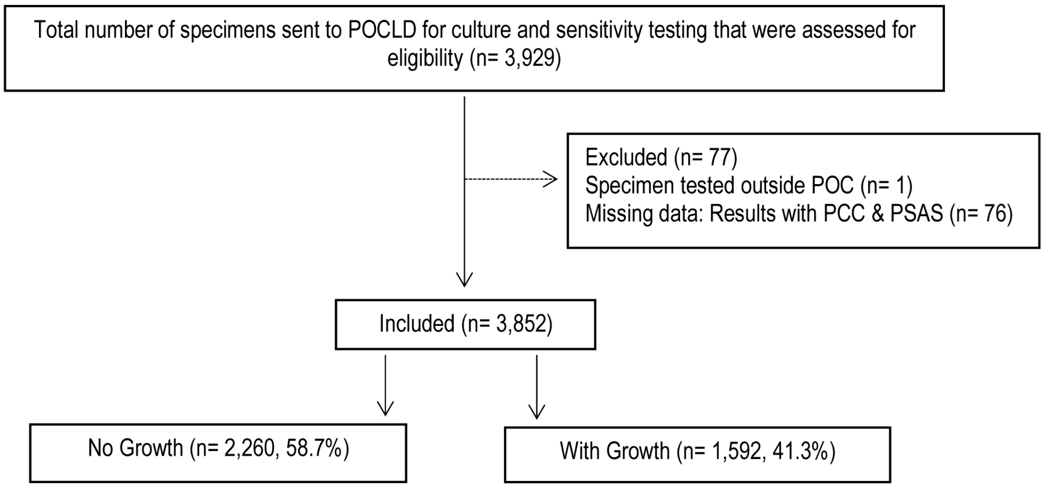

Table 1. *Percentage distribution of bacterial pathogens among samples obtained from different body sites in 2014*

Pathogens	Respiratory (n=112)	Urine (n=289)	Wound (n=837)	Blood (n=22)	Soft tissue (n=288)	Joint (n=32)	Others (n=12)
Enterobacter spp.	29.5	28.4	24.6	18.2	28.1	6.3	50
Proteus spp.	12.5	17	15.4	0	19.8	6.3	8.3
Staphylococcus aureus	3.6	0.7	16.5	9.1	14.6	34.4	0
Escherichia coli	0.9	33.2	4.3	0	9.4	0	0
Pseudomonas aeruginosa	17	4.5	12.1	9.1	7.6	6.3	8.3
CONS	5.4	4.8	9.1	31.8	11.1	34.4	25
Pseudomonas spp.	17	3.5	8.1	18.2	3.5	3.1	0
Citrobacter spp.	7.1	6.6	6.9	13.6	3.8	3.1	0
Others	7.1	1.4	3	0	2.1	6.3	8.3

Staphylococcus aureus (12%), *Escherichia coli* and *Pseudomonas aeruginosa* (10%), respectively. Majority of the bacterial pathogens in this institution were Gram-negative bacteria. Most of the bacterial pathogens were from the respiratory tract (70%), followed by urine (64%), and wound (42%), respectively.

Table 1 illustrated the percentage distribution of these bacterial pathogens obtained from different body sites for the year 2014 which included *Enterobacter spp*. (25%), *Staphylococcus aureus* (16%), and *Proteus spp.* (15%), respectively.

Most of the bacterial pathogens came from Spinal/Rehabilitation Ward (72%), followed by the Observation Unit (59%), and Male Service A (50%), respectively. Table 2 displays the percentage distribution of bacterial pathogens among samples obtained from clinical and special areas of the hospital in 2014. The most commonly occurring bacterial pathogen came from Spinal/Rehabilitation Ward (72%) which included the following: *Enterobacter* & *Proteus spp.* (24%) and *Escherichia coli* (15%); from Observation Unit (59%) which included *Enterobacter spp.*(24%), *Escherichia coli, Proteus spp.,* and *Pseudomonas aeruginosa* (16%); and from Male Service A (50%) which included *Enterobacter spp*. (30%), *Proteus spp.*(18%), and *Pseudomonas aeruginosa* (15%), respectively.

Cefepime, amikacin, and ceftazidime were the most effective antibiotics against the following gram negative organisms: *Proteus spp., Pseudomonas aeruginosa,* and *Pseudomonas*

Table 2. *Percentage distribution of bacterial pathogens among samples obtained from clinical and special areas of the hospital in 2014*

	Enterobacter spp.	Proteus spp.	Staphylococcus aureus	Escherichia coli	Pseudomonas aeruginosa	CONS	Pseudomonas spp.	Citrobacter spp.	Others
Spinal/Rehabilitation Ward (n= 315)	24.4	24.4	1.0	14.9	9.8	4.4	9.2	8.9	2.9
Observation Unit (n= 25)	24.0	16	4.0	16.0	16.0	0	8.0	4.0	12
Male Service A (n= 27)	29.6	18.5	0	7.4	14.8	7.4	11.1	11.1	0
Male Traction Ward (n= 57)	29.8	7.0	29.8	10.5	5.3	7.0	0	8.8	1.8
Pay 3rd (n= 33)	33.3	15.2	12.1	12.1	6.1	6.1	3.0	6.1	6.1
Pay 4 East (n= 28)	17.9	3.6	14.3	17.9	17.9	10.7	14.3	0	3.6
Out-patient Department (n= 325)	24.9	11.4	15.7	4.3	11.4	13.2	10.8	4.3	4
Emergency Room (n= 305)	27.2	12.5	20.7	7.2	5.6	12.8	3.6	8.2	2.3
Emergency Ward (n= 26)	26.9	23.1	0	7.7	11.5	15.4	7.7	7.7	0
Female Service Ward (n= 81)	28.4	12.3	4.9	23.5	13.6	9.9	4.9	2.5	0
Male Service B (n= 202)	30.7	18.8	10.4	6.9	12.4	4	6.9	5.9	4
Pay 4 West (n= 69)	21.7	21.7	15.9	17.4	13	2.9	1.4	4.3	1.4
Children's Ward (n= 84)	20.2	10.7	20.2	9.5	7.1	21.4	7.1	3.6	0
Operating Room (n= 6)	16.7	16.7	16.7	16.7	16.7	16.7	0	0	0
Recovery Room (n= 5)	0	40	40	0	0	20	0	0	0
Northeast Ward (n= 4)	25	0	0	0	0	0	50	0	25

spp.. On the other hand, vancomycin, Amoxicillin-Clavulanic acid (AMC), and gentamycin are the three most effective antibiotics against gram positive bacterial isolates, *Staphylococcus aureus* and Coagulase-negative *Staphylococcus spp.* Among all other antibiotics, resistance rate of gram negative bacteria which included *Enterobacter spp.*, *Proteus spp., Escherichia coli,* and *Citrobacter spp.* were highest in cefazolin for the years 2012-2014.

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There was a remarkable decrease in susceptibility of *Enterobacter spp*. to amoxicillin-clavulanic acid from 2012 (93%) until it reached 46% in 2014. Other active agents that remained consistently effective against this species for three years were ceftazidime, netilmicin, cefepime, nitrofurantoin, ciprofloxacin, ceftriaxone, and amikacin (Figure 2).

During the three-year period, the susceptibility profiles for *Proteus spp.* remained steady for most agents except for cefazolin and amoxicillin-clavulanic acid which showed an increased resistance rate from 2012-2014 (Figure 3).

Similarly, the susceptibility profiles for *Staphylococcus aureus* remained steady for almost all the agents for the study period except for an increased resistance to amoxicillin in 2014 (25%). Vancomycin and gentamycin remained effective against this species. Antimicrobial susceptibility of this species against oxacillin decreased in the three-year period (81%-69%) (Figure 4).

The most active agents against *Escherichia coli* were amikacin, nitrofurantoin, cefepime, netilmicin, and ceftazidime from 2012-2014. On the other hand, antibiotics such as cefazolin, cefalexin, ciprofloxacin, and cefuroxime exhibited high level of resistance. Amoxicillin-Clavulanic acid showed an increasing resistance in 2012-2014 (7% in 2012 to 33% in 2014) (Figure 5).

The results for *Pseudomonas aeruginosa* suggested increasing

Figure 2. *Susceptibility trend of Enterobacter spp. in 2012-2014*

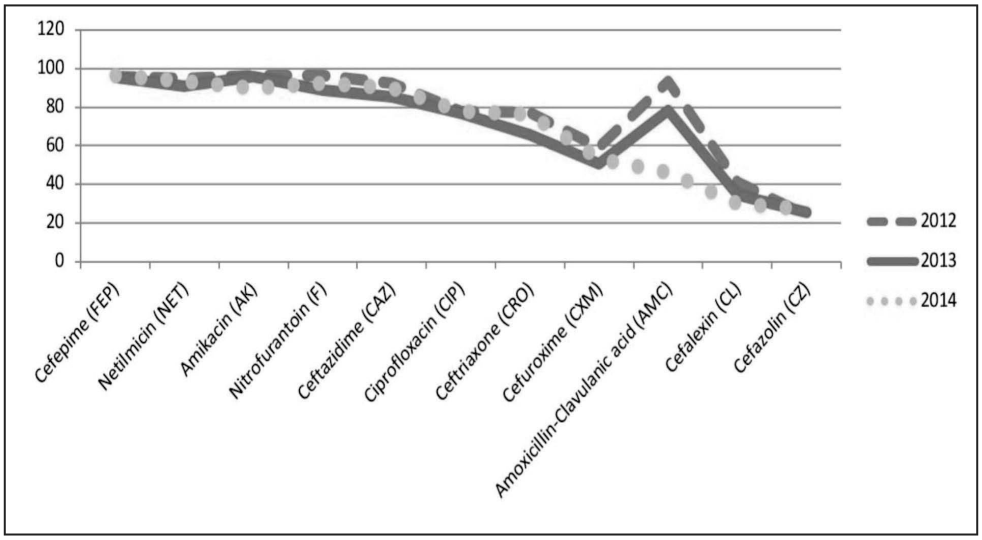


Figure 3. *Susceptibility trend of Proteus spp. in 2012-2014*

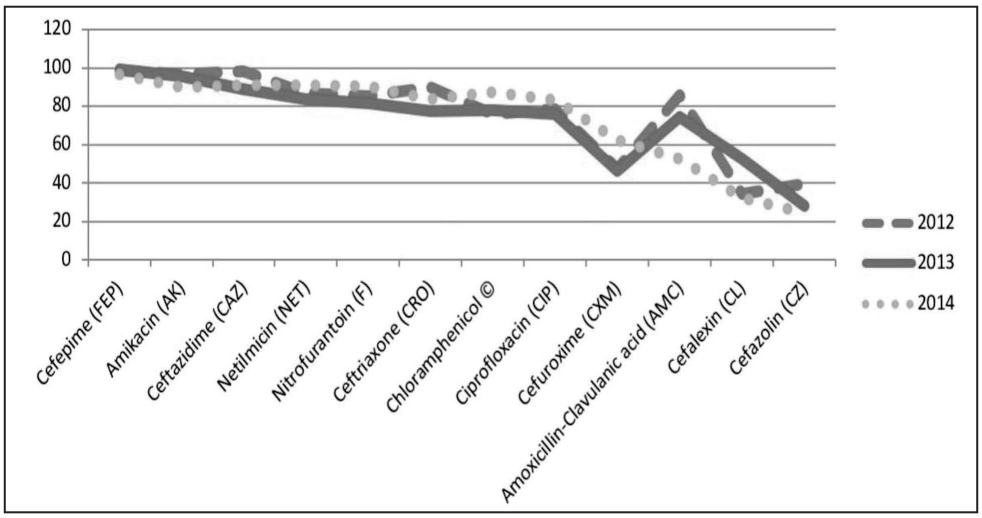


Figure 4. *Susceptibility trend of Staphylococcus aureus in 2012-2014*

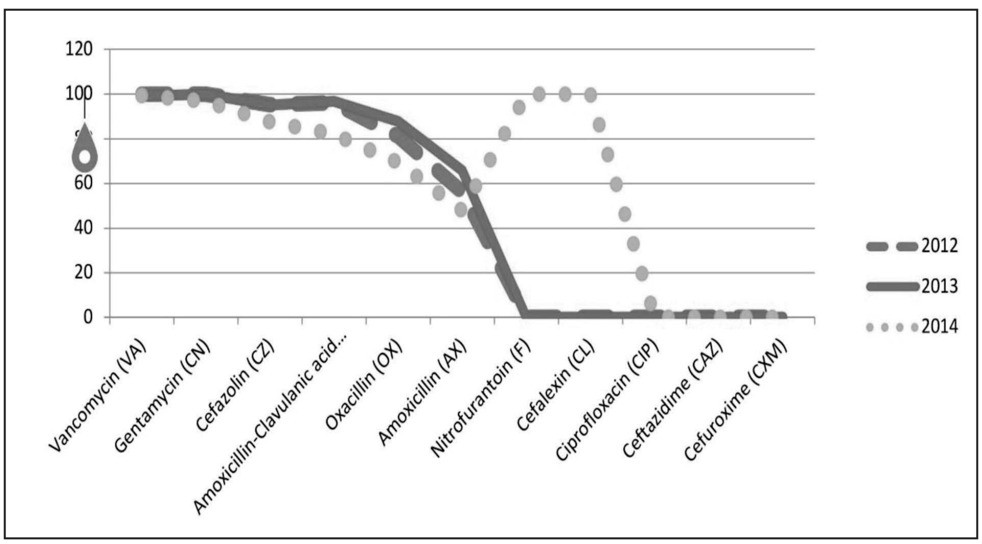


Figure 5. *Susceptibility trend of Escherichia coli in 2012-2014*

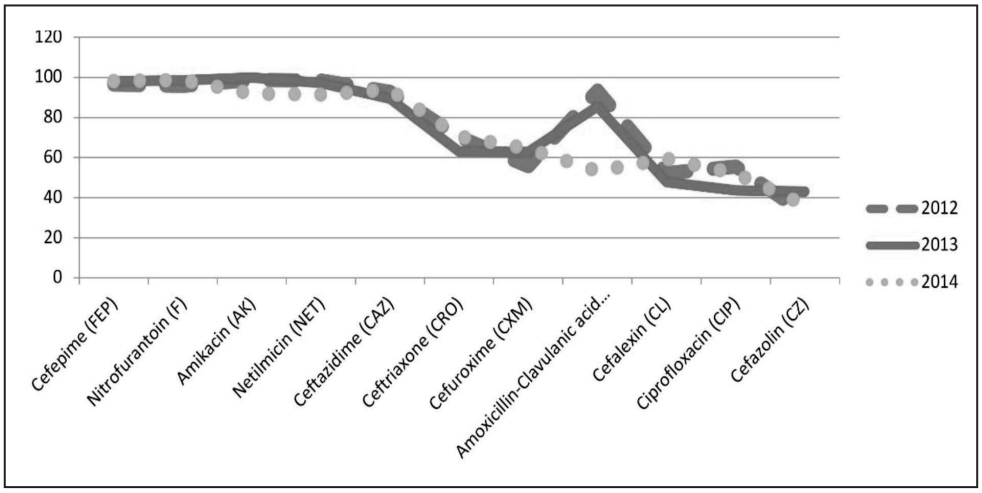


Figure 6. *Susceptibility trend of Pseudomonas aeruginosa in 2012-2014*

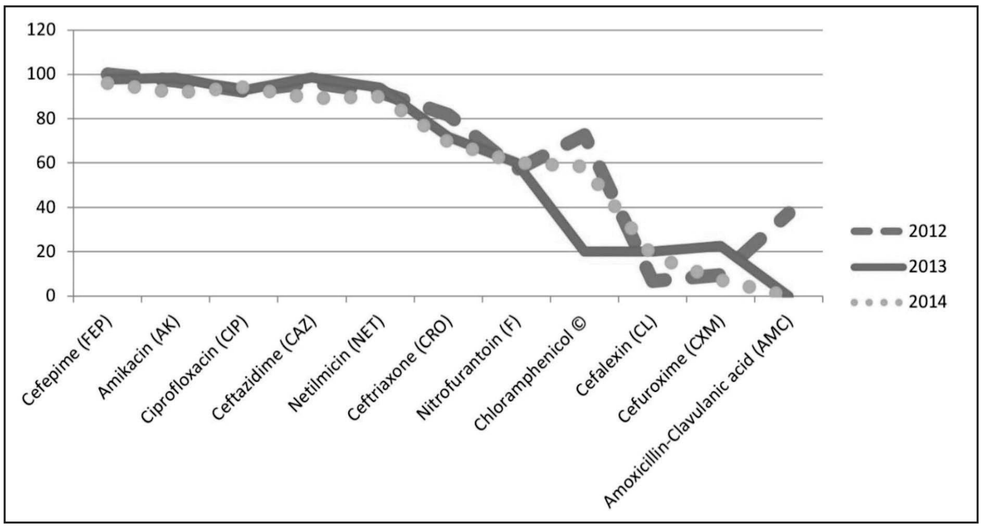
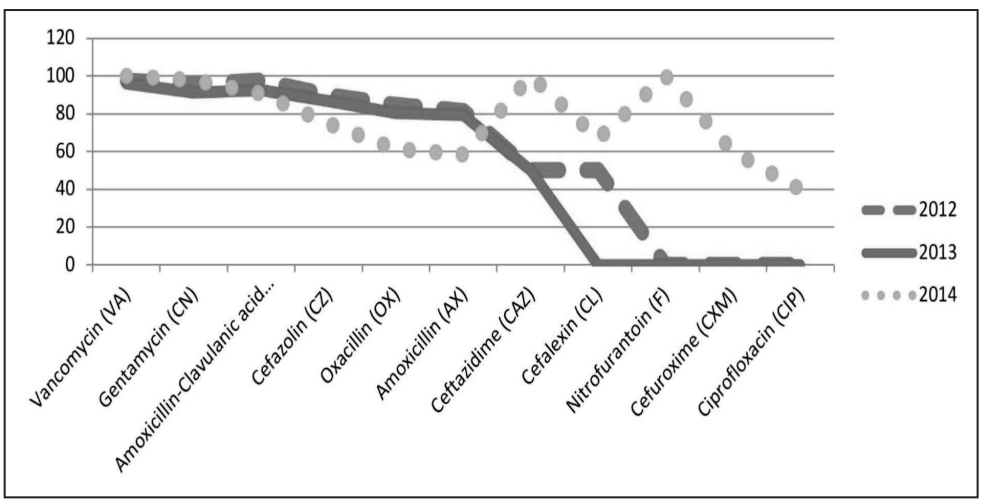


Figure 7. *Susceptibility trend of Coagulase-negative Staphylococcus spp. in 2012-2014*



resistance to netilmicin and amikacin in the three-year study period (Figure 6).

More than half of the antibiotic agents against *Coagulase-negative staphylococci* showed decreased effectivity in three years except for vancomycin, ceftazidime, and gentamycin. This species is most susceptible to ceftazidime and vancomycin (100%) in the year 2014. It was observed that there was a decrease in susceptibility of *Coagulase-negative staphylococci* to amoxicillin and oxacillin for three years (Figure 7).

More than half of the antibiotics tested against *Pseudomonas spp.* for three consecutive years were effective against this species (Figure 8).

During the three-year period, the susceptibility profiles for *Citrobacter spp.* remained steady for most agents. Its susceptibility to cefepime, ciprofloxacin, and ceftriaxone decreased more or less with time (Figure 9).

Discussion

Orthopedic patients are known to be susceptible to various nosocomial infections due to trauma and orthopedic procedures which carry a chance of infection because a portal of entry is made either by surgical incision or from traumatic laceration. Also, all of these procedures have distinctive infection risk factors and contamination of the surgical site by either direct or indirect means is a common cause of surgical-site infections. It was found out that more than half of the specimen sent had no growth. This result indicated true negative growth or might be due to sampling errors or conditions during

Figure 8. *Susceptibility trend of Pseudomonas spp. in 2012-2014*

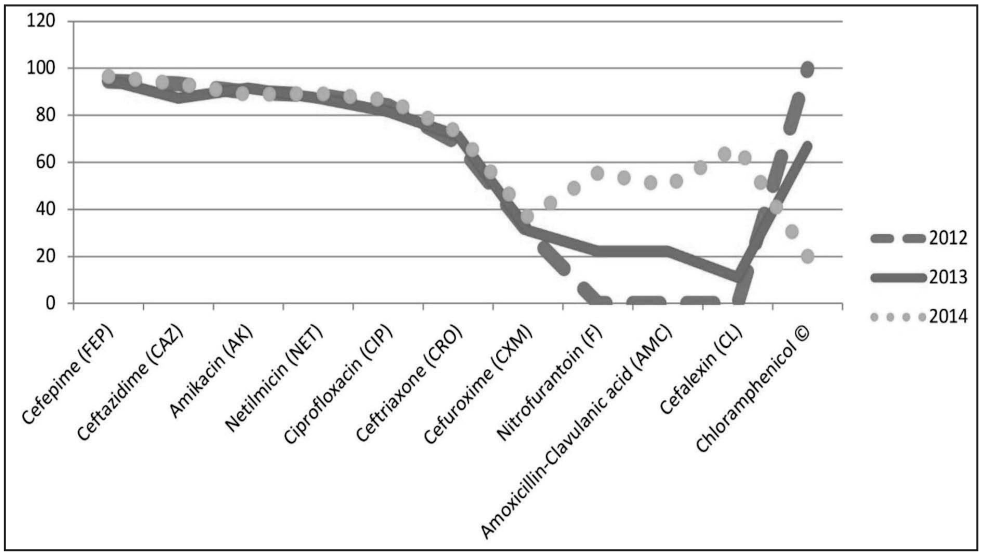
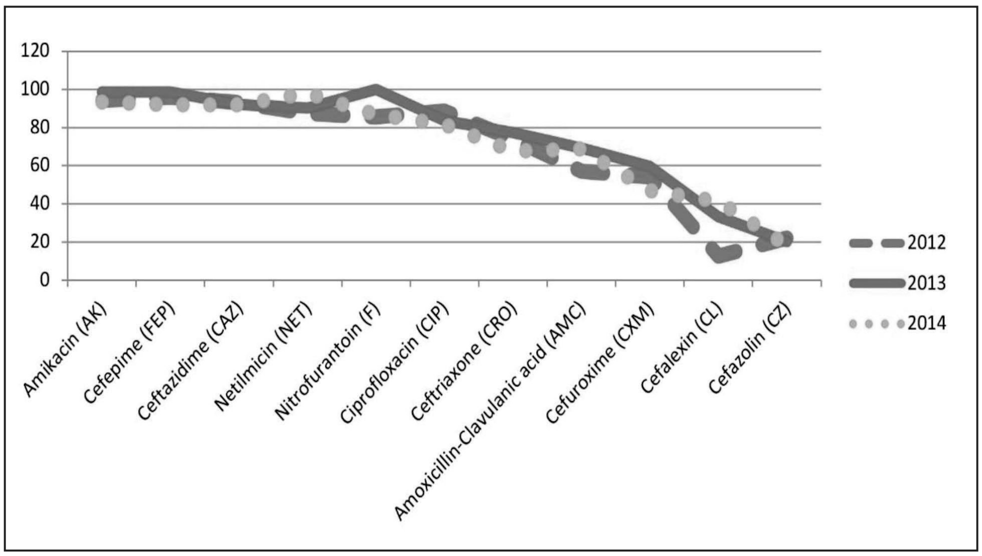


Figure 9. *Susceptibility trend of Citrobacter spp. in 2012-2014*



specimen collection and handling (e.g., prior or ongoing antibiotic use at time of collection, sterility techniques or contaminations during specimen extraction and culture, the transport of specimen to the laboratory, the sterile conditions during inoculation and performance of culture, stability of disk used, and variability inherent with each medical technologist performing the test).

Common Pathogens

This study showed that 41.3% of the specimens sent for culture and sensitivity testing have positive bacterial isolates. Most of the bacterial pathogens that were isolated in this study were Gram-negative bacteria. This is similar to another tertiary-care center in India where Gram-negative bacteria contributed to a significant increase in infections that are resistant to a myriad of antibiotics during the last few years (Bhatt, Tandel, Shete, & Rathi, 2015). Furthermore, the study revealed that the leading Gram-negative bacterial pathogens were *Enterobacter spp., Proteus spp., Escherichia coli, Pseudomonas aeruginosa, Pseudomonas spp.*, and *Citrobacter spp.*, and the most-common Gram-positive species was *Staphylococcus aureus* and Coagulase-negative *Staphylococcus spp.,* respectively. This is similar also to an orthopedic hospital in India where the most common Gram-negative bacterial pathogens were *E. coli*, *Pseudomonas spp.,* and *Proteus* while the most common Gram-positive bacterial pathogen was *Staphylococcus aureus (Agrawal, Jain, Jain,, & Raza, 2008)*. Same as the one reported by The Surveillance Network (a network of 300 laboratories in the USA) (Rubio, Oliveira, Rangel, Nogueira, & Almeida, 2013), *Staphylococcus aureus* was the most prevalent resistant Gram-positive cocci accounting for almost half (47.5%) of the total number of cases that remained relatively stable over a decade (Rubio, Oliveira, Rangel, Nogueira, & Almeida, 2013). Valinteliene, Gailiene, & Berzanskyte (2011) did a microbial investigation of HAIs and leading pathogens in Lithuania and the most common Gram-positive microorganism that they identified was *Staphylococcus aureus*, while the most common Gram-negative microorganisms were *Escherichia coli* and *Pseudomonas aeruginosa* in 2003 and 2007, and *Escherichia coli* and *Klebsiella pneumoniae* in 2005.

This study showed that *Enterobacter spp.* was the leading bacterial pathogen; the National Healthcare Safety Network (NHSN) reported this species as the eighth most common cause of HAIs (5% of all infections) and the fourth most common Gram-negative cause of HAIs between 2006 and 2007 (Hidron, et al., 2006-2007). In the current study, 24.9% of the bacterial pathogens at the OPD were *Enterobacter spp*. as opposed to the study of Fraser and Sinave (2015) which stated that community-acquired *Enterobacter* infections are rarely reported. This result regarding *Enterobacter spp*. and the reasons for the deviation from previous studies warrant further investigation.

The second most commonly occurring bacterial pathogen in this study was *Proteus spp.* This result is consistent with other studies since this species can be found in the community, long-term care facilities, and hospitals (Agrawal, Jain, Jain,, & Raza, 2008; Pandey, Narayan, & Tyagi, 2013; Douglas, 2000; Emori, 1993). In hospital settings, it is normal for Gram-negative bacilli to inhabit the skin and oral mucosa of both patients and hospital personnel, yet, this species is not the frequent cause of nosocomial infections (Gonzalez & Bronze, 2015). This species has a diverse mode of transmission causing infections in different anatomical sites(Pandey, Narayan, & Tyagi, 2013).

In the current study, *E. coli* ranked the 4th most commonly occurring bacterial pathogen (10.1%) whereas in an orthopedic hospital in India (Agrawal, Jain, Jain,, & Raza, 2008), it was the leading pathogen (34.4% cases). This result and the reasons for the deviation from previous studies warrant further investigation as well.

Common Pathogens According to Body Site

This study showed that the most commonly occurring bacterial pathogens came from the respiratory tract (sputum, tracheal aspirate, throat swab, and others) which included the following: *Enterobacter spp.*, *Pseudomonas aeruginosa,* and *Pseudomonas spp.*; from urine which included *Escherichia coli, Enterobacter spp.*, and *Proteus spp.*; and from wound which included *Enterobacter spp.*, *Staphylococcus aureus*, and *Proteus spp.*, respectively. Similarly, studies at a local hospital revealed that pneumonia (66%), urinary tract (31%), and surgical site (23%) were predominant infection sites contributed by *Enterobacteriaceae (Zoleta, Alejandria, & Berba, 2004).* The Centers for Disease Control and Prevention (2014) identified *Klebsiella, Proteus spp., Acinetobacter spp., Enterococcus spp.*, *Serratia, Pseudomonas aeruginosa, Escherichia coli,* and *Staphylococcus spp.* in the urinary tract (Vanchhawng & Climaco, 2013; Kibret & Abera, 2014) and *Haemophilus influenzae*, *Streptococcus pneumonia, Staphylococcus aureus, Enterobacteriaceae, Pseudomonas aeruginosa* in the respiratory tract (Kibret & Abera, 2014 ; Kishner, Khan, & Laborde, 2014 ; Brusselaers, Labeau, Vogelear, & Blot, 2012). *S. aureus* is the most common pathogenic organism recovered from bone, followed by *Pseudomonas,* and *Enterobacteriaceae (Kishner, Khan, & Laborde, 2014).* In Europe, the most common types of infections are urinary tract infections, followed by respiratory tract infections, infections after surgery, bloodstream infections, and others (including diarrhea due to *Clostridium difficile*) (European Centre for Disease Prevention and Control, 2015). There are notable deviations on the distribution of isolated organisms especially on respiratory tract samples which warrant further investigation.

Common Pathogens According to Clinical and Special Areas in the Hospital

In this study, 72.4% of the specimens sent per area having a positive bacterial result were from Spinal/Rehabilitation Ward, followed by Observation Unit (59.5%), and Male Service A (50%), respectively. It is also notable to mention that more than one third of these pathogens came from the Out-patient Department (39.9%) and Emergency Room (39.3%), the areas where patients from the community are seen or admitted into the hospital.

The Spinal/Rehabilitation Ward had the most distribution of bacterial pathogens likely because patients admitted in this area are those that require long and repeated hospital stays. In the Spinal/Rehabilitation Ward, patients usually receive high-dose glucocorticoids, possess neurogenic bladder, and suffer from frequent episodes of UTI caused by urinary stasis and frequent catheterization (Montgomerie, 1997). Moreover, skin breakdown, immobility, disuse-induced muscle atrophy, urinary leakage, fecal contamination, stress, malnutrition, renal failure, paralytic ileus, and abnormal state of consciousness caused by associated head injury can predispose patients to aspiration pneumonia, infection of pressure sores, and others which result to a higher rate of hospital-acquired infections than the other groups of patients (Darouiche, 2015). Similar to this study, *E. coli, Proteus spp.,* and species of *Pseudomonas, Staphylococcus aureus, Klebsiella*, streptococci, and *Enterococcus* are the most commonly occurring bacterial pathogens among these types of patients(Montgomerie, 1997).

The Observation Unit ranked as the second to the highest area where most of the bacterial pathogens were obtained. This area, which is similar to the ICU of other institutions, had 59.5% of samples which had positive growth for bacterial pathogens. Thirty percent of the ICU-patients in the study of Volles (2008) were affected by HAIs and they occur five to ten times more often than in non-ICU patients (De Oliveira Costa, Atta, & Da Silva, 2015). Patients admitted at OU are in-patients from other wards, except Emergency Ward (EW) and Spinal Ward (SW) who had been evaluated to be critically ill, deteriorating and needs close monitoring, in respiratory distress with different contraptions like endotracheal tubes, mechanical ventilators, nasogastric tube, and chest tube. This result was the same with the literature (Rubio, Oliveira, Rangel, Nogueira, & Almeida, 2013) where the numbers of multi-drug resistant and Gram-negative bacterial pathogens were statistically higher in the ICU compared to the other units. Almost 75,000 gram-negative microorganisms were isolated from ICU patients in the United States between 1993 and 2004 and *Enterobacter spp.* comprised 13.5% of the isolates (Lockhart, Abramson, & Beekmann, 2007). Also, in the ICU, the chance of acquiring nosocomial infections are greater than in general wards since patients are predominantly hooked to invasive devices and their exposure to a larger number of antibiotic-resistant pathogens are high (Meng, et al., 2011). In a local government hospital, the most common isolates in their ICU are the following: *Klebsiella pneumoniae* (41.6%), *Escherichia coli* (17.5%), *Enterobacter cloacae* (16.8%), and *Klebsiella ozanae* (10.3%) (Zoleta, Alejandria, & Berba, 2004). In a study at a large tertiary-care center, most of the resistant isolates were obtained from acute wards (42.9%) and intensive care units (ICUs) (29.5%), followed by other wards (23.2%) and the out-patient department (OPD) (4.4%) (Bhatt, Tandel, Shete, & Rathi, 2015).

Common Pathogens Resistant to Antibiotics

It is also important to mention the type of specimen where there were bacterial pathogens with increasing resistance in the current study. Most of *Pseudomonas aeruginosa* and *Pseudomonas spp*. are found in the respiratory tract (17%), wound (10.1%), & soft tissue (5.55%), respectively.

In the current study, it is notable that the most number of above mentioned bacteria were obtained from Out-patient Department (11.1%), followed by Male Service B (9.65%), and Spinal/Rehabilitation Ward (9.5%). The Out-patient Department accepts new patients from the community, referred patients from other institutions, and follow-up patients who were previously seen or admitted at the hospital. Hence, these resistant organisms may be either community- or hospital-acquired. Male Service B is a ward where male patients with musculoskeletal disorders not requiring traction and scheduled for surgery regardless of wound culture result are transferred. Patients in this ward also include those who underwent surgery whose culture and sensitivity results revealed positive for infectious microorganisms such as spore-forming bacilli and *Pseudomonas*. *Pseudomonas aeruginosa* and *Pseudomonas ssp.* can commonly be seen in patients who are debilitated, with longer hospital stay, and patients with compromised host defense mechanisms similar to those patients in Spinal/Rehabilitation Ward. These patients are also susceptible due to placement of intravenous lines, urinary tract catheterization, and trauma (Friedrich & Lessnau, 2015). Furthermore, hospital-acquired infections are usually caused by interruption of the closed sterile system by hospital personnel.

The increasing rates of drug resistance of both Gram-negative and positive pathogens are being documented in many hospitals (Nurain, Bilal, & Ibrahim, 2015). This study demonstrated increasing resistance rates of Gram-negative bacterial pathogens to cefazolin and netilmicin. On the other hand, Gram-positive bacterial pathogens had increasing resistance rates to cefazolin which is in opposition with a study done at an ICU of a teaching hospital affiliated to a medical school where Gram-positive cocci were assessed for resistance to penicillin and oxacillin (Rubio, Oliveira, Rangel, Nogueira, & Almeida, 2013).

Antimicrobial Susceptibility Patterns and Trends

The antimicrobial susceptibilities of the most commonly occurring bacterial pathogens suggest an alarming pattern of antibiotic resistance specifically in *Enterobacter spp*. and *Pseudomonas aeruginosa*. It was found out that cefepime, ceftazidime, and amikacin were the three most effective antibiotics against the Gram-negative organisms. On the other hand, vancomycin, amoxicillin-clavulanic acid, and gentamycin are the three most effective antibiotics against Gram- positive bacterial isolates.

In the 6-year surveillance study (Rosenthal, et al., 2008) where they included intensive care units (ICUs) in Latin America, Asia, Africa, and Europe (using CDC's NNIS definitions), they had reported *Enterobacter spp.* resistance to ceftriaxone. Conversely in this study, *Enterobacter spp.* remained susceptible to ceftriaxone for the three-year study period (65.76%-77.13%).

Since the susceptibility profile of *Proteus spp*. remained steady for most agents, continued utilization of most of the antibiotics that are being used against this species is possible except for cefalexin and cefazolin. In a study where they had isolated and characterized the urine of male students of the University of Abuja, it was revealed that *Proteus spp*. were susceptible to ciprofloxacin, gentamycin, pefloxacin, and sparfloxacin and as such are suitable for the treatment of urinary tract infections caused by these pathogens (Ugoh, Nneji, & Umoru, 2013). In a similar study, this species were highly resistant to ampicillin (40.5%) and least resistant to cefotaxime (10.1%), ciprofloxacin (6.1%), and pefloxacin (4.7%) (Yah, Eghafona, Oranusi, & Abouo, 2007). Susceptibility of *Proteus spp*. to ciprofloxacin in the current study increased from 78.47%-83.24% for the three-year study period. Moreover, gentamycin being available in this institution may also be considered to treat infections caused by *Proteus spp*.

The current study revealed susceptibility of *Staphylococcus aureus* to oxacillin which, however, appears decreased in 2014. This is in contrast to a study in a Pediatric Care Unit in Mangalore (Prabhu, Bhat, & Rao, 2010) where 63.4% of the *S. aureus* strains showed resistance to penicillin. Similar in this study, vancomycin remains the drug of choice for the Gram-positive bacterial isolates (Prabhu, Bhat, & Rao, 2010). Furthermore, WHO (2014) reported resistance of *Staphylococcus aureus* to beta-lactam antibacterial drugs (methicillin, methicillin-resistant *S. aureus* [MRSA]).

In this study *Escherichia coli* was found resistant to cefazolin and was susceptible to amikacin, nitrofurantoin, cefepime, netilmicin, and ceftazidime for the three- year study period. In another local government hospital, very high resistance rates of *Escherichia coli* were seen against co-trimoxazole and chloramphenicol (69% and 53%) but relatively lower resistance rates to aminopenicillins (34% & 40%), 2nd and 3rd generation cephalosporins (20-32%), and ciprofloxacin (28%) (Zoleta, Alejandria, & Berba, 2004). It had fair resistance rate to amikacin (11%), very low resistance rate to cefepime (2%), and no resistance was seen with piperacillin-tazobactam and carbapenems (Zoleta, Alejandria, & Berba, 2004). In a 2-year study of evaluating antibiotic resistance profiles in nosocomial blood stream and urinary tract pathogens in Besat Hospital in Iran (Ghadiri, Vaez, Khosravi, & Soleymani, 2012), *E. coli*'s highest resistance rate was against nalidixic acid (57.7%). WHO (2014) reported resistance of *E. coli* to third-generation cephalosporins and to fluoroquinolones.

The results for *Pseudomonas aeruginosa* suggested susceptibility to netilmicin, cefepime, ceftriaxone, and amikacin. *Pseudomonas aeruginosa* in this study had high susceptibility to ciprofloxacin for the three year period. In contrast to the 6-year surveillance study from 2002-2007 of Rosenthal, et al. (2008) where they included intensive care units (ICUs) in Latin America, Asia, Africa, and Europe (using CDC's NNIS definitions), they had reported higher *Pseudomonas aeruginosa* resistance to fluoroquinolones (Rosenthal, et al., International Nosocomial Infection Control Consortium report, data summary for 2002-2007, 2008).

This study suggested high susceptibility of Coagulase-negative *staphylococci spp*. to vancomycin. It is also interesting to note the increasing resistance rate against amoxicillin (10.92%-22.66%) for 3 consecutive years. This result is similar to a 2-year study of evaluating antibiotic resistance profiles in nosocomial blood stream and urinary tract pathogens in Besat Hospital in Iran (Ghadiri, Vaez, Khosravi, & Soleymani, The Antibiotic Resistance Profiles of Bacterial Strains Isolated from Patients with Hospital-Acquired Bloodstream and Urinary Tract Infections, 2012), where Coagulase-negative *staphylococci spp.* was highly resistant to penicillin (91.1%), followed by ampicillin (75.6%), and the lowest rate was against vancomycin (4.4%).

Conclusion and Recommendations

In conclusion, the variability in the resistance patterns might be attributed to the status of antibiotic use in the hospital. This study reiterated the significance of having data on the bacteriological profile of the hospital that will serve as a guide in the modification of drug regimen strategy. Fostering rational antibiotic use is an important step in formulating infection control guidelines that will match the unique setting of the institution.

This study emphasizes the need for the following: (1) employment of an efficient infection control program to establish a rational antibiotic stewardship for the sustainable management of such infections and outcome evaluation through measurement of success of infection control techniques, (2) training about transmission risks and preventive measures for health and non-health professionals, (3) benchmarking in hospital-acquired infections through monthly surveillance data on infection rate and type of infection, networking opportunities, annual reports, and infection audits, and (4) availability of written guidelines and infection control manual. Nurses have the responsibility to (1) consistently apply evidence-informed measures to prevent and control transmission of microorganisms, (2) exercise clinical judgement relevant to each patient situation and infection prevention and control practices, (3) reduce the risk to self and others by handling, cleaning and disposing of materials, equipment and waste according to best practice, and (4) use effective and timely communication strategies with patients and their significant others, the health care team, and the community when discussing infection prevention and control issues.

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"You can't learn how to tell someone else's story until you first learn how to tell your own…You can't analyze others until you've analyzed yourself."

- Johnny Saldaña, 2018