ISSN 0976 – 3333

Available Online at www.ijpba.info

International Journal of Pharmaceutical & Biological Archives 2011; 2(6):1598-1610

REVIEW ARTICLE

Antibiogram of Nosocomial Infections and Its Antimicrobial Drug Resistance

P.Saranraj* and D.Stella

Department of Microbiology,Annamalai University,Annamalai Nagar,Chidambaram – 608 002, Tamil Nadu, India

Received 29 Aug 2011; Revised 03 Nov 2011; Accepted 09 Nov 2011

ABSTRACT

Nosocomial infections occur worldwide and affect both developed and resource-poor countries. Infections acquired in health care settings are among the major causes of death and increased morbidity among hospitalized patients. Antibiograms are the aggregate percentages of organisms susceptible to various antibiotics on a hospital formulary and are usually presented on an annual basis. The main purpose of this information is to guide empiric antimicrobial therapy before specific patient culture results are available. The prevalence of nosocomial infection causing bacteria and their antimicrobial susceptibility pattern are reviewed in this study. Antibiograms are used to track the antibiotic resistance patterns of clinically important microorganisms detected by laboratories. Hospital antibiograms can be used to provide useful information for the selection of an empiric therapy for a presumptive diagnosis as well as detect trends towards antimicrobial resistance. Hospital laboratories usually generate an antibiogram from every six to twelve months and the data is then entered into an antibiogram database. Limitations of hospital antibiograms are that they do not sort out community-acquired infections from nosocomial infections and some laboratories may not thoroughly unduplicate their data, thus giving a picture of a larger number of resistant isolates than is the case. This review assesses the following topics: Impact of nosocomial infection, Nosocomial infection sites, Microorganisms causing nosocomial infections, Methods of acquisition of nosocomial infections, Antimicrobial use and drug resistance in nosocomial infection, Antibiogram of nosocomial infection causing bacteria and Limitation of antibiogram.

Key words: Nosocomial infections, Antimicrobial therapy, Antibiogram, Antibiotics and Antimicrobial drug resistance.

1. INTRODUCTION

A nosocomial infection also called “hospital acquired infection” can be defined as: An infection acquired in hospital by a patient who was admitted for a reason other than that infection. An infection occurring in a patient in a hospital or other health care facility in whom the infection was not present or incubating at the time of admission. This includes infections acquired in the hospital but appearing after discharge, and also occupational infections among staff of the facility [1].

Nosocomial infections may also be considered either endemic or epidemic. Endemic infections are most common. Epidemic infections occur during outbreaks, defined as an unusual increase above the baseline of a specific infection or infecting organism. Changes in health care delivery have resulted in shorter hospital stays and increased outpatient care. It has been suggested the term nosocomial infections should encompass infections occurring in patients receiving treatment in any health care setting. Infections acquired by staff or visitors to the hospital or other health care setting may also are considered as nosocomial infections.

Nosocomial infections occur worldwide and affect both developed and resource-poor countries. Infections acquired in health care settings are among the major causes of death and increased morbidity among hospitalized patients. They are a significant burden for the patients and for public health. A prevalence survey conducted under the auspices of WHO in 55 hospitals of 14 countries representing 4 WHO Regions (Europe, Eastern Mediterranean, South-East Asia and Western Pacific) showed an average of 8.7% of hospital patients had nosocomial infections. At any time, over 1.4 million people worldwide suffer from infectious complications acquired in hospital [2].

The highest frequencies of nosocomial infections were reported from hospitals in the Eastern

***Corresponding Author:** P.Saranraj**, Email:** microsaranraj@gmail.com, **Phone No:** +91- 9994146964

Mediterranean and South-East Asia Regions (11.8 and 10.0% respectively), with a prevalence of 7.7 and 9.0% respectively in the European and Western Pacific Regions. The most frequent nosocomial infections are infections of surgical wounds, urinary tract infections and lower respiratory tract infections. The WHO studies, and others, have also shown that the highest prevalence of nosocomial infections occur in intensive care units and in acute surgical and orthopaedic wards. Infection rates are higher among patients with increased susceptibility because of old age, underlying disease, or chemotherapy [3].

Nosocomial infections in the developing countries pose greater threats to patient safety than in Western countries. In West, the crude mortality rate for patients with device-associated infections ranged from 35.2% (for CVC-associated bloodstream infection) to 44.9% (for VAP) [4]. In India, *Pseudomonas aeruginosa* was the commonest species isolated from VAP patients in ICUs (55%) and from wound infections (59%) with high mortality rates ranging from 16% to 46%. Emergence of MDR in *Pseudomonas aeruginosa* in many hospitals across the country is of great concern [5].

Patients are exposed to a variety of microorganisms during a hospital stay, but contact between a patient and an organism does not necessarily guarantee infection. Other factors influence the nature and frequency of infections. Organisms vary in resistance to antimicrobials and in intrinsic virulence. Bacteria, viruses, fungi, and parasites can all cause nosocomial infections. There are multiple ways of acquiring such an organism. The organisms can be transferred from one patient to another (cross-infection). They can be part of a patient's own flora (endogenous infection). They can be transferred from an inanimate object or from a substance recently contaminated by another human source (environmental transfer). The organisms that cause most hospital acquired infections are common in the general population, in which setting they are relatively harmless. They may cause no disease or a milder form of disease than in hospitalized patients [6].

The organisms that cause nosocomial infections are often drug-resistant. The regular use of antimicrobials for treatment therapy or prophylaxis promotes the development of resistance. Through antimicrobial-driven selection and the exchange of genetic resistance elements, multi-drug resistant strains of bacteria emerge. Antimicrobial-sensitive microorganisms that are part of the endogenous flora are suppressed, while the resistant strains survive. Many strains of *Pneumococci*, *Staphylococci*, *Enterococci*, and *Mycobacterium* are currently resistant to most or all antimicrobials which were once effective. This present review detailly explains about the nosocomial infections and its antimicrobial drug resistance.

2. IMPACT OF NOSOCOMIAL INFECTION

Hospital-acquired infections add to functional disability and emotional stress of the patient and may in some cases, lead to disabling conditions that reduce the quality of life. Nosocomial infections are also one of the leading causes of death. The economic costs are considerable. The increased length of stay for infected patients is the greatest contributor to cost. Coella (2003)[7] showed that the overall increase in the duration of hospitalization for patients with surgical wound infections was 8.2 days, ranging from 3 days for gynaecology to 9.9 for general surgery and 19.8 for orthopaedic surgery. Prolonged stay not only increases direct costs to patients or payers but also indirect costs due to lost work. The increased use of drugs, the need for isolation, and the use of additional laboratory and other diagnostic studies also contribute to costs.

Hospital-acquired infections add to the imbalance between resource allocation for primary and secondary health care by diverting scarce funds to the management of potentially preventable conditions. The advancing age of patients admitted to health care settings, the greater prevalence of chronic diseases among admitted patients, and the increased use of diagnostic and therapeutic procedures which affect the host defenses will provide continuing pressure on nosocomial infections in the future. Organisms causing nosocomial infections can be transmitted to the community through discharged patients, staff, and visitors. If organisms are multiresistant, they may cause significant disease in the community [8].

3. NOSOCOMIAL INFECTION SITES

3.1. Urinary infections

Urinary infection is the most common nosocomial infection; 80% of infections are associated with the use of an indwelling bladder catheter [9]. Urinary infections are associated with less morbidity than other nosocomial infections, but can occasionally lead to bacteremia and death. Infections are usually defined by microbiological criteria: positive quantitative urine culture ($\geq 10^{5}$" microorganisms/ml, with a maximum of 2 isolated

microbial species). The bacteria responsible arise from the gut flora, either normal (*Escherichia coli*) or acquired in hospital (multi-resistant *Klebsiella*).

3.2. Surgical infection site

Surgical site infections are also frequent: the incidence varies from 0.5 to 15% depending on the type of operation and underlying patient status. These are a significant problem which limits the potential benefits of surgical interventions. The impact on hospital costs and postoperative length of stay (between 3 and 20 additional days) is considerable. The definition is mainly clinical: purulent discharge around the wound or the insertion site of the drain, or spreading cellulitis from the wound. Infections of the surgical wound (whether above or below the aponeurosis), and deep infections of organs spaces are identified separately. The infection is usually acquired during the operation itself; either exogenously (e.g. from the air, medical equipment, surgeons and other staff), endogenously from the flora on the skin or in the operative site or, rarely, from blood used in surgery [10].

The infecting microorganisms are variable, depending on the type and location of surgery, and antimicrobials received by the patient. The main risk factor is the extent of contamination during the procedure (clean, clean contaminated, contaminated, dirty), which is to a large part dependent on the length of the operation, and the patient's general condition [11]. Other factors include the quality of surgical technique, the presence of foreign bodies including drains, the virulence of the microorganisms, concomitant infection at other sites, the use of preoperative shaving, and the experience of the surgical team.

3.3. Nosocomial pneumonia

Nosocomial pneumonia occurs in several different patient groups. The most important are patients on ventilators in intensive care units, where the rate of pneumonia is 3% per day. There is a high case fatality rate associated with ventilator-associated pneumonia, although the attributable risk is difficult to determine because patient co-morbidity is so high. Microorganisms colonize the stomach, upper airway and bronchi, and cause infection in the lungs (pneumonia): they are often endogenous (digestive system or nose and throat), but may be exogenous, often from contaminated respiratory equipment [12].

The definition of pneumonia may be based on clinical and radiological criteria which are readily available but non-specific: recent and progressive radiological opacities of the pulmonary parenchyma, purulent sputum, and recent onset of fever. Diagnosis is more specific when quantitative microbiological samples are obtained using specialized protected bronchoscopy methods. Known risk factors for infection include the type and duration of ventilation, the quality of respiratory care, severity of the patient's condition (organ failure), and previous use of antibiotics [13].

Apart from ventilator-associated pneumonia, patients with seizures or decreased level of consciousness are at risk for nosocomial infection, even if not intubated. Viral bronchiolitis (Respiratory Syncytial Virus, RSV) is common in children's units, and influenza and secondary bacterial pneumonia may occur in institutions for the elderly. With highly immunocompromised patients, *Legionella* spp. and *Aspergillus* pneumonia may occur. In countries with a high prevalence of tuberculosis, particularly multiresistant strains, transmission in health care settings may be an important problem [14].

3.4. Nosocomial bacteremia

These infections represent a small proportion of nosocomial infections (approximately 5%) but case fatality rates are high more than 50% for some microorganisms. The incidence is increasing, particularly for certain organisms such as multiresistant Coagulase-negative *Staphylococcus* and *Candida* sp. [15]. Infection may occur at the skin entry site of the intravascular device, or in the subcutaneous path of the catheter (tunnel infection). Organisms colonizing the catheter within the vessel may produce bacteremia without visible external infection. The resident or transient cutaneous flora is the source of infection. The main risk factors are the length of catheterization, level of asepsis at insertion, and continuing catheter care [16].

3.5. Other nosocomial infections

These are the four most frequent and important nosocomial infections, but there are many other potential sites of infection. For example:

- Skin and soft tissue infections: open sores (ulcers, burns and bedsores) encourage bacterial colonization and may lead to systemic infection.
- Gastroenteritis is the most common nosocomial infection in children, where rotavirus is a chief pathogen: *Clostridium difficile* is the major cause of nosocomial gastroenteritis in adults in developed countries.

- Sinusitis and other enteric infections, infections of the eye and conjunctiva.
- Endometritis and other infections of the reproductive organs following child birth.

4.MICROORGANISMS CAUSING NOSOCOMIAL INFECTIONS

Many different pathogens may cause nosocomial infections. The infecting organisms vary among different patient populations, different health care settings, different facilities, and different countries.

4.1. Bacteria

Commensal bacteria found in normal flora of healthy humans. These have a significant protective role by preventing colonization by pathogenic microorganisms. Some commensal bacteria may cause infection if the natural host is compromised. For example, cutaneous Coagulase negative *Staphylococci* cause intravascular line infection and intestinal *Escherichia coli* are the most common cause of urinary infection [17].

Pathogenic bacteria have greater virulence, and cause infections (sporadic or epidemic) regardless of host status. For example: Anaerobic Gram-positive rods (e.g. *Clostridium*) cause gangrene. Gram-positive bacteria: *Staphylococcus aureus* (cutaneous bacteria that colonize the skin and nose of both hospital staff and patients) cause a wide variety of lung, bone, heart and bloodstream infections and are frequently resistant to antibiotics; beta-haemolytic *Streptococci* are also important [18].

Gram-negative bacteria: Enterobacteriaceae (e.g. *Escherichia coli*, *Proteus*, *Klebsiella*, *Enterobacter*, *Serratia marcescens*), may colonize sites when the host defences are compromised (catheter insertion, bladder catheter, cannula insertion) and cause serious infections (surgical site, lung, bacteremia, peritoneum infection). They may also be highly resistant. Gram-negative organisms such as *Pseudomonas* spp. are often isolated in water and damp areas. They may colonize the digestive tract of hospitalized patients. Selected other bacteria are a unique risk in hospitals. For instance, *Legionella* species may cause pneumonia (sporadic or endemic) through inhalation of aerosols containing contaminated water (air conditioning, showers, therapeutic aerosols) [19].

Serratia marcescens, a member of the tribe Klebsiellae, has been reported with increasing frequency as a cause of nosocomial infection. Urinary tract infection, bacteremia, respiratory tract infection and wound infection involving *Serratia marcescens* have been often encountered in hospitalized patients with severe underlying diseases. Most of *Serratia marcescens* strains are resistant to β-lactam compounds, aminoglycosides, nalidixic acid and colistin. The mechanism of antimicrobial resistance is mostly due to drug inactivating enzymes such as jS-lactamase mediated by R-plasmids [20].

Infections caused by *Pseudomonas aeruginosa* are particularly problematic because the organism is inherently resistant to many drug classes and is able to acquire resistance to even most potent antimicrobial drugs [21]. The high intrinsic antibiotic resistance of this organism is attributed to factors such as active drug efflux and β-lactamase production [22]. Extensive and increasing use of broad-spectrum antibiotics in India both in community as well as in hospitals located in urban metropolitan cities [23] has served to eliminate competing bacteria and created a vacant ecological niche, which might enhance the ability of particular resistant clones to colonize and subsequently cause infection in susceptible patients.

Pseudomonas aeruginosa is implicated in a wide spectrum of nosocomial infections, including bacteremia, secondary meningitis, wound infection, severe sepsis, ocular and urinary tract infection, but their most important role appears to be as agents of nosocomial pneumonia, particularly ventilator-associated pneumonia (VAP) in patients confined to hospital intensive care units (ICUs). Chronically infected cystic fibrosis patients also known to be colonized by distinct strains of *Pseudomonas aeruginosa*. These organisms seem to have a remarkable ability to acquire antibiotic resistance genes, to persist in the hospital environment and to spread easily from patient to patient [24]. Outbreaks of multiresistant *Pseudomonas aeruginosa* infection in hospitals with efficient infection control policies may be due to advanced invasive procedures adopted in ICUs. Such situations have also resulted in the dissemination of only a few particular persistent resistant clones in hospitals [25].

Staphylococcus aureus is recognized worldwide as a common cause of infection in humans and animals. *Staphylococcus aureus* produces a spectrum of exotoxins and other determinants of virulence that contribute to its pathogenicity. *Staphylococcal* enterotoxins (SEs) are recognized as being the most important virulence factors involved in cases of food poisoning in humans [26]. In Korea, food poisoning outbreaks occurred

primarily by consumption of meat (27.9%), shellfish and its processed products (26%), and ready-to eat meals (24%), such as *kimbap* and packed lunch boxes, according to the food poisoning statistic data reported by the Korean Food and Drug Administration between 2000 and 2002 [27]. In fact, 9.62% of food poisoning outbreaks in Korea have been caused by *Staphylococcus aureus*, the third most common pathogen being outnumbered only by *Vibrio parahaemolyticus* and *Salmonella* species [28].

Staphylococcus aureus is a dangerous pathogen and one of the most common causative agents of hospital infections (nosocomial infections) in human beings. Surface of vegetables may be contaminated by this organism through human handling and other environmental factors and can be able to survive for several weeks. Human skin and nasal cavity is the main reservoir of *Staphylococci*. Contamination of food stuffs during distribution and handling may allow bacterial growth and subsequently production of toxins which may represent a potential risk to humans [29].

4.2. Viruses

There is the possibility of nosocomial transmission of many viruses, including the Hepatitis B and C viruses (transfusions, dialysis, injections, endoscopy), Respiratory Syncytial Virus (RSV), Rotavirus, and Enteroviruses (transmitted by hand-to-mouth contact and *via* the faecal-oral route). Other viruses such as Cytomegalovirus, HIV, Ebola, Influenza viruses, Herpes simplex virus, and Varicella-Zoster Virus, may also be transmitted [30].

4.3. Parasites and fungi

Some parasites (e.g. *Giardia lamblia*) are transmitted easily among adults or children. Many fungi and other parasites are opportunistic organisms and cause infections during extended antibiotic treatment and severe immunosuppression (*Candida albicans*, *Aspergillus* spp., *Cryptococcus neoformans* and *Cryptosporidium*). These are a major cause of systemic infections among immunocompromised patients. Environmental contamination by airborne organisms such as *Aspergillus* spp. which originate in dust and soil is also a concern, especially during hospital construction. *Sarcoptes scabies* (scabies) is an ectoparasite which has repeatedly caused outbreaks in health care facilities [31].

5. METHODS OF ACQUISITION OF NOSOCOMIAL INFECTION

Bacteria that cause nosocomial infections can be acquired in several ways. Endogenous infections can develop from the endogenous or transient flora of the patient. When bacteria present in the normal flora are transmitted to sites outside of their normal environment like the urinary tract, they can cause infection. Infection can also occur with tissue damage (wound) or with inappropriate antibiotic therapy that allows overgrowth of endogenous bacteria like *Clostridium difficile*. Exogenous cross-infection can occur with transfer of an organism from one patient or member of the staff to another patient or member of staff. The WHO guide summarizes this idea with the following statement:

Bacteria are transmitted between patients: (a) through direct contact between patients hands, saliva droplets or other body fluids), (b) in the air (droplets or dust contaminated by a patient's bacteria), (c) *via* staff contaminated through patient care (hands, clothes, nose and throat) who become transient or permanent carriers, subsequently transmitting bacteria to other patients by direct contact during care, (d) *via* objects contaminated by the patient (including equipment), the staff's hands, visitors or other environmental sources (e.g. water, other fluids, food). A final route of acquisition is through flora from the healthcare environment.

Certain microorganisms do well in the hospital environment. They may live in water, in damp areas, in sterile products or disinfectants (*Pseudomonas*, *Acinetobacter*, *Mycobacterium*), in linens, in food, in fine dust and droplet nuclei, and in equipment and supplies used in care [32]. People are central to all of these routes of transmission. They are the main reservoir and source for microorganisms. They are the main transmitters of organisms, and they are the receptors of organisms, in consequence becoming new reservoirs.

6. ANTIMICROBIAL USE AND DRUG RESISTANCE IN NOSOCOMIAL INFECTION

Resistance commonly involves plasmid-mediated production of drug modifying enzymes. The widespread occurrence of resistance appears to reflect the dissemination of R plasmids or resistance plasmids encoding these enzymes among bacterial species that prosper in the hospital environment. R plasmids are small extra-chromosomal genetic elements, which code for resistance to antibiotics, usually to several antibiotics. These may be transferable to bacteria belonging to the same or to different species

through conjugation, converting the recipients to resistance. There are many problems today in the use of antimicrobials. Problems include overprescribing, administration of sub-optimal doses, too short of a treatment period, and misdiagnosis leading to an inappropriate choice of agent. These problems lead to the emergence of resistant organisms that are spread when hand washing, barrier precautions and equipment cleaning are not optimal.

The World Health Organization offers guidelines for effective prescribing. They maintain that each healthcare facility should have its own effective use program. Some general guidelines include prescribing an antimicrobial with as narrow a spectrum as possible, using an antimicrobial that can be justified by the clinical diagnosis, and obtaining appropriate specimens for bacteriological examination prior to initiation of treatment. Using an appropriate dose is also emphasized; too low of a dose may not treat the infection and may also promote resistance. The WHO guide summarizes these ideas with the statement, "The aim of antimicrobial therapy is to choose a drug that is selectively active against the most likely pathogen(s) and the least likely to cause adverse effects or promote resistance".

When transmission of resistant organisms does occur, specific control measures must be instituted. These resistant organisms often cause nosocomial infections. Infection control measures for containing outbreaks of antimicrobial resistant organisms begin with identifying reservoirs such as colonized and infected patients and environmental contamination. The next step is stopping transmission by improving hand washing and asepsis, isolating colonized and infected patients, removing common sources, disinfecting the environment, and closing units to new admissions if necessary. The final control measure is to modify a patient's risk by controlling antibiotic use and removing compromising factors [33].

Some strains of Methicillin-resistant *Staphylococcus aureus* are particularly capable of causing nosocomial infections. These strains are often resistant to multiple antibiotics and sometimes are only sensitive to vancomycin and teicoplanin. Infections caused by MRSA are similar to those caused by methicillin sensitive strains (wound infections, lower respiratory and urinary tract infections, septicemia, infections of sites for invasive devices, pressures sores, burns and ulcers. MRSA has the potential for epidemic spread, regionally and nationally. Vancomycin-resistant *Enterococci* are also known causes of nosocomial infections [34].

The WHO suggests that all hospitals should have an Antimicrobial Use Committee. This committee bought to have a "simple, flexible and regularly updated antibiotic-prescribing policy on a disease specific basis, relying whenever possible on knowledge of prevailing antibiotic-sensitivity patterns and controlled use of reserve antibiotics." The hospital microbiology laboratory is very important in controlling antibiotic resistance. This lab should test for susceptibility, work with the Antimicrobial Use Committee, monitor and report trends in the prevalence of bacterial resistance to antimicrobial agents, and notify infection control of any unusual patterns of bacterial resistance. Antimicrobial use in healthcare facilities must be monitored, usually by the pharmacy department. These data are then reported to the Antimicrobial Use Committee and the Medical Advisory Committee. Occasional audits should then be undertaken to determine the appropriateness of antimicrobial use [35].

Nowadays, prevalence of MDR strains of *Pseudomonas aeruginosa* are seen mainly in hospital acquired infections due to the selective pressure exerted on the bacteria by over usage of broad-spectrum antibiotics. In a study carried out in Turkey, Chen *et al*. (1997)[36] isolated 60-83% multidrug-resistant *Pseudomonas aeruginosa* strains from ICU patients. These strains were resistant to Ceftazidime (34%), Imipenem (26%), Gentamicin (67%), and Amikacin (26%).

In another survey in Italy Singh *et al*., (2006)[37] reported that Meropenem followed by Amikacin was most effective drug against *Pseudomonas* infections. In Spain, Weber *et al.* (1999)[38] found that isolates from their intensive care units were more resistant to Aztreonam, Cefepime, Ceftazidime, Imepenem, Ticarcillin, piperacillin, and tazobactam than those from other clinical settings; isolates from their indoor patients were significantly often resistant to Ceftazidime, Imepenem, and Meropenem; and isolates from their outdoor patients were more often resistant to ciprofloxacin than were nosocomial isolates. Resistance to aminoglycosides is higher in Southern Europe than in Central and Northern Europe. Reports of the susceptibility of *Pseudomonas aeruginosa* to Gentamicin and Tobramycin have ranged from 49.8% to 77.7% in Greece, to as high as 96.6% to 99.2% in the United Kingdom. Previous studies reported that antipseudomonas effects of Amikacin were greater than those of Gentamycin.

7. ANTIBIOGRAM OF NOSOCOMIAL INFECTION CAUSING BACTERIA

Three decades ago infection control programmes were created to control antibiotic-resistant nosocomial infections, but numbers of these infections have continued to increase, leading many to question whether control is feasible. Methicillin-resistant *Staphylococcus aureus* and Vancomycin-resistant *Enterococci* were major problems during the 1990s. Many hospitals have tried antibiotic control but with limited efficacy against these pathogens [39].

Studies of antibiotic restriction, substitution, and cycling have been promising, but more definitive data are needed. Increased compliance with hand hygiene would help but is unlikely to control this problem alone as a result of frequent contamination of other surfaces even when hands are cleansed and high transmission rates when hand hygiene is neglected. For 17 years, the Centers for Disease Control and Prevention have recommended contact precautions for preventing nosocomial spread of important antibiotic-resistant pathogens. Many studies confirm that this approach works when sufficient active surveillance cultures are undertaken to detect the reservoir for spread. However, most healthcare facilities have not yet tried this approach.

Anwar Akram (1998)[40] investigated the *Staphylococcus aureus* infections in patients. Of 63 isolates available for analysis, 46 (73.0%) expressed type 8 capsular polysaccharide; 13 (20.7%), type 5 capsular polysaccharide; only 4 isolates (6.3%) did not express type 5 or type 8 antibodies. The strains fitted in 7 different antibiogram types, with the type showing resistance only to penicillin and ampicillin prevalent in 34 out of 63 isolates (54.0%). Of the 12 Methicillin-resistant *Staphylococcus aureus* (MRSA) isolates (19.1%), 8 (66.7%) possessed the type 8 capsule and 4 (33.7%) the type 5 capsule. Analyzing the results of the capsular and antibiogram typing schemes in conjunction proved useful and suggested that such an analysis can be employed as a helpful epidemiological tool in hospitals with limited resources.

Webster *et al*. (1999)[41] compared the molecular relationships and antibiograms of nosocomial isolates of *Acinetobacter* sp. from two acute-care hospitals, with different hospital infection control problems and procedures. In contrast to Nottingham, where randomly amplified polymorphic DNA fingerprinting demonstrated that a single multiresistant strain of *Acinetobacter baumannii* has predominated in the hospital intensive care unit over an 11 year period, the Soweto isolates formed a heterogeneous group of unrelated molecular clusters of different antibiograms, with numerous different strains of *Acinetobacter baumannii*, and *Acinetobacter* sp. apparently being endemic throughout the hospital. The contrasting results illustrate the need to maintain exemplary infection control procedures in hospitals where high standards have been achieved and warn of what might result if such measures are diminished.

Scott Fridkin *et al*. (2001)[42] reported the data during the same months to both the infection-based surveillance and the laboratory-based surveillance. Paired comparisons of the percentage of isolates resistant were made between systems within each ICU. No significant differences existed between the percentage of isolates resistant from the infection-based system and laboratory-based system for all antimicrobial-resistant organisms studied, except methicillin resistance in *Staphylococcus* species. The mean difference in percentage resistance was higher from the infection-based system than the laboratory-based system for *Staphylococcus aureus* and Coagulase-negative *Staphylococci*. Overall, hospital antibiograms reflected susceptibility patterns among isolates associated with hospital-acquired infections. Hospital antibiograms may underestimate the relative frequency of methicillin resistance among *Staphylococcus* species when associated with hospital-acquired infections.

Nabeela Noor *et al*. (2004)[43] assessed the breadth of multidrug resistance among these isolates, culture medium incorporation method was employed using ampicillin, fosfomycin, chloramphenicol, tetracycline, and three aminoglycosides (kanamycin, gentamicin, and streptomycin). Of these isolates, 30% offered multidrug resistance to three or more agents. Among multidrug resistant isolates, 100% were resistant to ampicillin, 47% to streptomycin, 41% to chloramphenicol, gentamicin and tetracycline, 35% offered resistance to kanamycin while only 6% showed resistance to fosfomycin. After curing treatment with acridine orange, some of the isolates lost their resistance, thereby indicating the extrachromosomal location of the resistance determinants.

Yaman *et al*. (2004)[44] investigated the resistance patterns of 570 bacteria (390 Gram-negative, 180 Gram-positive) against meropenem, imipenem, ceftazidime, cefotaxime, cefepime, piperacillin/tazobactam, ciprofloxacin and

tobramycin using the E-test. Extended-spectrum beta-lactamase (ESBL) production was determined using ceftazidime and ceftazidime/clavulanic acid E-test strips. Meropenem was the most effective antibiotic against Gram-negative organisms (89.0%); this was followed by imipenem (87.2%) and piperacillin/tazobactam (66.4%). The most active antibiotic against Gram-positive bacteria was imipenem (87.2%) and this was followed by piperacillin/tazobactam (81.7%) and meropenem (77.8%). The rates of production of ESBL by *Escherichia coli* were 20.9%, *Klebsiella pneumoniae* 50% and *Serratia marcescens* were 46.7%. Extended-spectrum beta-lactamase production increased each year (21.7%, 22.1% and 45.5%). All of the ESBL producing isolates were sensitive to meropenem and 98.5% sensitive to imipenem. AmpC beta-lactamase was produced by 20.9% of the *Enterobacter* sp., *Citrobacter* sp. and *Serratia marcescens*. All of these were sensitive to meropenem and 77.8% to imipenem and ciprofloxacin. Multi-drug resistance rates in *Acinetobacter* sp. were 45.4% and 37.7% in *Pseudomonas aeruginosa* isolates.

Jin San Moon *et al*. (2007)[45] examined 297 *Staphylococcus aureus* isolates and found SE production in 57 (31.8%), 4 (7.8%), and 49 (73.1%) isolates from raw milk, raw meat, and vegetables, respectively. A high proportion of the isolates obtained from milk produced more than two types of toxins (mainly SEA, SEB, and/or SEC), whereas isolates from raw meat and vegetables primarily produced SEA alone. Most isolates were sensitive to Cephalothin (97.6%), Gentamicin (80.8%), Erythromycin (79.5%), and Tetracycline (72.7%), but were resistant to Penicillin (90.2%) and Ampicillin (88.9%). The proportion of antibiotic-resistant isolates differed according the source of the bacteria; the milk and vegetable isolates were more resistant to penicillin and ampicillin than were the meat isolates, whereas tetracycline resistance was limited to the milk and vegetables isolates.

Hare Krishna Tiwari *et al*. (2009)[46] isolated 162 *Staphylococcus aureus* strains from various clinical specimens, and antibiotic susceptibility tests were performed using disc diffusion, growth on Oxacillin screen agar, and Oxacillin minimum inhibitory concentration (MIC). One hundred and twelve (69.1%) strains were found to be MRSA, of which 37 (33.1%) were community acquired and 75 (66.9%) were hospital acquired. Of 112 MRSA strains, 45 (40.1%) were multi-drug resistant. All MRSA strains were found resistant to Penicillin, and 91.9%, 87.4%, 77%, and 55.5% were resistant to Amoxicillin, Ampicillin, Trimethoprim/Sulfamethoxazole and Cephalexin, respectively. However, low resistance was observed with Amikacin (19%), Ciprofloxacin (26.5%), and Norfloxacin (30.6%). All strains were sensitive to Vancomycin.

Akindele *et al*. (2010)[47] reported the prevalence of ß-lactamase producing *Staphylococcus aureus* infections and their antimicrobial susceptibility. Beta-lactamase production was detected using a standard starch paper technique on all the isolates. *In vitro* antimicrobial susceptibility study was conducted by agar disc diffusion method. One hundred *Staphylococcus aureus* isolates obtained from different clinical specimens were studied. Out of total 100 strains of *Staphylococcus aureus*, 80% were found to be ß-lactamase producer, which probably accounted for 100% and 96% resistant rate obtained for penicillin and ampicillin respectively. Among the ß-Lactamase producing organisms, susceptibility to antibiotics were: erythromycin (82.5%), Cephalexin (71%) Ceftriaxone (70%), Cloxacillin (66%), others were Chloramphenicol, Gentamicin, Tetracycline and Streptomycin with 62.5%, 61%, 30% and 53.8% susceptible respectively.

Prasanth (2010)[48] compared the molecular relationships and antibiograms of nosocomial isolates of *Pseudomonas aeruginosa* obtained from three different genres of hospitals. Each of these hospitals, which follow different infection control strategies and various problems associated with it, were investigated. Antibiograms generated by disk diffusion susceptibility testing for clinically relevant antibiotics and genotyping through fluorescent amplified fragment length polymorphism analysis (fAFLP) were the tools used in the study. Molecular genotyping revealed a heterogeneous group of unrelated molecular clusters of *Pseudomonas aeruginosa* strains having higher resistance that are apparently being endemic throughout the tertiary care teaching hospital. In eye care hospital, only a few distinct strains of *Pseudomonas aeruginosa* predominating the study period were shown to be responsible for outbreaks. The third private hospital witnessed a group of resistant and persistent strains that might have clonally originated from a diverse collection of strains.

Ram Gopalakrishnan and Dorairaj Sureshkumar (2010)[49] found a 65% ESBL production rate in *Escherichia coli* and *Klebsiella* and up to 40% and 70% of *Pseudomonas* and *Acinetobacter* respectively were resistant to carbapenems.

Carbapenem resistance in *Klebsiella* has begun to emerge. CRBSI were largely Gram negative with MRSA contributing 6% of all isolates only. Over the 8 year study period, infection control efforts resulted in reduced CRBSI/VAP rates, fewer MRSA infections and improved sensitivities for *Pseudomonas* but not for other organisms. Resistance among Gram negative pathogens is a major problem in our tertiary care hospital. On the other hand *Clostridium difficile* and VRE are rarely encountered. Infection control measures were modestly effective in reducing CRBSI/ VAP rates but resistance rates among Gram negative pathogens were not significantly lowered.

Ramprasad Balikaran Pal *et al*. (2010)[50] determined the prevalence of strains of *Pseudomonas aeruginosa* in hospital environment, its incidence, clinical infections caused and to detect source of nosocomial infection by characterization of the *Pseudomonas* isolates. A total of 613 strains of *Pseudomonas* were isolated from different clinical specimens. 68 strains were isolated from environmental sites like Intensive Care Unit, Operation Theatre and Wards. Strains were identified by standard methods. Antibiogram and Pyocin typing was carried out for further characterization. Genotyping was performed by Pulsed Field Gel Electrophoresis. Highest percentage of *Pseudomonas aeruginosa* was from urine samples, followed by pus, tracheal secretions and sputa. Prevalence of the organism was highest in Intensive Care Unit followed by Intensive Care Medical Unit. The antibiogram showed maximum sensitivity to Piperacillin/Tazobactum, followed by Carbenicillin.

Yogeesha Babu *et al*. (2011)[51] detected the β-lactamase producing *Pseudomonas aeruginosa* (IR-MBLP-PA) from different hospital environmental sources from different areas of hospital, Antibiogram typing, to assess their role as source and reservoir of nosocomial infections and study the impact of infection control measures on environmental sources of IR-MBLP-PA. 460 environmental specimens collected and processed by standard laboratory procedures. Susceptibility testing was done by Kirby-Bauer disc diffusion method. IR-MBLP-PA detection was done by IMIPENEM+EDTA combined disc test. Impact of Infection control measures were assessed by percentage reduction of IR-MBLP-PA isolates from respective environmental sources. Study reported an incidence of 24.78 %; 5.65 % and 3.48%; 1.08% for *Pseudomonas aeruginosa* and IR-MBLP-PA respectively, before and after strict infection control measures. High incidence of IR-MBLP-PA of 14.8% and 10.52% in suction apparatus and mops respectively, 11.53%, 8.89% and 8.24% in Burns ward, ICCU and MICU respectively was reported. Six of the eight IR-MBLP-PA antibiogram types from environmental sources could be associated with fourteen nosocomial infections with two strains with no association.

8. LIMITATIONS OF ANTIBIOGRAM

Even if institutions were able to comply with all elements recommended for analysis and presentation of cumulative susceptibility data, antibiograms would still have only limited value for tracking antimicrobial resistance and guiding empiric therapy. A hospital antibiogram cannot be used to select empiric therapy in a patient with a subsequent infection because a patient's particular infection history, including past anti-microbial use, must be considered. Antibiograms provide susceptibility data, but they do not reveal additional information concerning microbial isolates, such as the timing of the isolate in relation to the patient's hospital admission. They do not even reveal if the organism was causing infection or was simply a colonizing strain.

Antibiograms reveal qualitative measures of susceptibility but do not provide quantitative data, such as minimum inhibitory concentrations (MICs). Any rises in MIC values that occur during a given time period that remain below the susceptible breakpoint cannot be detected. A further limitation of antibiograms is that they only capture the aggregate proportion of susceptible isolates for a given organism-antibiotic combination; one cannot determine what proportion of other antibiotics are also active, and they do not reveal trends in cross-resistance to multiple antibiotics. Information about these trends may help facilitate the use of local institutional susceptibility data for guiding empiric antibiotic coverage, such as in the treatment of hospital-acquired pneumonia.

Due to the high prevalence of cross-resistance among *Pseudomonas aeruginosa* isolates, a research group constructed a novel combination antibiogram for identification of optimal empiric dual combination therapy for infections due to *Pseudomonas aeruginosa*. The researchers developed the annual hospital antibiogram in a matrix that showed susceptibilities in both horizontal and vertical directions. Each box in the antibiogram listed the number and percentage of organisms susceptible to at least one of the two antibiotics. When compared with the hospital's

standard antibiogram, however, the novel antibiogram was not found to be superior in selecting optimal antibiotic combinations.

Aggregating susceptibility data across an entire hospital can be misleading, as hospital wide susceptibility data may hide trends in specific hospital wards or areas. Antimicrobial resistance is likely to be more prevalent in ICUs than in other areas of the hospital. Surveillance of antimicrobial resistance within a hospital should ideally involve tracking resistance rates from several patient areas, provided enough isolates are available to analyze. Laboratories commonly combine *Pseudomonas aeruginosa* isolates from patients with cystic fibrosis with other isolates of *Pseudomonas* when reporting antibiograms. However, this practice underestimates the activity of some anti-infective classes, such as fluoroquinolones and aminoglycosides, against *Pseudomonas* isolates from patients without cystic fibrosis. Another limitation of antibiograms is that their susceptibility data represent isolates from various body sites, as susceptibility data from organisms causing bloodstream infections only or pneumonias, for example, are usually not available.

9. PREVENTION OF NOSOCOMIAL INFECTIONS

Hospitals take a variety of steps to prevent nosocomial infections, including:

- Adopt an infection control program such as the one sponsored by the U.S. Centers for Disease Control (CDC), which includes quality control of procedures known to lead to infection, and a monitoring program to track infection rates to see if they go up or down.
- Employ an infection control practitioner for every 200 beds.
- Identify high-risk procedures and other possible sources of infection.
- Strict adherence to hand-washing rules by health care workers and visitors to avoid passing infectious microorganisms to or between hospitalized patients.
- Strict attention to aseptic (sterile) technique in the performance of procedures, including use of sterile gowns, gloves, masks, and barriers.
- Sterilization of all reusable equipment such as ventilators, humidifiers, and any devices that come in contact with the respiratory tract.
- Frequent changing of dressings for wounds and use of antibacterial ointments under dressings.
- Remove nasogastric (nose to stomach) and endotracheal (mouth to stomach) tubes as soon as possible.
- Use of an antibacterial-coated venous catheter that destroys bacteria before they can get into the blood stream.
- Prevent contact between respiratory secretions and health care providers by using barriers and masks as needed.
- Use of silver alloy-coated urinary catheters that destroy bacteria before they can migrate up into the bladder.
- Limitations on the use and duration of high-risk procedures such as urinary catheterization.
- Isolation of patients with known infections.
- Sterilization of medical instruments and equipment to prevent contamination.
- Reductions in the general use of antibiotics to encourage better immune response in patients and reduce the cultivation of resistant bacteria.

CONCLUSION

From this review, it is concluded that the pathogenic nosocomial infection causing bacteria are present with varying antibiotic resistance. Surveillance of antimicrobial resistance in hospitals is paramount to ensuring the safety of a hospital's patients and its quality of healthcare. Through the use of antimicrobial resistance summary scores, hospital personnel can hold a better understanding of their hospitals overall burden of antimicrobial resistance and use the 15 information to better inform their use of pharmacotherapy. Furthermore, infection control practitioners may find the inclusion of a summary score of antimicrobial resistance, in conjunction with individual microbe rates of resistance, beneficial in describing the trends of overall resistance. Our review posits that a summary measure of antimicrobial resistance can be reliable over time, associated with known correlates of antimicrobial resistance, and clinically relevant.

REFERENCES

1. Kirkland K.B. 1999. The impact of surgical-site infections in the 1990's: attributable mortality, excess length of hospitalization and extra costs. *Infect Contr Hosp Epidemiol*, 20:725–730.

2. Chambers, H.F. 2001. The changing epidemiology of *Staphylococcus aureus*? *Emerg Infect Dis*., 7: 178–182.
3. Subedi, S and Brahmadathan, K.N. 2005. Antimicrobial susceptibility patterns of clinical isolates of *Staphylococcus aureus* in Nepal. *Eur Soci Clin Microbiol Infect Dis*., 11: 35-37.
4. Rosenthal, VD, Maki DG, Salomao R, Moreno CA, Mehta Y and Higuera F. 2006. Device-associated nosocomial infections in 55 intensive care units of 8 developing countries. *Ann Intern Med*.,145:582-591.
5. Scott Fridkin, Jonathan Edwards, Robert Gaynes and John McGowan. 2001. Antimicrobial resistance prevalence rates in hospital antibiogram reflects prevalence rates among pathogens associated with hospital infections. *Clinical infection diseases*, 33: 324-330.
6. Agarwal, G., Kapil, A., Kabra, S.K., Chandra, R., Das, B and Diwedi S.N. 2005. Characterization of *Pseudomonas aeruginosa* isolated from chronically infected children with cystic fibrosis in India. *BMC Microbiol*., 5:43.
7. Coella, R. 1993. The cost of infection in surgical patients: a case study. *J Hosp Infect*., 25:239– 250.
8. Kumari, N., Mohapatra, T.M and Singh, Y.I. 2008. Prevalence of Methicillin-Resistant *Staphylococcus aureus* (MRSA) in a Tertiary-Care Hospital in Eastern Nepal. *J Nepal Med Assoc*., 47: 53-56.
9. Emmerson, A.M. 1996. The second national prevalence survey of infection in hospitals — overview of the results. *J Hosp Infect.*, 32:175–190.
10. Qureshi, A.H, Rafi, S., Qureshi, S.M and Ali, A.M. 2004. The current susceptibility patterns of Methicillin resistant *Staphylococcus aureus* to conventional anti *Staphylococcus* antimicrobials at Rawalpindi. *Pak J Med Sci*., 20: 361–364.
11. Goff, D.A and Dowzicky M.J. 2007. Prevalence and regional variation in Methicillin-resistant *Staphylococcus aureus* (MRSA) in the USA and comparative *in vitro* activity of tigecycline, a glycylcycline antimicrobial. *J Med Microbiol*., 56: 1189-1193.
12. Majumder, D., Bordoloi, J.N., Phukan AC and Mahanta J (2001) Antimicrobial susceptibility pattern among Methicillin resistant *Staphylococcus* isolates in Assam. *Indian J Med Microbiol*., 19: 138–140.
13. Anupurba, S., Sen, M.R., Nath, G., Sharma, B.M., Gulati, A.K and Mohapatra, T.M. 2003. Prevalence of methicillin resistant *Staphylococcus aureus* in a Tertiary care Referral Hospital in Eastern UttarPradesh. *Indian J Med Microbiol*., 21: 49–51.
14. Rajaduraipandi, K., Mani, K.R., Panneerselvam, K., Mani, M., Bhaskar, M., Manikandan, P. 2006. Prevalence and antimicrobial susceptibility pattern of methicillin resistant *Staphylococcus aureus*: A multicentre study. *Ind J Med Microbiol*., 24: 34–38.
15. Holloway, K. 2000. Antimicrobial resistance: the facts. Essential Drug Monitor WHO, 28 & 29: 7–8.
16. Hart, C.A and Kariuki, S. 1998. Antimicrobial resistance in developing countries. *BMJ*, 317: 647-650.
17. Sorlozano, A., Gutiérrez, J., Roman, J., Liebana, J and Piedrola, G. 2009. Activity of Daptomycin against multiresistant clinical isolates of *Staphylococcus aureus* and *Streptococcus agalactiae*. *Microb Drug Resist*., 15: 125-127.
18. Tenover, F.C. 2006. Mechanisms of antimicrobial resistance in bacteria. *Indian J Med Sciences*, 54: 535–540.
19. Zapantis, A., Lacy, M.K and Horvat, R.T. 2005. Nationwide antibiogram analysis using NCCLS M39-A guidelines. *J Clin Microbiol*., 43: 2629–34.
20. Lai, P. S., Ngeow, Y. E., Puthucheary, P. and Wang, C. W. 1983. Comparison of two methods for bacteriocin typing of *Serratia marcescens*. *J. Clin. Microbiol*., 17: 1-6.
21. Navon-Venezia S, Ben-Ami R and Carmeli Y. 2005. Update on *Pseudomonas aeruginosa* and *Acinetobacter baumannii* infections in the healthcare setting. *Curr Opin Infect Dis*., 18:306-13.
22. Hancock, R.E and Speert, D.P. 2000. Antibiotic resistance in *Pseudomonas aeruginosa*: mechanisms and impact on treatment. *Drug Resist Updat*., 3: 247-255.
23. Kaul S, Brahmadathan KN, Jagannati M, Sudarsanam TD, Pitchamuthu K, Abraham OC, and John G. 2007. One year trends in the Gram-negative bacterial antibiotic susceptibility patterns in a medical

intensive care unit in South India. *Indian J Med Microbiol*., 25: 230-235.
24. Kenchappa, P., Rao, K.R., Ahmed, N., Joshi, S., Ghousunnissa,S and Vijayalakshmi. 2006. Fluorescent amplified fragment length polymorphism (FAFLP) based molecular epidemiology of hospital infections in a tertiary care setting in Hyderabad, India. *Infect Genet Evol*., 6: 220-227.
25. Agarwal G, Kapil A, Kabra SK, Chandra R, Das B and Diwedi SN. 2002. Phenotypic and genotypic variants of *Pseudomonas aeruginosa* isolated from children with cystic fibrosis in India. *Indian J Med Res*., 116:73-81.
26. Boerema, J. A., R. Clemens, and G. Brightwell. 2006. Evaluation of molecular methods to determine enterotoxigenic status and molecular genotype of bovine, ovine, human and food isolates of *Staphylococcus aureus. Int. J. Food Microbiol.*, 107:192–201.
27. Cha, J. O., J. K. Lee, Y. H. Jung, J. I. Yoo, Y. K. Park, B. S. Kim, and Y. S. Lee. 2006. Molecular analysis of *Staphylococcus aureus* isolates associated with *Staphylococcal* food poisoning in South Korea. *J. Appl. Microbiol.*, 101:864–871.
28. Kwon, N. H., K. T. Park, W. K. Jung, H. Y. Youn, Y. Lee, S. H. Kim, W. Bae, J. Y. Lim, J. Y. Kim, J. M. Kim, S. K. Hong, and Y. H. Park. 2006. Characterization of Methicillin-resistant *Staphylococcus aureus* isolated from chicken meat and hospitalized dogs in Korea and their epidemiological relatedness. *Vet. Microbiol.*, 117:304-312.
29. Erkan, B., Eckert, J. W and Ogawa, J. M. 2008. The chemical control of postharvest diseases: deciduous fruits, berries, vegetables and root/tuber crops. *Annual Review Phytopathology*, 26: 433–469.
30. Fridkin, S.K., Edwards, J.R and Tenover, F.C. 2001. Antimicrobial resistance prevalence rates in hospital antibiograms reflect prevalence rates among pathogens associated with hospital-acquired infections. *Clin Infect Dis*., 33: 324–330.
31. Magee, J.T. 2004. Effects of duplicate and screening isolates on surveillance of community and hospital antibiotic resistance. *J Antimicrob Chemother*., 54: 155–162.
32. Coffin SE and Zaoutis TE. 2005. Infection Control, Hospital Epidemiology, and Patient Safety. *Infect Dis Clin* :647-665
33. Ducel, G., Fabry, J., and L. Nicolle. 2002. "Prevention of hospital acquired infections: A Practical Guide, 2nd Edition," *World Health Organization*.
34. Gordis, Leon, "Epidemiology, Third Edition," *Elsevier Saunders* 2004.
35. Wenzel, RP. Prevention and Control of Nosocomial Infections. 3rd Ed. Williams and Wilkins, 1997.
36. Chen C.H., Tsou T.L., Chiang H.Y., Lee S.H., Lee F and Lee J.H. 1997. Susceptibility of *Pseudomonas aeruginosa* of various pyocin types to the newly synthesized Ampicillin derivative, *N*-(6, 7-difluoroquinolonyl)- ampicillin. *J. antimicrob. Chemother.*, 39: 325-330.
37. Singh A., Goering RV., Simjee S, Foley S.L. and Zervos MJ. 2006. Application of Molecular Techniques to the Study of Hospital Infection. *Clin Micribiol Rev.*, 19 (3): 512-530.
38. Weber DJ, Raasch R and Rutala WA. 1999. Nosocomial infections in the ICU: the growing importance of antibiotic-resistant pathogens. *Chest*, 115: 34S- 41S.
39. Farr, M.M., C.D.Salkodao, T.B.Karchmer and R.J.Sheritz. 2001. Can antibiotic resistant nosocomial infection can be controlled? *Lascet infectious Diseases*, 1 (1): 38-45.
40. Anwar Akram Issa Dudin. 1998. Molecular, antibiogram and serotype testing of *Staphylococcus aureus* isolates recovered from East Jerusulem. *Tropical Medicine and International Health*, 3(7): 576-583.
41. Webster, T.A., K.J.Towner and G.L.Saunders. 1999. Comparison of antibiogram, *Staphylococcus* enterotoxin productivity, and coagulase genotypes among the *Staphylococcus aureus* isolated from animal and vegetable sources. *European Journal of Clinical Microbiology and Infectious Diseases*, 18 (8): 595-598.
42. Scott Fridkin, Jonathan Edwards, Robert Gaynes and John McGowan. 2001. Antimicrobial resistance prevalence rates in hospital antibiogram reflect prevalence rates among pathogens associated with

hospital infections. *Clinical infection diseases*, 33: 324-330.

43. Nabeela Noor, Munazza Ajaz, Asim Razool and Imran Naazeer. 2004. Urinary tract infection associated with multidrug resistant enteric bacilli characterization and genetical studies. *Pakisthan Journal of Pharmacological studies*, 17 (2): 115-123.
44. Yanman, A., S.Tasova, F.Kibar, B.Kurtan and I.H.Dundar. 2004. Investigation of the antibiotic susceptibility of pathogen causing nosocomial infection. *Saudi Medical Journal*, 25 (10): 1403-1409.
45. Jin San Moon, Mal Nam Kim, Yu Chung and Yong Hoo. 2007. Comparison of antibiogram, *Staphylococcal* enterotoxin productivity, and Coagulase genotypes among the *Staphylococcus aureus* isolated from animal and vegetable sources. *Journal of Food Protection*, 70 (11): 2541-2548.
46. Hare Krishna Tiwary, Ayan Kumar Das, Darshan Sapkota and Vijay Kumar Phava. 2009. Methicillin resistant *Staphylococcus aureus*: prevalence and antibiogram in a tertiary care hospital in Western Nepal. *J Infect Dev Ctries*., 3 (9): 681-684.
47. Akindele, A.A., I.K.Adewuyi, S.A.Adedokum and A.O.Olaolu. 2010. Antibiogram and beta lactamase production of *Staphylococcus aureus* isolates from different human clinical specimens in a Tertiary health institution of Nigeria. *American Journal of Scientific Research*, 5 (4): 230-233.
48. Prasanth,K., S.K.Singh, R.Kanungo, S.Joshi, S.Sharma and S.Jayachandran. 2010. Correlation between genotyping and antibiogram of clinical isolates of *Pseudomonas aeruginosa* from three different South Indian Hospitals. *Indian Journal of Medical Microbiology*, 28(2): 132-137.
49. Ram Gopalakrishnan and Dorairajan Sureshkumar. 2010. Changing trends in antibiotic susceptibility and hospital acquired infection over an 8 year period in a Tertiary care hospital in relation to infection control programme. *Supplement to JAPI*, 58: 25-32.
50. Ramprasad Balikaran Pal, Marissa Rodriguez and Supramma Datta. 2010. Role of *Pseudomonas* sp. in nosocomial infection and biological characterization of local strains. *Bioscience Technology*, 1 (4): 170-179.
51. Yogeesha Babu, K.V., Amruta Kumara and V.Vijayananth. 2011. Study of Berta lactamase antibiotic resistant *Pseudomonas aeruginosa* from different hospital environment. *Journal of Pure and Applied Microbiology*, 5 (1): 195-203.